600 NE Grand Ave.
Portland, OR 97232-2736

Metro | *Agenda*

Meeting: Metro Council Work Session
Date: Tuesday, May 1, 2012
Time: 1 p.m.
Place: Council Chambers

CALL TO ORDER AND ROLL CALL

1 PM	**1.**	**ADMINISTRATIVE/ COUNCIL AGENDA FOR MAY 3, 2012/CHIEF OPERATING OFFICER COMMUNICATIONS**	
1:15 PM	**2.**	**DEPARTMENT OF LAND CONSERVATION AND DEVELOPMENT REPORT ON URBAN GROWTH BOUNDARY DECISION – INFORMATION / DISCUSSION**	**Bennett Benner**
1:45 PM	**3.**	**FY 2012-2013 BUDGET DISCUSSION – INFORMATION / DISCUSSION**	**Norton Rutkowski**
3:15 PM	**4.**	**COUNCIL BRIEFINGS/COMMUNICATION**	

ADJOURN

Agenda Item No. 2.0

DEPARTMENT OF LAND CONSERVATION AND DEVELOPMENT REPORT ON URBAN GROWTH BOUNDARY DECISION

Metro Council Work Session
Tuesday, May 1, 2012
Metro, Council Chamber

600 NE Grand Ave.
Portland, OR 97232-2736
www.oregonmetro.gov

Metro | *Memo*

Date: Thursday, April 26, 2012
To: President Hughes and Metro Council
From: John Williams
Subject: DLCD staff recommendation on 2011 growth management decision

We have time scheduled on your May 1 work session to discuss the DLCD staff recommendation on the 2011 growth management decision. Dick Benner is leading the work to file our response and will present it on Tuesday. Included here is an overview of the items raised in the DLCD report and the direction we're headed with our technical response. Please note that in addition to this technical work, we are also coordinating with supportive stakeholders and partners to provide a consistent overall message to the Commission: the Metro Council's decision has broad regional support, protects farm and forest land, and focuses investment, jobs and growth in our existing communities. We can discuss our strategy more on May 1 as well.

Remand recommendations from DLCD staff:

1. Reconcile forecasted housing and residential land needs to the population forecast. Upon resubmittal, either (1) demonstrate that the findings and conclusions contained in the housing and residential land needs analyses are supported by substantial evidence and based on the population forecast of 625,183, or (2) include the required findings and conclusions and reconsider whether or how much land needs to be added to the UGB. See Section V.B of this report.

   Key points in our draft response: Metro's work substantially complies with needed housing requirements; the department is calling for new levels of analysis and justification not required by law. Goal 14 includes a provision that needs determinations "should not be held to an unreasonably high level of precision."

2. Complete an employment land inventory in compliance with OAR 660-015-0015, as required by OAR 660-024-0050(1). Upon resubmittal, either (1) demonstrate, based on evidence in the record, that the inventory of employment land within the UGB was completed according to these administrative rules, or (2) include a detailed inventory that identifies the supply of sites suitable for the expected uses as required by administrative rule. See subsection C.3 of Attachment B.

   Key points in our draft response: Metro's inventory work (which we'll describe again) substantially complies with applicable rules, and is appropriate for analysis of employment lands at a regional scale. Oregon Administrative Rules state that "20 year need determinations are estimates…which should not be held to an unreasonably high level of precision" and that "a jurisdiction's planning effort is adequate if it uses the best available or readily collectable information."

3. Complete the UGB location analysis in a manner consistent with Goal 14 location factors and OAR 660-024-0060. Upon resubmittal, either (1) demonstrate through evidence in the record that the method used by Metro in selection of analysis areas complied with Goal 14

and administrative rules, or (2) include additional findings demonstrating that the decision on selection of areas considered for inclusion in the UGB complies with Goal 14 and OAR 660-024-0060. See subsection V.D.2 of this report.

Key points in our draft response: Metro has substantially complied with the law and has provided the analysis called for by the Department. Any divergence is minor and technical in nature.

4. Demonstrate that the final decision complies with the Goal 14 location factors. Upon resubmittal, either (1) demonstrate based on evidence in the record that the comparative analysis of alternative UGB expansion areas complied with the Goal 14 locational analysis independently of local location factors from the Metro Code, or (2) complete a new alternatives analysis that applies the Goal 14 factors separately from local factors. See subsection V.D.3 of this report.

   Key points in our draft response: Metro completed all analyses required by Goal 14 and clearly provided findings to demonstrate this compliance. The Commission should take administrative notice of the extensive work done throughout the reserves process to analyze areas and conclude that our decision is in substantial compliance with the rules.

Agenda Item No. 3.0

FY 2012-2013 BUDGET DISCUSSION

Metro Council Work Session
Tuesday, May 1, 2012
Metro, Council Chamber

Materials following this page were distributed at the meeting.

600 NE Grand Ave.
Portland, OR 97232-2736

Metro | *Agenda*

Meeting: Metro Council
Date: Thursday, May 3, 2012
Time: 2 p.m.
Place: Metro, Council Chamber

CALL TO ORDER AND ROLL CALL

1. INTRODUCTIONS

2. CITIZEN COMMUNICATION

3. METRO AUDITOR REPORT – "METRO'S NATURAL AREAS: MAINTENANCE STRATEGY NEEDED" **Flynn**

4. CONSIDERATION OF THE MINUTES FOR APRIL 26, 2012

5. PROCLAMATIONS

5.1 **Resolution No. 12-4348**, For the Purpose of Proclaiming the Week of May 5 through May 13, 2012 as National Travel and Tourism Week. **Craddick**

6. ORDINANCES – SECOND READING

6.1 **Ordinance No. 12-1274**, For the Purpose of Adopting the Annual Budget for Fiscal Year FY 2012-13, Making Appropriations, Levying Ad Valorem Taxes, and Authorizing an Interfund Loan. **Hughes**

Public Hearing

7. RESOLUTIONS

7.1 **Resolution No. 12-4338**, For the Purpose of Approving the FY 2012-13 Budget, Setting Property Tax Levies and Transmitting the Approved Budget to the Multnomah County Tax Supervising and Conservation Commission. **Hughes**

8. CHIEF OPERATING OFFICER COMMUNICATION

9. COUNCILOR COMMUNICATION

ADJOURN

Television schedule for May 3, 2012 Metro Council meeting

Clackamas, Multnomah and Washington counties, and Vancouver, WA Channel 30 – Community Access Network *Web site*: www.tvctv.org *Ph*: 503-629-8534 *Date*: Thursday, May 3, Live	**Portland** Channel 30 – Portland Community Media *Web site*: www.pcmtv.org *Ph*: 503-288-1515 *Date:* Sunday, May 6, 7:30 p.m. *Date*: Monday, May 7, 9 a.m.
Gresham Channel 30 - MCTV *Web site*: www.metroeast.org *Ph*: 503-491-7636 *Date*: Monday, May 7, 2 p.m.	**Washington County** Channel 30– TVC TV *Web site*: www.tvctv.org *Ph*: 503-629-8534 *Date*: Saturday, May 5, 11 p.m. *Date*: Sunday, May 6, 11 p.m. *Date*: Tuesday, May 8, 6 a.m. *Date*: Wednesday, May 9, 4 p.m.
Oregon City, Gladstone Channel 28 – Willamette Falls Television *Web site*: http://www.wftvmedia.org/ *Ph*: 503-650-0275 Call or visit web site for program times.	**West Linn** Channel 30 – Willamette Falls Television *Web site*: http://www.wftvmedia.org/ *Ph*: 503-650-0275 Call or visit web site for program times.

PLEASE NOTE: Show times are tentative and in some cases the entire meeting may not be shown due to length. Call or check your community access station web site to confirm program times.

Agenda items may not be considered in the exact order. For questions about the agenda, call the Metro Council Office at 503-797-1540. Public hearings are held on all ordinances second read. Documents for the record must be submitted to the Regional Engagement Coordinator to be included in the decision record. Documents can be submitted by e-mail, fax or mail or in person to the Regional Engagement Coordinator. For additional information about testifying before the Metro Council please go to the Metro web site www.oregonmetro.gov and click on public comment opportunities. For assistance per the American Disabilities Act (ADA), dial TDD 503-797-1804 or 503-797-1540 (Council Office).

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Metro | *Office of Metro Attorney*

April 30, 2012

Mr. Larry French
Periodic Review Coordinator
Department of Land Conservation & Development
635 Capitol Street NE, Suite 150
Salem, OR 97301

Subject: Exceptions to April 19, 2012, Department's Report on Metro Capacity and UGB Ordinances

Dear Mr. French:

Below are Metro's exceptions, filed pursuant to OAR 660-025-0160(5), to the Department's Report on Metro Capacity and UGB Ordinances (Ordinances No. 10-1244B and 11-1264B). The report recommends remand of Metro's work on four grounds. Metro addresses each of the grounds here and urges the Commission to approve the two ordinances, adopted to use land inside the UGB more efficiently (1244B) and to meet the region's capacity needs with a small UGB expansion (less than 2,000 acres) (1264B).

Ground 1: The Department recommends that the Commission remand the UGB expansion to Metro to reconcile housing and residential land needs to the population forecast

The department recommends that the Commission remand Metro's two ordinances to Metro to "revise its housing needs analysis to conform to the point forecast, including housing types and densities." Report at p. 21. The Department's analysis of Metro's analysis of capacity for housing, at pages 15-26 of the report, is surprising, startling and deeply disappointing. It indicts an approach that Metro used in its last capacity analysis, an approach that LCDC approved and survived appeal. It calls for a level of analysis not asked of Metro in 2002, never done by Metro, not required by law, and unachievable in any reasonable way. Were the Commission to approve the report and remand Metro's ordinance to respond to all the points in these pages of the report, it would require Metro to begin its capacity analysis anew. This would be the very "numbers chase" the Metro Council wanted to avoid so that it could focus on building efficient communities and reducing UGB expansion. That is what the Capacity and UGB Ordinances accomplished. That work is endangered by the department's analysis and recommendation.

Metro Has Satisfied Needed Housing Requirements

Metro completed an analysis of housing need and supply as part of the Capacity Ordinance that is more thorough and sophisticated than any it had done before. It is much improved over the analysis done in support of the UGB expansion made by Ordinance No. 02-969B in 2002 (acknowledged by LCDC). The analysis provides every item of information specified in ORS 197.296(3). There is, of course, a significant difference between the 2002 analysis and this 2009 analysis: Metro began the 2002 analysis with a

precise (point) population forecast. Metro began the 2009 capacity analysis with a range forecast. The 2009 analysis, therefore, showed a range of housing need. This was a deliberate decision made by the Metro Council to respond to the real world, particularly the housing market, and to position Metro to make the best choices at the end of the analysis. The department, with some trepidation, endorsed this approach, warning Metro that, in the end, Metro must come to a point. Metro came to a point: 625,183 more people and approximately 254,100 new housing units by 2030. This point falls at the low end of the middle third of Metro's population range forecast. Framed by housing needs analyses at the high and low ends of the range, Metro's adoption of a point forecast completes the housing needs analysis. The department wants Metro to retrace its analysis of capacity using these numbers.

The context of Metro analysis, not recognized in the department's report, is essential to understanding the analysis and why doing it over would achieve no useful objective. First, Metro found more zoned capacity within the UGB than needed, even at the high end of the population forecast range. This capacity reflects all the changes to plans and zoning ordinances made by cities and counties in the region in the late 1990s and early 2000s to implement the 1995 2040 Growth Concept and addition of housing capacity to the UGB in 2002. LCDC accepted this capacity analysis when it acknowledged Ordinance No. 02-969B. LCDC also accepted Metro's demonstration that the actions taken by that ordinance accommodated the region's housing needs under Goal 10 and ORS 197.296(3).

Second, Metro learned that the market would not absorb the region's full zoned capacity under policies in place at the time of the analysis (2009). Instead, the market would send much of the housing outside the UGB to nearby cities, principally, the city of Vancouver. This market information confronted Metro with policy choices: given zoned capacity for more housing units than needed even at the high end of the forecast range, how should the region reconcile conflicting objectives?

Third, Metro found unacceptable a set of choices that would send housing to surrounding cities, likely to result in sprawl and diminish efforts by Metro and cities of the region to build compact, mixed-used, pedestrian-friendly and transit-supportive communities. Consequently, Metro adopted policies and strategies, set forth in the Capacity Ordinance, to stimulate the market to use more of the land inside the UGB. When Metro tested the effects on the market of these new policies and strategies (using MetroScope, Metro's econometric model), the result showed that the market would absorb another 30,300 housing units of capacity available under existing zoning. This is the same zoning, with a few new "upzones," that was in place at the time of LCDC's approval of the 2002 capacity analysis and accommodation of housing need.

In other words, the efficiency actions taken in the Capacity Ordinance will accommodate all but 15,896 of the 254,100 units needed to house 625,183 new people by 2030. The UGB Ordinance added 1,656 acres of housing capacity with conditions that it be zoned to allow a minimum of approximately 15 units/net acre. MetroScope demonstrates that this combination of efficiency actions and added UGB capacity, relying upon the densities and mix of types housing needs allowed in city and county residential zoning ordinances, will accommodate the housing need identified by Metro in the UGR. Metro's approach, though different from what cities outside the region do (relying on zoned capacity), is consistent with state law on housing needs.

The Department is Calling for New Levels of Analysis and Justification Not Required by Law
Example: The report (p. 23) calls for findings and analysis to justify Metro's determination in the UGR of land for places of worship and social organizations:

> "Metro uses a formula of 1.4 acres per 1000 new residents in order to estimate 20-year need for churches, which it took from its 1997 UGR. Cap. Ord. Rec. at 2065. The UGR lacks findings supported by evidence justifying use of a 1997 formula for the 2010-2030 periods."

This analysis is not part of Metro's housing need analysis and is not required by Goal 10 or the needed housing statutes. Metro proposes no UGB expansion for places of assembly or social organizations. No objector raised this issue. Yet the department recommends LCDC send Metro analysis of housing need back to Metro for this analysis and new findings.

Example: The report (p. 24)calls for analysis and findings that reconcile Metro's efficiency measures to the buildable land inventory or housing needs analysis:

> "Metro identified that efficiency measures inside the UGB account for 30,300 dwelling units, but does not identify what type of housing units they would be, at what density, and what the deficit would be requiring Metro to expand the UGB."

We may be misunderstanding this startling requirement, but here is what it says to us: Metro must pre-determine the number, type and density of housing units that will result from each of its actions taken by Ordinance No. 10-1244B (urban renewal/tax increment financing; investments in new high-capacity transit; investments in transit-oriented development; the many local actions to be taken by the cities of the region; etc.) to use the region's existing zoned capacity more efficiently. Metro did estimate and attribute the number of units expected from the efficiency actions taken by the Capacity Ordinance. Findings of Fact pp. 3-11. It is simply not possible, in any responsible way, to try to determine the types, mix of types and densities of housing that will result from these efforts over the next 20 years.

Example: The report (p. 25) calls upon Metro to provide higher planned residential densities:

> "OAR 660-007-0035 requires that, region-wide, planned residential densities must be considerably in excess of the residential density assumed in Metro's 1980 'UGB Findings.' The standards in this rule for new construction density and mix, and the criteria for varying from them, take into consideration and also satisfy the price range and rent level criteria for needed housing as set forth in ORS 197.303."

We find no such requirement in OAR 660-007-0035. Of course, revisions to zoning made by the cities and counties of the region to implement the 1995 2040 Growth Concept allow and require (in response to Metro's minimum density requirement) much higher densities than allowed in 1980. The Metro Council, prior to UGB Ordinance No. 11-1264B, had required at least 10 units/net developable acre in

areas added to the UGB. This UGB Ordinance imposes conditions that areas added to the UGB for residential capacity yield at least 15 units/net developable acre. But neither OAR 660-007-0035 nor any other state law of which we are aware requires higher planned densities than Metro now requires.

Example: The report (p. 26) calls upon Metro to determine the types, mix and density of the dwelling units expected in the areas added to the UGB:

> " . . . the record does not adequately demonstrate:
>
> "The capacity for the areas added, and whether there is sufficient assurance that it will be zoned to provide for the needs for which it was included and whether rules on housing types and density are being followed for this land."

Metro adopted conditions for the areas added to the UGB for residential capacity that require the cities responsible for planning to provide a minimum zoned capacity for a specified number of units. Of course, this planning and zoning has not yet occurred. It will take place after Commission approval of the UGB expansion (within two years). LCDC has never before asked Metro to pre-determine the types and densities for areas added to the UGB. The overall density for each area can be derived from the conditions adopted by UGB Ordinance 11-1264B and Metro's analysis of buildable land, all in the record (minimum of approximately 15 units/net acre). But Metro did not attempt to pre-determine the types or mix of housing, nor does the law require it. Metro's practice is to participate in the city planning and zoning of areas added to the UGB to ensure conditions and the law are satisfied. It is noteworthy that the requirements of OAR 660-007-0035 and the rest of the Metropolitan Housing Rule will apply to this planning by Hillsboro, Beaverton and Tigard.

Summary
Metro reminds the Commission about the wise provision in the Goal 14 rule that determinations of needs "should not be held to an unreasonably high level of precision" [OAR 660-024-0040(1)]. Metro urges the Commission to find Metro in substantial compliance with state laws on housing needs.

Ground 2: The Department recommends that the Commission remand the UGB expansion to Metro to complete an employment land inventory

The Department faults Metro's analysis of the region's supply of employment land for not complying with the Goal 14 rule. OAR 660-024-0050(1) calls for an inventory to determine whether the UGB contains adequate capacity for the next 20 years. The Department acknowledges that Metro did "valuable work." In fact, the Department states: "...Goal 14 does not provide specific requirements that Metro failed to address, and Hillsboro has failed to demonstrate that the capacity and UGB ordinances inadequately demonstrate compliance with the goal." Nonetheless, the Department would have the Commission send Metro back for additional analysis and greater detail in its inventory of the employment land supply. Report, pages B-4 to B-6.

The Department measures Metro's analysis against specifications in the Goal 9 rule for an "Economic Opportunities Analysis." Goal 9 does not apply to Metro. The Goal 14 rule, however, directs local governments, including Metro, to develop an "Inventory of Industrial and Other Employment Lands" to the specifications in OAR 660-009-0015(3). Here is the level of detail that rule requires:

> "(a) For sites inventoried under this section, plans must provide the following information:
>
> (A) The description, including site characteristics, of vacant or developed sites within each plan or zoning district;
>
> (B) A description of any development constraints or infrastructure needs that affect the buildable area of sites in the inventory; and
>
> (C) For cities and counties within a Metropolitan Planning Organization, the inventory must also include the approximate total acreage and percentage of sites within each plan or zoning district that comprise the short-term supply of land."

This level of analysis and detail may be appropriate for cities and urban portions of counties, to whom Goal 9 applies and who must do EOAs. Most cities and counties have a few hundred or a few thousand acres of employment land. But level of analysis and detail is not appropriate for a regional government with 25 cities and the urbanized portions of three counties. First, the region has more than 70,000 acres of land zoned for employment (or mixed-use that allows employment) within the UGB[1]; the magnitude of the inventory task is much greater. Second, cities and counties in Metro have already done this level of analysis, or will do it in periodic review. Tying Metro to this Goal 9 work through the Goal 14 rule forces Metro to duplicate this work. But there is no denying that LCDC rules now require this level of analysis and detail.

Metro's inventory of employment sites very nearly achieves this level of analysis and detail. There are approximately 13,000 gross vacant acres of land inside the UGB zoned for employment uses. The 2009 UGR inventoried approximately 10,000 net buildable acres zoned for employment uses. Despite the size of that inventory, the suitability analysis Metro completed is quite detailed. For each lot included in the inventory, the following information was assembled and reviewed by cities and counties for accuracy (Cap Ord Rec 4101-4105):

- Zoning designation (proxy for suitability for employment)
- Market subarea
- 2040 design type
- Buildable acres, accounting for constraints

[1] Appendix D; see analysis in UGR, Cap Ord Rec 4094-4114, informed by Metro's Regional Land Information System (RLIS) Rec 4101).

- Development readiness tier and assignment of each lot to short-term or long-term supply, based on assessment of:
  a. Environmental constraints
  b. Availability of infrastructure
  c. Access to transportation
  d. Zoning for urban use
  e. Brownfield contamination, aviation overlays, marine use restrictions and other development constraints
  f. Owner constraints
  g. Existing building and land values
  h. Location.

Metro addresses re-development of developed employment land with rates for infill and re-development rather than speculating which lots will fill or re-develop over time. Metro applied separate rates for industrial land and nonindustrial land, based upon the best available information.

Both the UGB rule [OAR 660-024-0040(1)][2] and the Goal 9 rule [OAR 660-009-0010(5)][3] mitigate the level of detail the rules otherwise require, sensitive to situations in which such detail is difficult or impossible to achieve, and would serve no useful purpose. Metro believes the Commission should apply these mitigating rules in this situation and find that Metro's inventory substantially complies with Goal 14 rule 0050(1); any divergence from the details required by 660-009-0015(3) is "technical or minor in nature." See ORS 197.747.

Ground 3: The Department recommends that the Commission remand the UGB expansion to Metro for further analysis to explain the basis for Metro's selection of 9,800 acres for detailed analysis from the total 28,256 acres Metro has designated as urban reserves

The efficiency measures adopted by the Metro Council in Ordinance No. 10-1244B ("the Capacity Ordinance") increased the capacity of the existing UGB by 30,300 housing units. The ordinance directed further efforts to meet the remaining need for housing units to a point between the low end and the high end of the middle third of the forecast range. This direction determined the remaining housing need at 15,600 to 26,600 units. Following a similar process, the Council determined that, following efforts to use employment land more efficiently, the region needed between 200 to 1,500 acres of large parcels for industrial use.

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[2] "The 20-year need determinations are estimates which, although based on the best available information and methodologies, should not be held to an unreasonably high level of precision."

[3] "The effort necessary to comply with OAR 660-009-0015 through 660-009-0030 will vary depending on the size of the jurisdiction, the detail of previous economic development planning efforts, and the extent of new information on national, state, regional, county, and local economic trends. A jurisdiction's planning effort is adequate if it uses the best available or readily collectable information to respond to the requirements of this division."

Metro then turned to its urban reserves to find capacity for the remaining housing and employment need. The analysis began with all 28,256 acres of urban reserves "on the table." It is the analysis from this point – with all 28,256 acres on the table – to the point at which the Council decided to study 9,800 acres of the urban reserves in greater detail that the department faults.

The Council explains its analysis in the Findings and Staff Report supporting Ordinance No. 11-1264B ("the UGB Ordinance"):

> "Metro began the search for the most appropriate land to add to the UGB for this capacity with review of the highest priority lands outside the UGB, prescribed by ORS 197.298(1): the 28,256 acres of land designated urban reserves pursuant to ORS 195.141. Metro neither studied nor included lower priority land. To evaluate urban reserves for possible inclusion, the Council used the location factors in Goal 14 and the relevant policies of Metro's Regional Framework Plan (RFP) as guides. The location factors and policies are implemented in Metro Code 3.07.1425C."
>
> ****
>
> In its first level of analysis, Metro considered all 28,256 acres of urban reserves. In 2010, Metro used past studies, such as the Great Communities Report, and findings from the urban and rural reserves process to eliminate some areas from further consideration. Metro also consulted with cities and counties to determine their interest in providing capacity for the needs identified, to provide governance and to provide infrastructure for areas that might be added. Following these consultations and consideration of Metro policies, Metro chose for detailed study approximately 8,300 acres close to the UGB and most suitable for the needs identified in the UGB. In 2011, Metro again invited local governments to propose other urban reserves to be more closely evaluated. Ultimately, Metro studied 9,800 acres. The process Metro followed is set forth at UGB Ord Rec 474-478.
>
> "The methodology for analysis of areas considered for addition to the UGB is described at UGB Ord Rec 478-494. Metro determined that the 9,800 acres contained approximately 5,500 acres of net buildable land. UGB Ord Rec 481. Metro relied upon two sources to determine the feasibility and estimated costs of providing public utilities, parks and schools to the areas: analysis done by Group MacKenzie under contract with Metro and information submitted by cities and counties responsible for particular areas under consideration. UGB Ord Rec 483-484. Metro completed its own analysis of feasibility of a transportation system to serve each area, based upon the arterial and collector road spacing standards in the Regional Transportation Plan. Metro used the ODOT Highway Economic Requirements System (HERS) to estimate costs. TriMet completed a preliminary evaluation of the areas for public transit, with

> estimated costs. UGB Ord Rec 486-487. Metro conducted its own "ESEE" analysis of the areas described at UGB Ord Rec 487-495. And Metro did an analysis of each area considering the factors in the Metro code that derive from policies in its Regional Framework Plan. UGB Ord Rec 495-496.
>
> "The results of these analyses for each area are set forth at UGB Ord Rec 499, Attachment 2. Attachment 3 to the Recommendations compares the estimated costs of transportation, public utilities, parks and schools of the areas considered. Attachment 4 compares the estimated costs of transportation. Attachment 5 displays the results of the environmental analysis. Attachment 6 shows TriMet's assessment of relative transit service costs. UGB Ord Rec 499, Attachments 3 to 6).

Findings, pp. 10-11. The methodology described in the Findings is more fully set forth in "Building a Sustainable, Prosperous and Equitable Region: Recommendations from Metro's Chief Operating Officer; Preliminary Analysis of Potential Urban Growth Boundary Expansion Areas," July 5, 2011.

A more detailed analysis of this approach is attached as Appendix A and may be found at pages 7268-7272 of Metro's Capacity Ordinance record and pages 471-477 of Metro's UGB Ordinance record.

The department and Commission should recall and appreciate the three years of analysis of lands suitable for urbanization and designation as urban reserve. This enormous, comprehensive and thorough years-long undertaking by the region was based on consideration of the "urban reserves factors" set forth at ORS 195.145(5). These statutory factors are nearly identical to the location factors in Goal 14. (For your comparison, these factors may be found in Appendix B to these exceptions.) LCDC ultimately approved the analysis and the designation of urban reserves. Reserves Order____, May _, 2012. Rather than send the UGB Ordinance back to Metro for a mechanical application of the location factors in Goal 14 to all 28,256 acres of urban reserve – a wasteful and expensive duplication of the region's reserves effort – the Commission should take administrative notice of its reserves order and conclude that the absence of a rote application of the location factors to 28,256 acres for a 1,985-acre UGB expansion is "technical or minor in nature." ORS 197.747.

Ground 4: **The Department recommends that the Commission remand the UGB expansion to Metro because Metro improperly mixed its consideration of factors from the Metro Code with the location factors of Goal 14 and did not apply all the location factors to all areas analyzed**

Metro explained its selection of 1,985 acres to meet its housing and employment needs in its Findings of Fact for the UGB Ordinance, pages 10 through 27, attached to this letter as Appendix C. The Council's Findings address each location factor and each Metro Code factor separately. The Findings compare the areas selected with those not selected on the basis of the factors.

Behind these 18 pages of Findings lie three years of analysis and hundreds of pages of analysis of specific areas considered for addition to the UGB, in both the Capacity and in the UGB Ordinances. Because the department judges this effort to be insufficient and improper, we will point to the places in the record where specific analysis of particular study areas may be found.

Factor 1 - Efficient Accommodation of Land Need

Capacity Ordinance: Although Metro did not expand the UGB in the Capacity Ordinance, as it intended prior to LCDC remand of certain urban reserves, Metro completed a study of areas for possible inclusion as part of that ordinance. That study devoted just under 200 pages to application of the factors to the study areas. The study may be found in the Capacity Ordinance record at pages 7296-7488.

The analysis addresses location factor 1 at 7272-7277; 7486 (transportation efficiency); 7487 (service efficiency); 7485 (constraints on efficient use of land). Each study area is discussed in pages 7468-7485. There is a description of the characteristics of each study area that lends itself to efficient land use, or otherwise (number and size of lots/parcels; proximity to the UGB; proximity to services within the UGB, etc.). There is further analysis of each area found in the Capacity Ordinance study. [4]

UGB Ordinance: The UGB Ordinance contains a second full analysis of study areas considered for inclusion in the UGB. That analysis includes a "Productivity Analysis" that discusses the efficiency of land use of the areas under consideration, at pages 477 to 481 of the UGB Ordinance record. There is further analysis of the productivity of each area in the UGB Ordinance study. [5]

It is noteworthy that Metro's analysis of areas under the efficiency factor led the Council to impose efficiency conditions on each area included in the UGB to provide housing capacity. See, for example, UGB Ordinance Exhibit B, Conditions on Land Added to the UGB: Hillsboro must identify a Town Center in the area (Condition 2) and ensure capacity for at least 10,766 dwelling units (Condition 3).

Factor 2 – Orderly and Economic Provision of Services

Capacity Ordinance: The analysis in the Capacity Ordinance addresses location factor 2 at pages 7277-7279 of the record. There is a comparative analysis (comparing areas under consideration) at pages 7460-7487. And there is analysis under factor 2 for each area in the Capacity Ordinance study.[6]

UGB Ordinance: The UGB Ordinance contains a second full analysis of study areas considered for inclusion in the UGB. The methodology is described at pages 482-484 of the UGB Ordinance record.

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[4] Pages 7296; 7306; 7315; 7324; 7343; 7352; 7361; 7370; 7379; 7388; 7397; 7407; 7416; 7425; 7434; 7443; 7452.

[5] Pages 497; 507; 516; 525; 535; 544; 553; 562; 571; 580; 589; 598; 608; 617; 626; 635; 644; 653; 662; 671; 679; 688; 698; 706.

[6] Pages 7297; 7307; 7316; 7325; 7335; 7344; 7353; 7362; 7371; 7380; 7389; 7408; 7417; 7425-26; 7435; 7444; 7452.

The study includes charts comparing service costs for study areas at pages 715, 716 and 718. There is further analysis in the record under factor 2 for each area.[7]

Factor 3 – EESE Consequences

Capacity Ordinance: The analysis in the Capacity Ordinance addresses location factor 3 and Metro's approach to analysis at pages 7280-7285 of the record. Charts at pages 7290 and 7488 provide comparative analysis. There is further analysis under factor 3, for each study area.[8]

UGB Ordinance: The UGB Ordinance contains a second full analysis of study areas considered for inclusion in the UGB. The methodology is described at pages 484-490 of the UGB Ordinance record. There is further analysis in the record under factor 3 for each area.[9] There is a chart summarizing the analysis, allowing comparison of the study areas, at page 717 of the record.

Factor 4 – Compatibility

Capacity Ordinance: The analysis in the Capacity Ordinance addresses location factor 4 at pages 7285 7287 of the record. There is further analysis under factor 3, for each study area.[10]

UGB Ordinance: The UGB Ordinance contains a second full analysis of study areas considered for inclusion in the UGB. The methodology is described at pages 490-93 of the UGB Ordinance record. There is a chart summarizing the analysis, allowing comparison of the study areas, at page 494 of the record. There is further analysis under factor 4 for each area in the UGB Ordinance record.[11]

The Council weighed the results of all this analysis and explained its selection with a conclusion for each selected area. In its conclusions, the Council discussed both location and code factors. Perhaps this is the mixing of location factors and code factors of which the department complains.[12] Metro believes it did precisely what the law requires and does not understand the department's complaint. Please turn to attached Appendix C (pages 11-16 of the UGB Ordinance Findings) to see Metro's analysis and conclusions supporting the addition of the "South Hillsboro Analysis Area." These findings plainly show that Metro evaluated each site on each Goal 14 location factor, separately from the factors in its own code. Metro addressed the location factors first, the code factors second. Metro's "Overall Conclusions for South Hillsboro" weighs how the area fares under the factors , compares South Hillsboro with other areas under the factors, then explains why it chose to include South Hillsboro.

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7 Pages 498; 508; 517; 526; 536; 545; 554; 563; 572; 581; 590; 599; 608-09; 617-18; 626-27;635-36; 644-46; 654; 662-63; 671-72; 680; 688-89; 698-99; 706-07.

8 Pages 7297-99; 7307-08; 7316-17; 7325-26; 7335-36; 7344-45; 7353-54; 7362-63; 7371-72; 7380-81; 7389-90; 7399-7400; 7408-09; 7417-18; 7426-27; 7435-36; 7444-45; 7453-54.

9 Pages 498; 508; 517; 526; 536-37; 545-46; 554-56; 563-64; 572-73; 581-82; 590-92; 600-01; 609-10; 618-19; 627-28; 636-37; 646-47; 654-55; 663-64; 672-73; 680-81; 689-90; 699-700; 707-08.

10 Pages 7299-7300; 7309-10; 7317-18; 7326-27; 7337; 7345-47; 7354-55; 7364; 7373-74; 7381-82; 7391; 7400-01; 7409-7410; 7427-28; 7436-37; 7445-46; 7454-55.

11 Pages 500; 510; 518; 527-29; 538; 547-48; 556-57;565-66; 574-75; 582-83; 592-93; 601-02; 610-11; 619-20; 628-29; 637-38; 647-48; 655-56; 664-65; 673-74; 681-82; 690-92; 700-01; 708-09.

12 "Metro must demonstrate that the analysis areas are subject to the weighing and balancing using all four Goal 14 location factors, and this must be completed *before* the local factors are applied." Report at p. 31.

Mr. Larry French
Periodic Review Coordinator
Department of Land Conservation & Development
April 30, 2012

The Department's concern appears to be that Metro's analysis mixes the location and code factors in its weighing and balancing. This concern is difficult to understand. There is no incompatibility between the location factors and the code factors. They complement one another: Metro's "equitable and efficient distribution of housing and employment" factor complements Goal 14 location factors 1 and 2; Metro's "Contribution to the purposes of Centers and Corridors" factor complements Goal 14 location factors 1 and 2; Metro's "Protection of farmland most important to the continuation of commercial agriculture in the region" factor complements Goal 14 location factor 4 (and Goal 14 itself); Metro's "Avoidance of conflict with regionally significant fish and wildlife habitat" factor complements Goal 14 location factor 3; Metro's "Clear transition between urban and rural lands" factor complements Goal 14 location factors 2, 3 and 4; Metro's "Workforce housing" factor complements Goal 14 location factor 1. Metro would understand the department's concern if consideration of Metro's code factors diminished its analysis of the Goal 14 factors, or outweighed them in a conclusion. But the department points to no such result, nor is there any such result.

The department cites the Court of Appeals in *City of West Linn v. LCDC*, 201 Or App 419, 446-447, for the proposition set forth on page 31 of the report, quoted in footnote 9, here. *West Linn* provides no support for that proposition. The court faulted Metro for failing to comply with its own code in its analysis of Study Area 94. The court held that Metro failed to demonstrate Area 94 fared "better than alternative sites" under the factors in its code. Metro made this demonstration in the analysis and conclusions for each area included in the UGB Ordinance. Once again, please see attached Appendix C for the South Hillsboro example.

In sum, Metro believes it has provided the analysis called for by the department. If the analysis diverges at some point from the department's prescription, it is "technical or minor in nature." ORS 197.747. Metro has substantially complied with the law.

Respectfully submitted,

Richard P. Benner
Senior Attorney
Office of Metro Attorney

RPB/sm
Enclosures: Appendices A through D

(w/ Enclosures)
cc: Jim Rue, Acting Director, DLCD
Metro Council
Martha J. Bennett, Metro Chief Operating Officer

www.oregonmetro.gov

Appendix 8 – Preliminary Analysis of Potential UGB Expansion Areas

August 2010

Metro | *People places. Open spaces.*

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ANALYSIS OF POTENTIAL UGB EXPANSION AREAS

INTRODUCTION

As part of an integrated community investment strategy, the Metro Council will be considering how to accommodate the region's forecasted 20-year population and employment growth while supporting the region's six desired outcomes, listed below.

- **Vibrant communities** – People live and work in vibrant communities where they can choose to walk for pleasure and to meet their everyday needs.
- **Economic prosperity** – Current and future residents benefit from the region's sustained economic competiveness and prosperity.
- **Safe and reliable transportation** – People have safe and reliable transportation choices that enhance their quality of life.
- **Leadership on climate change** – The region is a leader in minimizing contributions to global warming.
- **Clean air and water** – Current and future generations enjoy clean air, clean water, and healthy ecosystems
- **Equity** – The benefits and burdens of growth and change are distributed equitably.

The urban growth report (UGR), endorsed by the Metro Policy Advisory Committee (MPAC) and accepted by the Metro Council in December 2009, identified the capacity of the region's UGB to accommodate the next 20 years of expected population and employment growth. The 2009 UGR was intended to foster the development of an outcomes-based approach to growth management decision-making by discussing tradeoffs among various policy and investment choices. The UGR identified a gap between the forecast demand and the amount of zoned capacity that is likely to be developed in the next 20 years for residential and large-site industrial parcels that support the traded-sector. No gap was identified in the middle third of the demand forecast for non-industrial and general industrial employment.

The region can fill the identified capacity gap through actions that promote more efficient use of zoned capacity inside the current UGB, or by expanding the UGB, or a combination of both. Metro has been working with local governments individually and through the Metro Technical Advisory Committee (MTAC) and MPAC to identify and adopt local and regional actions that will achieve greater efficiencies within the existing UGB and minimize the need for UGB expansion at the end of the year.

As part of the process to maintain a 20-year land supply for residential and employment uses, Metro completed an assessment of approximately 8,298 acres of urban reserve land adjacent to the current UGB. These 8,289 acres are a subset of the 28,615 acres of urban reserves that Metro, in conjunction with Clackamas, Multnomah and Washington Counties adopted in June 2010 (Attachment 1). The designation of these areas as urban reserves is essentially the first filter in determining that the areas are suitable for urbanization. Metro staff, utilizing information from past studies such as the Great Communities Report and the findings from the urban and rural reserve

process, as well as local jurisdiction input and Metro policies that call for equity and balance in UGB expansions and to consider lands in all parts of the region, narrowed down the urban reserve lands to the 8,298 acres of analysis areas evaluated in this report.

Metro's Chief Operating Officer, Michael Jordan, issued a letter to the mayors and county commission chairs on August 2, 2010, inviting them to submit any additional urban reserve areas that they would like considered as part of the policy discussions in the fall 2010. All additional areas for consideration must be sponsored by local governments, as their support is critical for provision of infrastructure, governance, planning, and more. The additional areas will be considered by MPAC and the Metro Council prior to a final recommendation in October and subsequent public hearings in November.

The purpose of this analysis is to inform the Metro COO Recommendation, 2010 Growth Management Assessment (August 2010), and assist the Metro Council in evaluating the potential expansion areas to meet any identified residential and large-site industrial land need that they determine cannot be met through efficiencies on land inside the UGB. The information in this analysis will help the Metro Council determine which of the selected analysis areas merit further consideration as candidates for inclusion in the UGB. Finally, additional information regarding the effect of the final proposed UGB amendments on existing residential neighborhoods will be developed and sent to all households within one mile of the proposed UGB amendment areas, consistent with Metro Code Section 3.01.015. Figure 1 provides an overview of the UGB analysis area process.

It is beyond the scope of the analysis to provide a detailed, site planning level of analysis for each of the 18 areas. Furthermore, it is not possible to evaluate each potential sequence of urbanization, and the likely effects on surrounding areas under each sequence. This analysis does not compare the results of the UGB amendment factors for the potential expansion areas with the potential for refill or redevelopment of locations that are currently in the UGB.

The structure of this report is based on Metro's UGB Legislative Amendment factors located in Metro Code Section 3.01.020, which implement the boundary locational factors of Statewide Planning Goal 14. The following list identifies the Goal 14 and Metro UGB amendment factors:

- *Metro UGB Amendment Factor & Statewide Planning Goal 14 Factor 1 – Efficient accommodation of identified land needs.*

- *Metro UGB Amendment Factor & Statewide Planning Goal 14 Factor 2 – Orderly and economic provision of public facilities and services.*

- *Metro UGB Amendment Factor & Statewide planning Goal 14 Factor 3 – Comparative environmental, energy, economic and social consequences.*

- *Metro UGB Amendment Factor & Statewide Planning Goal 14 Factor 4 – Compatibility of the proposed urban uses with nearby agricultural and forest activities occurring on farm and forest land outside the UGB.*

In addition, Metro Code Section 3.01.020 provides five additional factors that must be considered when evaluating land for inclusion in the UGB:

- *Equitable and efficient distribution of housing and employment opportunities throughout the region;*
- *Contribution to the purposes of Centers;*
- *Protection of farmland that is most important for the continuation of commercial agriculture in the region;*
- *Avoidance of conflict with regionally significant fish and wildlife habitat; and*
- *Clear transition between urban and rural lands, using natural and built features to mark the transition.*

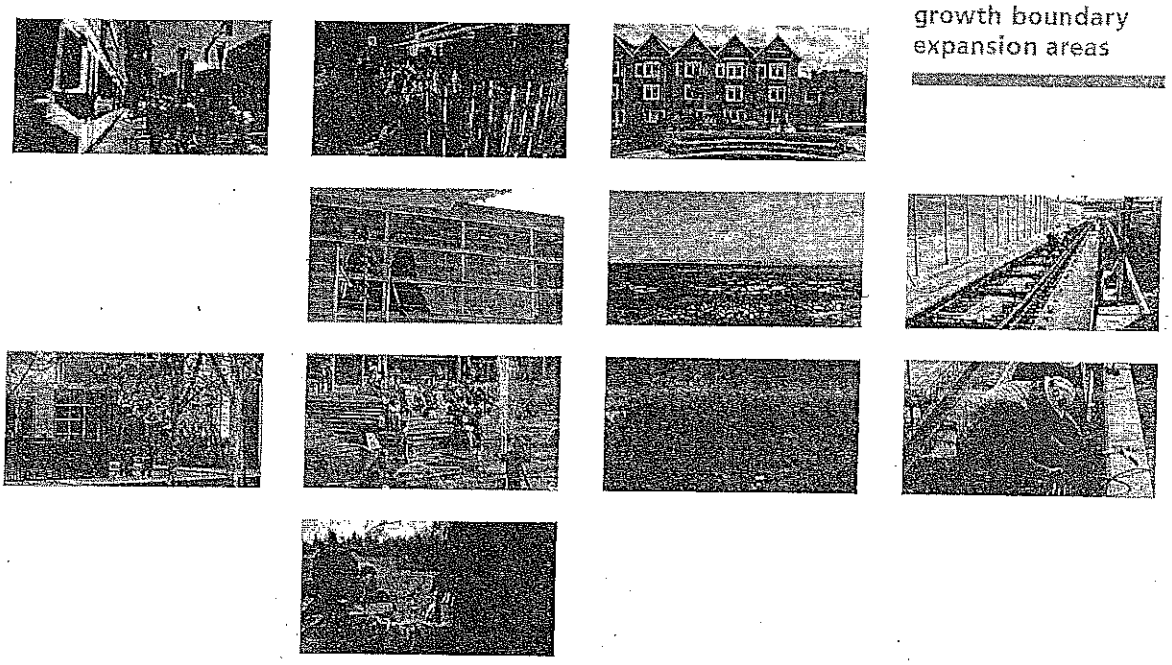
The essence of the six desired outcomes is embodied in these urban growth boundary (UGB) assessment factors and the state legislation and administrative rules which enabled the region to pursue urban and rural reserves.

The report begins with an explanation of the methodology used to evaluate each analysis area for the factors listed above. Please note that Statewide Planning Goal Factor 1 and the first additional Metro factor, are not evaluated for each analysis area, but findings for these two factors are made on the final UGB expansion decision. Following the methodology section is a brief summary of the results, including a table indicating the ratings applied to most of the factors noted above. The individual analysis area summaries that include basic quantitative information for each area, as well as descriptive information about site characteristics, development patterns, physical attributes, environmental features and the feasibility of providing urban services are found in Attachment 2.

METHODOLOGY

PRODUCTIVITY ASSESSMENT

The productivity assessments conducted for this study follow general procedures used for most buildable lands studies. Vacant areas are first identified. Areas that are unbuildable such as power line easements and environmentally sensitive areas are then removed from vacant lands. Specific categories of tax-exempt lands are also considered unbuildable. The inventory of vacant land is then reduced to account for future streets and public facilities needed to accommodate urbanization.



COMMUNITY INVESTMENT STRATEGY

Building a sustainable, prosperous and equitable region

Recommendations from Metro's Chief Operating Officer

Preliminary analysis of potential urban growth boundary expansion areas

July 5, 2011

Metro | *Making a great place*

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INTRODUCTION

As part of an integrated community investment strategy, the Metro Council will be considering how to accommodate the region's forecasted 20-year population and employment growth while supporting the region's six desired outcomes, listed below.

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The urban growth report (UGR), endorsed by the Metro Policy Advisory Committee (MPAC) and adopted by the Metro Council in December 2010, identified the capacity of the region's urban growth boundary (UGB) to accommodate the next 20 years of expected population and employment growth. The 2009 UGR was intended to foster the development of an outcomes-based approach to growth management decision-making by discussing tradeoffs among various policy and investment choices. The UGR identified a gap between the forecast demand and the amount of zoned capacity that is likely to be developed in the next 20 years for residential and large-site industrial parcels that support the traded-sector. No gap was identified in the middle third of the demand forecast for non-industrial and general industrial employment.

The region can fill the identified capacity gap through actions that promote more efficient use of zoned capacity inside the current UGB, or by expanding the UGB, or a combination of both. In 2009, Metro worked with local governments individually and through the Metro Technical Advisory Committee (MTAC) and MPAC to identify and adopt local and regional actions that achieved greater efficiencies within the existing UGB, which minimized the need for UGB expansion. These efficiencies are documented in Metro Ordinance No. 10-1244B, adopted by the Metro Council on December 16, 2010.

As part of the process to maintain a 20-year land supply for residential and employment uses, Metro completed an assessment of approximately 9,800 acres of urban reserve land adjacent to the current UGB. These 9,800 acres are a subset of the more than 28,000 acres of urban reserves that Metro, in conjunction with Clackamas, Multnomah and Washington Counties adopted in April 2011 (Attachment 1). The designation of these areas as urban reserves is essentially the first filter in determining that the areas are suitable for urbanization. Metro staff, utilizing information from past

studies such as the Great Communities Report and the findings from the urban and rural reserve process, as well as local government staff input and Metro policies that call for equity and balance in UGB expansions and to consider lands in all parts of the region, narrowed down the urban reserve lands to the approximately 9,800 acres of analysis areas evaluated in this report.

In October 2010 the Land Conservation and Development Commission (LCDC) made an oral decision on urban and rural reserves, remanding a portion of the urban reserves and all of the rural reserves in Washington County. The Washington County Board of Commissioners and the Metro Council held a joint public hearing on March 15, 2011, resulting in a revised Intergovernmental Agreement for urban and rural reserves in Washington County in response to the LCDC oral decision. In late April 2011, Metro and the three counties re-adopted overall findings for urban and rural reserves in the region, reflecting the new urban and rural reserves in Washington County.

As a result of the urban and rural reserves remand, the adoption of new urban and rural reserves in Washington County and Metro's desire to provide a formal opportunity for local governments to submit areas for consideration, a three-step analysis process occurred. Initially, Metro staff analyzed 8,298 acres of land for consideration as outlined in Appendix 8 of the Metro Chief Operating Officer's report, Community Investment Strategy: *Building a sustainable, prosperous and equitable region.* In August 2010 and again in April 2011, Metro's Chief Operating Officer issued a formal letter to the mayors and county commission chairs, inviting them to submit any additional urban reserve areas that they would like considered as part of the growth management policy discussions. All additional areas submitted for consideration must be sponsored by local governments, as their support is critical for provision of infrastructure, governance, and planning, and must include an assessment of how the subject area is responsive to Metro's legislative UGB amendment criteria, contained in Metro Code Section 3.07.1425. Below is a list of the urban reserve analysis areas that were submitted by the local governments through these two requests.

In response to the August 2010 COO invitation, the following additional areas were submitted for inclusion in the UGB analysis process:

- The City of Beaverton submitted a 453 acre portion of urban reserve area 6C. The area is north of SW Scholls Ferry Road and east of SW Tile Flat Road and is identified as South Cooper Mountain Analysis Area (6B) in the report.
- The City of Cornelius submitted a 62 acre portion of urban reserve 7C. The area is north of the Tualatin Valley Highway, east of the current city limits and is identified as the Cornelius East Analysis Area (7C) in the report.
- The City of Forest Grove submitted a 114 acre portion of urban reserve 7B. The area is located at the intersection of NW Purdin Road and NW Thatcher Road and is identified as the Forest Grove North Purdin Road Analysis Area (7B) in the report. A different portion of urban reserve 7B was included as part of Metro staff's original analysis, thus there are two urban reserve 7B sections in the report.

- The City of Forest Grove also submitted urban reserve 7E for consideration. This 37 acre area is located on the south side of Forest Grove at the end of Elm Street and is identified as the Forest Grove South Analysis Area (7E) in the report.
- The City of Hillsboro submitted a 458 acre portion of urban reserve 8A. The area is located east of NW Jackson School Road and south of Highway 26, along NW Meek Road and is identified as the Hillsboro North-Jackson School Road Analysis Area (8A) in the report. A different portion of urban reserve 8A was included as part of Metro staff's original analysis, thus there are two urban reserve 8A sections in the report.

In response to the April 2011 COO invitation, the following two additional areas were submitted for inclusion in the UGB analysis process:

- The City of Tigard submitted a 138 acre portion of urban reserve area 6C. The area is south of SW Scholls Ferry Road, between the current UGB and SW Vandermost Road and is identified as the Vandermost Road Analysis Area (6C) in the report.
- The City of Hillsboro submitted the 352 acre urban reserve north of Highway 26 that was adopted by Metro and Washington County in April of this year. The area is west of existing urban reserve 8B, south of NW West Union Road and east of NW Groveland Road and is identified as the Groveland Road Analysis Area (8B) in the report. The Shute Road Interchange (8B) was included as part of Metro staff's original analysis, thus there are two urban reserve 8B sections in the report.

As noted above, a requirement of the local government submittals was an assessment of how the subject area is responsive to Metro's legislative UGB amendment criteria, therefore the analysis area assessments in the report for these areas submitted in 2010 and 2011 in response to the COO request, were completed by the local government staff with some minor editing by Metro staff for consistency.

The purpose of this analysis is to inform the Metro COO Recommendation for the 2011 Growth Management Decision (July 2011), and assist the Metro Council in evaluating the potential expansion areas to meet any identified shortfalls for residential and large-site industrial land need. The information in this analysis will help the Metro Council determine which of the selected analysis areas merit further consideration as candidates for inclusion in the UGB. Finally, additional information regarding the effect of the final proposed UGB amendments on existing residential neighborhoods will be developed and sent to all households within one mile of the proposed UGB amendment areas, consistent with Metro Code Section 3.07.1420 (26-29 Report).

It is beyond the scope of the analysis to provide a detailed, site planning level of analysis for each of the 25 areas. Furthermore, it is not possible to evaluate each potential sequence of urbanization, and the likely effects on surrounding areas under each sequence. This analysis does not compare the results of the UGB amendment factors for the potential expansion areas with the potential for refill or redevelopment of locations that are currently in the UGB.

The structure of this report is based on Metro's UGB Legislative Amendment factors located in Metro Code Section 3.07.1425, which implement the boundary locational factors of Statewide Planning Goal 14. The following list identifies the Goal 14 and Metro UGB amendment factors:

- *Metro UGB Amendment Factor & Statewide Planning Goal 14 Factor 1 – Efficient accommodation of identified land needs.*

- *Metro UGB Amendment Factor & Statewide Planning Goal 14 Factor 2 – Orderly and economic provision of public facilities and services.*

- *Metro UGB Amendment Factor & Statewide planning Goal 14 Factor 3 – Comparative environmental, energy, economic and social consequences.*

- *Metro UGB Amendment Factor & Statewide Planning Goal 14 Factor 4 – Compatibility of the proposed urban uses with nearby agricultural and forest activities occurring on farm and forest land outside the UGB.*

In addition, Metro Code Section 3.07.1425 provides five additional factors that must be considered when evaluating land for inclusion in the UGB:

- *Equitable and efficient distribution of housing and employment opportunities throughout the region;*
- *Contribution to the purposes of Centers;*
- *Protection of farmland that is most important for the continuation of commercial agriculture in the region;*
- *Avoidance of conflict with regionally significant fish and wildlife habitat; and*
- *Clear transition between urban and rural lands, using natural and built features to mark the transition.*

The essence of the six desired outcomes is embodied in these urban growth boundary (UGB) assessment factors and the state legislation and administrative rules which enabled the region to pursue urban and rural reserves.

The report begins with an explanation of the methodology used to evaluate each analysis area for the factors listed above. Please note that Statewide Planning Goal Factor 1 and the first additional Metro factor, are not evaluated for each analysis area, but findings for these two factors are made on the final UGB expansion decision. Following the methodology section is a brief summary of the results, including a table indicating the ratings applied to most of the factors noted above. The individual analysis area summaries that include basic quantitative information for each area, as

well as descriptive information about site characteristics, development patterns, physical attributes, environmental features and the feasibility of providing urban services are found in Attachment 2.

METHODOLOGY

PRODUCTIVITY ASSESSMENT

The productivity assessments conducted for this study follow general procedures used for most buildable lands studies. Vacant areas are first identified. Areas that are unbuildable such as power line easements and environmentally sensitive areas are then removed from vacant lands. Specific categories of tax-exempt lands are also considered unbuildable. The inventory of vacant land is then reduced to account for future streets and public facilities needed to accommodate urbanization.

The majority of tabular data used in this analysis has been generated from Geographic Information Systems (GIS). In GIS, digital, coordinate-based spatial data layers are used to represent real world features such as tax lots, wetlands and floodplains, and zoning areas. All of the GIS data used in this analysis are from Metro's Research Center.

Of course, electronic data representing real world features are rarely perfect. Data representing features like floodplains and tax lots will have some positional inaccuracies, which, in turn, will be reflected in numbers representing them. In addition, much of the assessment information that is included in Metro's Regional Land Information System (RLIS) database comes directly from county assessment offices, where local updates may be conducted at different intervals. For a variety of reasons such as these, the study helps to point out general patterns, but is not intended to be accurate at extremely small levels of geography.

Step 1: Determine which lands within the study areas are vacant

For this study all of the land in the analysis areas was assumed to be "vacant", meaning all of the non-public land area that is not constrained by environmental resources or other constraints such as power line easements or parks is available for development. This determination is based on a comparison of land value to improvement value completed by Metro Economic & Land Use Forecasting staff that indicated the existing rural residences would most likely redevelop due to a substantial increase in land value as the rural lands are added to the UGB. In addition, Metro Planning staff's experience with concept planning of new urban areas generally validates this assumption. It is understood however, that some high valued residences will remain as rural lands are urbanized, but it is beyond the scope of this project to complete a more detailed economic analysis of all the parcels under evaluation to determine this small amount of land that would remain in the future. Metro's most recent vacant lands analysis, completed for the land inside the UGB, does not extend to the urban reserve areas.

Goal 14: Urbanization
OAR 660-015-0000(14)
Version of this Goal Effective April 28, 2006

"Boundary Location

The location of the urban growth boundary and changes to the boundary shall be determined by evaluating alternative boundary locations with ORS 197.298 and with consideration of the following factors:

(1) Efficient accommodation of identified land needs;

(2) Orderly and economic provision of public facilities and services;

(3) Comparative environmental, energy, economic and social consequences; and

(4) Compatibility of the proposed urban uses with nearby agricultural and forest activities occurring on farm and forest land outside the UGB."

Senate Bill 1011
Oregon Laws Chapter 723
ORS 195.137

"SECTION 6. ORS 195.145 is amended to read:

(5) A district and a county shall base the designation of urban reserves under subsection (1)(b) of this section upon consideration of factors including, but not limited to, whether land proposed for designation as urban reserves, alone or in conjunction with land inside the urban growth boundary:

(a) Can be developed at urban densities in a way that makes efficient use of existing and future public infrastructure investments;

(b) Includes sufficient development capacity to support a healthy urban economy;

(c) Can be served by public schools and other urban-level public facilities and services efficiently and cost-effectively by appropriate and financially capable service providers;

(d) Can be designed to be walkable and served by a well-connected system of streets by appropriate service providers;

(e) Can be designed to preserve and enhance natural ecological systems; and

(f) Includes sufficient land suitable for a range of housing types."

Exhibit D to Ordinance No. 11-1264B
Findings of Fact and Conclusions of Law

Ordinance No 11-1264B ("UGB ordinance") expands the region's urban growth boundary to add capacity for industries that need large parcels and for housing the current UGB cannot reasonably accommodate. Actions taken by this ordinance and its predecessor in this periodic review process – Ordinance No. 10-1244B ("capacity ordinance") - fulfill Metro's responsibilities under Goal 14, ORS 197.296(6) and 197.299(2).

These findings and conclusions incorporate and supplement the findings made by the Metro Council in the capacity ordinance. That ordinance adopted actions to use land inside the UGB more efficiently to address the capacity shortages identified in the 2009 Urban Growth Report (UGR). As explained in the capacity ordinance findings, the adopted actions reduced, but did not fully close, the identified gaps. This UGB ordinance addresses the remaining gaps.

Outline:

I. General Findings

A. Coordination with Local Governments, Districts and State Agencies

These findings address the coordination requirements of ORS 197.299(4)(b), statewide planning Goal 2 and Regional Framework Plan (RFP) Policies 1.3.10; 1.4.3; 1.9.5; 1.9.13; 1.11.3; and 1.14. Metro worked closely with the cities and counties of the region to determine the capacity of the region, to select the urban reserves to study in greater detail, and which reserves to choose to meet the needs identified in the capacity ordinance. Cap Ord Rec 3873; 4194; 4212; 4224-4225. Metro staff selected an initial set of reserves (approximately 8,300 acres) early in 2010,

employment forecasts, complies with Land Need Factor 1 and 2 of Goal 14 through its analysis of existing industries that use and prefer large parcels.

B. Capacity Added to UGB

Metro began the search for the most appropriate land to add to the UGB for this capacity with review of the highest priority lands outside the UGB, prescribed by ORS 197.298(1): the 28,256 acres of land designated urban reserves pursuant to ORS 195.141. Metro neither studied nor included lower priority land. To evaluate urban reserves for possible inclusion, the Council used the location factors in Goal 14 and the relevant policies of Metro's Regional Framework Plan (RFP) as guides.[9] The location factors and policies are implemented in Metro Code 3.07.1425C.

The Council concludes that drawing UGB expansion from urban reserves complies with ORS 197.298(1), Policy 1.9.3 of the Regional Framework Plan and Metro Code 3.07.1425C(7).

In its first level of analysis, Metro considered all 28,256 acres of urban reserves. In 2010, Metro used past studies, such as the Great Communities Report, and findings from the urban and rural reserves process to eliminate some areas from further consideration. Metro also consulted with cities and counties to determine their interest in providing capacity for the needs identified, to provide governance and to provide infrastructure for areas that might be added. Following these consultations and consideration of Metro policies,[10] Metro chose for further study approximately 8,300 acres close to the UGB and most suitable for the needs identified in the UGB. In 2011, Metro again invited local governments to propose other urban reserves to be more closely evaluated. Ultimately, Metro studied 9,800 acres. The process Metro followed is set forth at UGB Ord Rec 474-478.

The methodology for analysis of areas considered for addition to the UGB is described at UGB Ord Rec 478-494. Metro determined that the 9,800 acres contained approximately 5,500 acres of net buildable land. UGB Ord Rec 481. Metro relied upon two sources to determine the feasibility and estimated costs of providing public utilities, parks and schools to the areas: analysis done by Group MacKenzie under contract with Metro and information submitted by cities and counties responsible for particular areas under consideration. UGB Ord Rec 483-484. Metro completed its own analysis of feasibility of a transportation system to serve each area, based upon the arterial and collector road spacing standards in the Regional Transportation Plan. Metro used the ODOT Highway Economic Requirements System (HERS) to estimate costs. TriMet completed a preliminary evaluation of the areas for public transit, with estimated costs. UGB Ord Rec 486-487. Metro conducted its own "ESEE" analysis[11] of the areas described at UGB Ord Rec 487-495. And Metro did an analysis of each area considering the factors in the Metro code that derive from policies in its Regional Framework Plan. UGB Ord Rec 495-496.

The results of these analyses for each area are set forth at UGB Ord Rec 499, Attachment 2. Attachment 3 to the Recommendations compares the estimated costs of transportation, public utilities, parks and schools of the areas considered. Attachment 4 compares the estimated costs of transportation. Attachment 5 displays the results of the environmental analysis. Attachment 6

[9] The Six Outcomes; RFP Policies 1.9.8; 1.9.9; 1.9.10; 1.9.12.
[10] Policies 1.4 (Employment Choices) and 1.5 (Economic Vitality).
[11] Environmental, social, energy and economic consequences of added land to the UGB, derived from Goal 14.

shows TriMet's assessment of relative transit service costs. UGB Ord Rec 499, Attachments 3 to 6).

1. Added Housing Capacity

The Metro Council added three areas to the UGB – South Hillsboro, South Cooper Mountain and a portion of the Roy Rogers area – to close the gap between need and capacity for housing (1,656 acres total). Through implementation of Title 11 (Planning for New Urban Areas) of the Urban Growth Management Functional Plan[12] and conditions imposed by Exhibit B to the UGB ordinance, the three areas will be zoned to allow a minimum of 15,896 dwellings units. This capacity, combined with increased capacity within the pre-expansion UGB to be achieved by efficiency measures adopted by the capacity ordinance, provides total residential capacity to accommodate 625,183 new people, near the low end of the middle third of the population range forecast accepted by the Metro Council in the capacity ordinance and adopted by this UGB ordinance. UGB Ordinance; Staff Report, October 14, 2011, pp. 5-6, UGB Ord Rec Part 1.

South Hillsboro Analysis Area

The UGB ordinance adds 1,063 gross vacant buildable acres from the South Hillsboro Urban Reserve 6A. Addition of this South Hillsboro area ("SHA") will provide capacity for approximately 10,766 dwellings. UGB Ordinance, Rec Part 1; UGB Ordinance Exhibit B, Rec Part 1; UGB Ord Rec 499....

- Factor 1: Efficient Accommodation of Identified Land Needs

SHA has significant advantages over other areas considered for addition to the UGB: few owners; large parcels; flat land and little existing development. Two owners have parcels comprising 650 acres.[13] These large parcels have no significant improvements. UGB Ord Rec 601; 1242; 1773. Most of the area is flat, and only 2.6 percent of the area has slopes greater than 25 percent. There are few if any geographic or physical obstacles to development. UGB Ord Rec 601; 717. Intel's Aloha campus lies directly east of SHA, across 209th.

The SHA and a larger area have been subject to extensive planning by Hillsboro and landowners. The planning and tentative agreements with landowners demonstrate the area can be urbanized efficiently.

Approximately 79 percent of the gross buildable acres in SHA is unconstrained. Only eight of the other 23 areas studied yield a higher percentage of unconstrained land.[14] UGB Ord Rec 497-711. None of these eight, however, has the advantages noted above.

The Council concludes that these characteristics position SHA to accommodate residential development more efficiently – especially for street connectivity and public transit - than any other area considered. No other area has SHA's combination of extensive community planning for flat land in large, undeveloped parcels in an area close to a proposed High Capacity Transit

[12] See Metro Code 3.07.1120C(3).
[13] Newlands Properties owns "Reeds Crossing", 463 acres; Joe Hanauer (Hagg Lake, LLC) owns 189 acres.
[14] Norwood; Sherwood West; Forest Grove North; Forest Grove North Purdin; Forest Grove South; Cornelius East; Cornelius South; Hillsboro North Jackson School.

line.[15] The Council concludes the area can develop as a Great Community and help achieve the Outcomes in the Regional Framework Plan.

- Factor 2: Orderly and Economic Provision of Public Facilities and Services

SHA has high suitability for sewer, water and transportation services. Only eight other areas of the 24 studied have similar high suitabilities.[16] UGB Ord Rec 715. Hillsboro and private landowners have capacity and financial capability to provide the public facilities needed; the city has expressed its willingness to do so. The city anticipates private developers will pay 70 to 80 percent of the cost of infrastructure. UGB Ord Rec 598-604; 1641; 1767-1771. Metro's Regional High Capacity Transit System Plan designates the TV Highway passing by the northern edge of South Hillsboro as a High Capacity Transit Corridor. SHA is the only area studied to which TriMet currently extends high frequency bus service. Cap Ord Rec 5820.

As with all areas under consideration, utilities, parks and schools will be expensive. UGB Ord Rec 715. But the city, in conjunction with developers and property owners in the area, has developed a community plan and an infrastructure financing strategy. UGB Ord Rec 1107; 1385; 1767-1772. The Hillsboro School District has an option to acquire school sites within SHA. UGB Ord Rec 1682. Hillsboro, service districts and landowners are updating agreements from 2008 to finance water, sewer, stormwater and road improvements. The agreement being negotiated estimates a $90 million funding gap for transportation and a $21 million gap for parks for "build-out" in 20 years. The parties to the agreement will eliminate or close these gaps through supplemental SDCs (paid by developers). UGB Ord Rec 1242; 1767-1771; 1773.

The Council concludes that these efforts by the city put the South Hillsboro in a better position to provide services in an orderly and economic manner than any other area considered for expansion for housing capacity.

- Factor 3: Comparative Environmental, Energy, Economic and Social Consequences

SHA includes segments of several streams, including Butternut Creek, which has associated wetlands and floodplains in the area. These constrained portions, however, are small in relation to the unconstrained portions. Environmental consequences to these resources will be relatively easily minimized and mitigated through application of Titles 3 and 13 of Metro's Urban Growth Management Functional Plan[17] (UGMFP), compared to other areas studied. UGB Ord Rec 598-604; 717.

Because most of the area is devoted to agriculture, there will be adverse economic and social consequences to farmers and to agriculture in the area from loss of land base. But the consequences are limited given that the Reserves Golf Course borders the area to the west and the northern portion is bordered on three sides by the UGB and urban development. UGB Ord Rec 600-601.

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[15] The Tualatin Valley Highway (State Highway 8, the northern boundary of the South Hillsboro area, is designated a high-capacity transit corridor in the Regional High Capacity Transit Plan, an element of the 2035 RTP. Cap Ord Rec 5820.

[16] South Cooper Mountain; Forest Grove North; Forest Grove South; Cornelius East; Hillsboro North; Hillsboro Jackson School; Shute Road Interchange; and Groveland Road

[17] Title 3 (Water Quality and Flood Management), Metro Code 3.07.310; Title 13 (Nature in Neighborhoods), Metro Code 3.07.1310.

The Council concludes that the environmental, energy, economic and social consequences of urbanization of SHA are tolerable if mitigated as required by conditions in Ordinance No. 11-1264A and by Titles 3 and 13 of the UGMFP. The consequences are less adverse than those expected from urbanization of most other areas studied. UGB Ord Rec 598-604; 717. (See overall conclusions.)

- Factor 4: Compatibility of Proposed Uses with Nearby Agricultural and Forest Activities

There is no significant portion of SHA or nearby land that is devoted to forest management. Significant agricultural land in farm use borders the area to the south and west, however, and presents compatibility issues. Pockets of rural residential development would serve as buffers between farm practices and urban development for a portion of the "edge" of SHA: the west side of River Road; southwest of the Reserves Golf Course along SW Rosa and River Roads. The golf course itself forms a buffer to the west. This development and existing large-lot rural residential development toward the southern edge reduce compatibility problems. The most important and valuable agriculture takes place south of Butternut Creek and its tributaries. There is no existing buffer between urbanization and agriculture in this part of the area. Mitigation measures, imposed by the UGB ordinance, will be required to reduce incompatibility. UGB Ordinance, Exhibit A, Rec Part 1; UGB Ord Rec 598-604.

A few of the areas studied do not present compatibility issues with agriculture, generally because these areas do not border land in farm use or have natural or built buffers.[18] UGB Ord Rec 598-604. But most areas studied present compatibility issues similar to those faced by urbanization of SHA, especially those areas that border land designated for agriculture. Compared to these areas, SHA has milder compatibility problems because of its extensive edge coterminous with the UGB, the golf course to the west, large-lot residential development toward the southern edge and stream corridors (see Factor 3). UGB Ord Rec 598-604. As with the others, mitigation will reduce incompatibility. The UGB ordinance imposes a condition that requires the adoption of measures to enhance compatibility in the plan and land use regulations for urbanization of SHA. UGB Ordinance, Exhibit B, Rec Part 1. The mitigation required, together with natural and built buffers, will limit adverse effects on nearby agricultural practices.

The Council concludes that the SHA performs as well as most areas studied under this compatibility factor, and that areas more compatible have other disadvantages that make them less satisfactory for addition to the UGB (see overall conclusions.)

- Factor 5: Equitable and Efficient Distribution of Housing and Employment Opportunities Throughout the Region

The addition of SHA to the UGB to accommodate new housing will provide housing opportunities in the part of the region where employment is growing fastest. UGB Ord Rec 1840. The expansions of the UGB made since 1998 added little residential capacity on the west side of the region.[19] Most residential capacity was added to the east side (Damascus). Hillsboro has had

[18] Maplelane; Beavercreek Bluffs; Sherwood West; Sherwood South; Tonquin; Graham's Ferry; Cornelius East.
[19] Since 1998, 14,263 acres have been added to the Clackamas County part of the UGB. Only 6,102 acres have been added to the Washington County portion.

a high ratio of jobs to housing for some time. Addition of capacity for more than 10,700 new dwellings in SHA will bring new housing close to Hillsboro's employment areas and reduce the jobs/housing ratio. The Council concludes that addition of SHA will lead to a more equitable and efficient distribution of housing and employment.

- Factor 6: Contribution to the Purposes of Centers and Corridors

There are two centers near SHA: Aloha Town Center lies approximately 1.2 miles east along the TV Highway; Hillsboro Regional Center lies approximately four miles east. The Aloha Center has a low jobs/housing ratio. Urbanization of SHA will not likely improve Aloha's ratio and may worsen it, particularly if there is a new commercial center built in SHA are as planned. Residents of the area may seek services in the Hillsboro Regional Center that are not provided in SHA, providing some enhancement of the regional center. UGB Ord Rec 583-584.

The SoHi Plan developed by Hillsboro and landowners in the area proposes a town center in SHA. The UGB ordinance designates a town center at that location. UGB Ordinance Exhibit B, Rec Part1; UGB Ord Rec 1714-1717. The center will perform the role of town center in the Regional Framework Plan for the 10,700 new dwellings expected in SHA.

The Council concludes that, although addition of SHA is not likely to enhance the roles of the two existing centers closest to the area, it will establish a new town center to serve approximately 25,000 new residents. The South Hillsboro area performs as well as most areas considered on this factor.

- Factor 7: Protection of Farmland Most Important to the Continuation of Commercial Agriculture in the Region

The large majority of SHA is currently farmed and zoned for farm use. By adoption of rural reserves, the region has determined which farmland is most important for the continuation of commercial agriculture in the region. SHA itself is designated urban reserve, in part because the Oregon Department of Agriculture identified the northern portion of it as "conflicted agricultural land", not likely to contribute to commercial agriculture in the long run. The area to the west of SHA is also designated urban reserve. The area to the southwest and south, however, is mostly designated rural reserve and is very important to the continuation of commercial agriculture in the region. The UGB ordinance adds no rural reserve, nor can it given ORS 195.141(2)(c). But urbanization of SHA will present issues of compatibility with farm practices in the rural reserves. These issues are discussed above under Factor 4.

The Council concludes that SHA is no longer part of the most important farmland base, given the identification of its northern part as "conflicted agriculture land" and its designation as urban reserve.

- Factor 8: Avoidance of Conflict with Regionally Significant Fish and Wildlife Habitat

Given that most of the area is devoted to agriculture, there are few natural buffers to protect the inventoried habitat in the South Hillsboro area. Metro has inventoried habitat in the area. But there are no resources in the area protected by Washington County's Goal 5 program. Protection will have to come from implementation by Hillsboro of Metro's Titles 3 and 13 and the city's own land use regulations.

The Council concludes that, although natural resources in SHA may be adversely affected by urban development, the resources will have better protection with application of Titles 3 and 13 than under today's county land use regulations.

- Factor 9: Clear Transition Between Urban and Rural Lands

Findings for Factors 3 and 4 describe natural and built buffers between urban uses in SHA and lands that remain rural. As discussed under these factors, a portion of the "edge" with rural land has no buffer. Mitigation measures required to enhance compatibility with farm practices to the south (see Factor 4) will establish some buffering. SW Rosedale Road and the rural reserve designation, will establish an artificial, but long-lived edge.

The Council concludes that SHA performs as well as most areas studied under this factor, and that areas that provide better transitions between urban uses and rural uses have other disadvantages that make them less satisfactory for addition to the UGB. (See overall conclusions.)

- Policy 1.9.12 on Workforce Housing

The South Hillsboro Community Plan states that 88 percent of all rental units proposed for the area would be affordable to households earning less than 80 percent of median household income. The plan estimates that 42 percent of owner-occupied units will be affordable to households earning the median income. UGB Ord Rec 1697-1698; 1726-1728; South Hillsboro Community Plan, Spring, 2010, pp. 2; 4; 19-21. The Council concludes that these efforts will help achieve Policy 1.9.12 and Regional Framework Plan Outcome 6.

Overall Conclusions for South Hillsboro

The Council concludes that SHA measures up better under the applicable factors for providing housing capacity than any area studied. With its large parcels, few owners, flat topography, a willing and capable city, developers ready to contribute millions of dollars to the capital cost of infrastructure, its presence on conflicted agricultural land, the large boundary it shares with the UGB and the Reserves Golf Course, its suitability for a compact, mixed-use, pedestrian and bicycle-friendly and transit-supportive development pattern, SHA is more likely than any area considered to become a "great community" and achieve the Outcomes set forth in the RFP.

Compared to SHA, Gresham East has lower suitabilities for water, sewer and transportation services; and small parcels, many with development, that will make urbanization more difficult. Maplelane has the same disadvantages, but also has a high ratio of constrained to unconstrained gross vacant land, which limits its residential capacity. Beavercreek Bluffs has the same difficulties as Maplelane, but a higher constrained land ratio. The Norwood area has lower water, sewer and transportation suitability than SHA. I-5 East has a high ratio of constrained to unconstrained land, including steep slopes that would fracture urban development in its northern portion, and many small parcels, 85 percent of which are improved. Elligsen, too, has much constrained land, difficult infrastructure issues and no easy way to ensure compatibility with agriculture to the south. The Advance area suffers from the same disadvantages. Sherwood West has a low ratio of constrained to unconstrained land, but lower suitabilities for water, sewer and transportation services than SHA. Urbanization of Sherwood West would likely divert the

city's effort from enhancing its town center. Sherwood South has a high ratio of constrained to unconstrained land, a large number of small parcels with improvements and difficult infrastructure issues. Efforts to urbanize it, too, may divert Sherwood's effort to enhance its town center.

The Tonquin area, a quarry, has low suitability for housing and infrastructure issues. Roy Rogers West (Urban Reserve Area 6C) measures well under several factors, but has no easy way to ensure compatibility with agriculture to the west and south. Its rural residential development pattern will make it more difficult to urbanize in a compact, efficient pattern.

Compared to SHA, the Vandermost Road area has a high ratio of constrained to unconstrained land and likely moderate to high adverse economic, social and energy consequences from urbanization. The Forest Grove North area has high suitability for services and medium sized parcels, suitable for urbanization (though not nearly as large as South Hillsboro). But it borders an extensive block of intensely farmed land with no effective buffers, rendering it incompatible with nearby agricultural practices. The Forest Grove North Purdin Road area shows lower suitability for public services than South Hillsboro. Its parcelization pattern makes it conducive to compact and efficient development. But like the Forest Grove North area, it borders an important agricultural area; urbanization there would present larger compatibility challenges than urbanization of SHA. The Forest Grove South area is small (37 acres) and sought by the city for industrial use in conjunction with an industrial site (25 acres) inside the UGB. It is well-suited for efficient and economically-serviced development. But, like the Forest Grove North study areas, Forest Grove South borders an extensive block of important farmland to the south, west and east; the impact of urban development on that block of agricultural land concerns the Council. Cornelius East has high suitability for public services and it presents few compatibility problems or adverse consequences. But its small parcels with residential development would make it very difficult to achieve efficient, compact urban development. The Cornelius South area has the same advantages as Cornelius East. Like the Forest Grove study areas, however, Cornelius South borders an extensive block of important farmland (south and east); the impact of urban development on that block of agricultural land concerns the Council.

The Hillsboro North-Jackson School Road area is highly suitable for efficient, compact development. But it is separated from the UGB (by the Hillsboro North area, added to the UGB by this ordinance) and, hence, not immediately adjacent to urban services as is the South Hillsboro area. It is, itself, important farmland and it borders an extensive block of important farmland, which is not protected from urbanization by North-Jackson School Road or by buffering natural or built features. The Shute Road Interchange area is also highly suitable for efficient, compact development. But it faces farmland compatibility issues. Given its location across Highway 26 and some distance from the Hillsboro and Tanasbourne/Amberglen Regional Centers, it is not likely to contribute to enhancement of those centers. UGB Ord Rec 588-705.

South Cooper Mountain Analysis Area

The UGB ordinance adds 543 acres from the South Cooper Mountain Urban Reserve 6B (1,776). The South Cooper Mountain area (SCMA) will provide capacity for at least 4,354 dwellings. UGB Ordinance, Exhibit B, UGB Ord Rec Part 1; 608-616.

- Factor 1: Efficient Accommodation of Identified Land Needs

The area contains 21 parcels, all but three greater than 10 acres in size. There are seven parcels larger than 30 acres and two larger than 60 acres each. UGB Ord Rec 608-616. Ten ownerships comprise 448 of the 543 acres in SCMA. This parcelization pattern is conducive to efficient urbanization. All of the owners support addition to the UGB and are committed to annexation to Beaverton. Because these owners represent 83 percent of the land, it is likely the city will be able to annex the territory. UGB Order Rec 1; 384. This governance situation is also conducive to the efficient accommodation of development in the area. Finally, the presence of a site for a high school (owned by the Beaverton School District) will make travel between dwellings and school more efficient than in other areas studied. UGB Order Rec 382; 844.

Approximately 30-35 percent of SCMA is constrained by natural resources (stream corridors, wetlands and steep slopes). The large parcel pattern compensates for these constraints; compact urban development is still possible. UGB Ord Rec 608-616. The Council concludes that SCMA can urbanize more efficiently than most areas studied (see overall conclusions, below).

- Factor 2: Orderly and Economic Provision of Public Facilities and Services

SCMA has high suitability for sewer, water and transportation services. UGB Ord Rec 608-616; 715. Beaverton and Clean Water Services have capacity to provide the public facilities and have expressed their willingness to do so. UGB Order Rec 384. These and other services will be expensive. But there are park and schools sites within the area and the school and park districts support addition of the area to the UGB. UGB Order Rec 844. Urban services are adjacent to or nearby the SCMA. UGB Order Rec 368.

The Council finds that these efforts put SCMA in a better position to provide services in an orderly and economic manner than most other areas considered for expansion for housing capacity (see overall conclusions, below).

- Factor 3: Comparative Environmental, Energy, Economic and Social Consequences

Approximately 30-35 percent of SCMA is constrained by natural resources (stream corridors, wetlands, steep slopes and upland habitat). Application of Titles 3 and 13 during comprehensive planning will mitigate effects on these resources. UGB Ord Rec 608-616; 717. The Council concludes that the environmental, energy, economic and social consequences of urbanization of SCMA are tolerable if mitigated as required by conditions in Ordinance No. 11-1264B and by Titles 3 and 13 of the UGMFP. The consequences are less adverse than those expected from urbanization of most other areas studied, (see overall conclusions). UGB Ord Rec 717.

- Factor 4: Compatibility of Proposed Uses with Nearby Agricultural and Forest Activities

The UGB borders SCMA on the east. State Highway 210 (Scholls Ferry Road) forms the southern boundary. There are no compatibility issues to the east; Highway 210 serves as an edge and significant buffer between the area and farms to the south. Pockets of rural residential development to the southwest and the north, a large tract of forest land, and Metro's Cooper Mountain Nature Park isolate SCMA from the most extensive areas of agriculture nearby, and reduce compatibility problems. UGB Ord Rec 608-616. The UGB ordinance imposes

mitigation conditions to reduce incompatibility further. UGB Ordinance, Exhibit B, UGB Ord Rec Part 1.

The Council concludes that SCMA area performs as well as most areas studied under this compatibility factor, and that areas more compatible have other disadvantages that make them less satisfactory for addition to the UGB. (See overall conclusions.)

- Factor 5: Equitable and Efficient Distribution of Housing and Employment Opportunities Throughout the Region

Expansions of the UGB made since 1998 added little residential capacity on the westside of the region.[20] Most residential capacity in that cycle was added to the east side (Damascus). The addition of SCMA to the UGB to accommodate new housing will provide housing opportunities in Beaverton that are in short supply. The conversion (infill and redevelopment) of some central Beaverton neighborhoods from single-family to multi-family (apartments and condominiums) has left a shortage of capacity for small-lot detached single-family dwellings. The city proposes a more balanced mix of housing types in SCMA. Cap Ord Rec 377-378; 389-394; 399. The Council concludes that addition of SCMA will lead to a more equitable and efficient distribution of housing in the Beaverton region.

- Factor 6: Contribution to the Purposes of Centers and Corridors

The Murray Scholls Town Center lies two-thirds of a mile east of SCMA on Scholls Ferry Road. Urbanization of the area will contribute to the center by adding residents to support commercial services in the town center. Residents will also add to the employment base of the center. UGB Ord Rec 374; 608-616. The major owner of commercial properties in the center (Gramor Development, Inc.) supports addition of the SCMA to the UGB. UGB Ord Rec 380.

- Factor 7: Protection of Farmland Most Important to the Continuation of Commercial Agriculture in the Region

By adoption of rural reserves, the region has determined which farmland is most important for the continuation of commercial agriculture in the region. SCMA itself is designated urban reserve. The area to the west of the South Hillsboro area is also designated urban reserve. The area to the southwest and south, however, is designated rural reserve and is very important to the continuation of commercial agriculture in the region. Urbanization of SCMA will present some issues of compatibility with farm practices in the rural reserves. These issues are discussed above under Factor 4.

- Factor 8: Avoidance of Conflict with Regionally Significant Fish and Wildlife Habitat

SCMA contains a significant amount of riparian and upland habitat, associated with two stream corridors. The area has 19 acres of habitat on Washington County's Goal 5 inventory. UGB Ord Rec 368 (p. 19). Even with the protection of land use regulations to implement Titles 3 and 13 of Metro's UGMFP, urbanization of the area will likely have adverse effects on the habitat. UGB Ord Rec 608-616;717. The Council concludes that SCMA does not rate well under this factor.

[20] Since 1998, 14,263 acres have been added to the Clackamas County part of the UGB. Only 6,102 acres have been added to the Washington County portion.

- Factor 9: Clear Transition Between Urban and Rural Lands

There are no natural or built features that provide a clear transition between urban uses in SCMA and the rural lands on portion of its perimeter. The features described under Factor 4, above, will provide some transitional uses. Nonetheless, the Council concludes that SCMA does not rate well under this factor.

- Policy 1.9.12 on Workforce Housing

Beaverton's "Prospectus" for the SCMA area proposes a full range of housing types and lot sizes to accommodate the full range of housing needs. The city estimates its planning under Title 11 of the UGMFP will accomplish average densities in the range of 14 to 22 units per net developable acre. UGB Ord Rec 391-397. Title 11 requires the city to provide capacity for affordable housing.[21] The UGB ordinance sets a minimum zoned capacity for SCMA of 4,651 dwelling units (more than 15 units/net developable acre). UGB Ordinance, Exhibit B, UGB Ord Rec Part 1). The Council concludes that efforts by the city described in the Prospectus, agreements the city has achieved with owners of large parcels in the area, and planning by the city to comply with Title 11 will provide capacity for workforce housing in SCMA and help achieve Regional Framework Plan Outcome 6.

Overall Conclusions for South Cooper Mountain:

As explained under Factors 1 and 2 above, the parcelization and ownership patterns in the South Cooper Mountain area (SCMA) are conducive both to efficient accommodation of residential development and to the orderly and economic provision of public facilities and services. Only the South Hillsboro area, also added to the UGB, and SCMA have these two important characteristics in larger quantity than other areas considered. SCMA is not as regularly flat as the South Hillsboro area. Nonetheless, the parcelization and ownership patterns render SCMA almost as susceptibility to a compact, mixed-use, pedestrian and bicycle-friendly and transit-supportive development pattern as South Hillsboro. Further, as described under Factors 3, 4, 7 and 9, the combination of natural and built features in and near SCMA causes the area to rate well under those factors in comparison with other areas studied. And, given its proximity to the Murray-Scholls Town Center and the large number of new residences it would add, SCMA area will help support the commercial uses in the center.

Compared to SCMA, Gresham East has lower suitabilities for water, sewer and transportation services; and small parcels, many with development, that will make urbanization more difficult. Maplelane has the same disadvantages, but also has a high ratio of constrained to unconstrained gross vacant land, which will limits its capacity. Beavercreek Bluffs has the same difficulties as Maplelane, but a higher constrained land ratio. The Norwood area has lower water, sewer, transportation suitability than SCMA. I-5 East has a high ratio of constrained to unconstrained land, including steep slopes that would fracture urban development in its northern portion, and many small parcels, 85 percent of which are improved. Elligsen, too, has much constrained land, difficult infrastructure issues and no easy way to ensure compatibility with agriculture to the south. The Advance area suffers from the same disadvantages. Sherwood West has a low ratio of constrained to unconstrained land, but lower suitabilities for water, sewer and transportation services than SCMA. Urbanization of Sherwood West would likely divert the city's effort from enhancing its town center. Sherwood South has high ratio of constrained to unconstrained land,

[21] Metro Code 3.07.1110B(1)(c); 3.07.1110C(4); 3.07.1120C(4)

a large number of small parcels with improvements, difficult infrastructure issues. Efforts to urbanize it, too, may divert Sherwood's effort to enhance its town center.

The Tonquin area, a quarry, has low suitability for housing and infrastructure issues. Roy Rogers West measures well under several factors, but has no easy way to ensure compatibility with agriculture to the west and south. Its rural residential development pattern will make it more difficult to urbanize in a compact, efficient pattern.

Compared to SCMA, the Vandermost Road area has a high ratio of constrained to unconstrained land and likely moderate to high adverse economic, social and energy consequences from urbanization. The Forest Grove North area has high suitability for services and medium sized parcels, suitable for urbanization (though not nearly as large as SCMA). But it borders an extensive block of intensely farmed land with no effective buffers, rendering it not compatible with nearby agricultural practices. The Forest Grove North Purdin Road area shows lower suitability for public services than SCMA. Its parcelization pattern makes it conducive to compact and efficient development. But like the Forest Grove North area, it borders an important agricultural area; urbanization there would present larger compatibility challenges than urbanization of SCMA. The Forest Grove South area is small (37 acres) and sought by the city for industrial use in conjunction with an industrial site (25 acres) inside the UGB. It is well-suited for efficient and economically-serviced development. But, like the Forest Grove North study areas, however, Forest Grove South borders an extensive block of important farmland to the south, west and east; the impact of urban development on that block of agricultural land concerns the Council. Cornelius East has high suitability for public services and it presents few compatibility problems or adverse consequences. But its small parcels with residential development would make it very difficult for efficient, compact urban development. The Cornelius South area has the same advantages as Cornelius East. Like the Forest Grove study areas, however, Cornelius South borders an extensive block of important farmland (south and east); the impact of urban development on that block of agricultural land concerns the Council.

The Hillsboro North-Jackson School Road area is highly suitable for efficient, compact development. But it is separated from the UGB (by the Hillsboro North area, added to the UGB by this ordinance) and, hence, not immediately adjacent to or near urban services as is the SCMA. It is, itself, important farmland and it borders an extensive block of important farmland which is not protected from urbanization by buffering natural or built features. The Shute Road Interchange area is also highly suitable for efficient, compact development. But it faces farmland compatibility issues. Given its location across Highway 26 and some distance from the Hillsboro and Tanasbourne/Amberglen Regional Centers, it is not likely to contribute to enhancement of those centers. UGB Ord Rec 688-705.

Roy Rogers West Analysis Area

The UGB ordinance adds 51.6 acres of the 256-acre Roy Rogers Urban Reserve 6C. Addition of this portion to the UGB will provide capacity for at least 479 dwellings. UGB Ordinance, Exhibit B; Staff Report, October 14, 2011, p. 6, UGB Ord Rec Part 1. Addition of the area will also facilitate urbanization of two areas added to the UGB in 2002.

- Factor 1: Efficient Accommodation of Identified Land Needs

Addition of this 51.6 acres ("RRWA") will facilitate efficient urbanization of two proximate, but noncontiguous areas added to the UGB in 2002, Areas 63 and 64 (219 and 248 acres, respectively). The West Bull Mountain Concept Plan, adopted by Washington County in December, 2010, included Areas 63 and 64 and the whole of the Roy Rogers West Urban Reserve in order to ensure orderly and economic efficient delivery across an integrated planning area. With cooperation from Washington County and Beaverton, Tigard annexed Area 64 ("River Terrace") on September 30, 2011. Area 63 remains in unincorporated Washington County, and difficult for Tigard to annex due to the presence of unincorporated urban development between Tigard and Area 63. Both Washington County and the Tigard have agreed that both areas 63 and 64 are most efficiently urbanized by a city capable of providing the full range of urban services. Addition of the two parcels totaling 51.6 acres is the minimum portion of RRWA necessary to extend utility and transportation connections to Area 63, and implement Metro's 2002 UGB expansion and the West Bull Mountain Concept Plan. UGB Ord Rec 348; 844; 1080; 1097; 1228; Staff Report, October 14, 2011, p. 6, UGB Ord Rec Part 1. .

Of the 51.6 acres that comprise RRWA, 2.9 acres are the right-of-way of Roy Rogers Road. Two parcels comprise the majority of RRWA, each with an existing dwelling. This development pattern will allow for efficient, compact development. Accounting for constraints and other streets, roads, parks and schools, 32 net developable acres remain and provide capacity for 479 dwelling units, required by the UGB ordinance (approximately 15 dwelling units/net acre). UGB Ordinance, Exhibit B, Rec Part 1; Staff Report, October 14, 2011, p. 6, UGB Ord Rec Part 1.

The Council concludes that addition of RRWA will lead to efficient accommodation of residential land needs, both in RRWA and Areas 63 and 64, previously added to the UGB.

- Factor 2: Orderly and Economic Provision of Public Facilities and Services

Addition of RRWA will facilitate the provision of public utilities and transportation facilities to the area and to the Areas 63 and 64. Added to the UGB in 2002, Areas 63 and 64 are not contiguous and, until September 30, 2011, were not serviceable by a city capable of extending services for urbanization. The West Bull Mountain Concept Plan found the RRWA to be the most logical corridor for services to the entire area. Maps of water, sewer, stormwater and streets and roads from the West Bull Mountain demonstrate the advantage of including RRWA in the arrangement of services to Areas 63 and 64. UGB Ord Rec 1080; 1228; Staff Report, October 14, 2011, p. 6, UGB Ord Rec Part 1. .

On September 30, 2011, Tigard, with the support of Washington County and Beaverton, annexed Area 64 ("River Terrace") and assumed responsibility for providing community planning and urban services delivery to the entirety of the West Bull Mountain planning area. Although Tigard requested addition to the UGB of all of Urban Reserve 6C, the addition of the 51.6-acre portion provides a logical and feasible service corridor to allow the orderly and economic provision of services to lands already within the UGB. UGB Ord Rec 1080; 1228; Staff Report, October 14, 2011, p. 6, UGB Ord Rec Part 1.

The Council concludes that Tigard can provide public facilities and services to RRWA in an orderly and economic manner and that inclusion of RRWA makes provision of facilities and services to old study Areas 63 and 64 more orderly and economic.

- Factor 3: Comparative Environmental, Energy, Economic and Social Consequences

There are no wetlands or floodplains in RRWA. The Tualatin National Wildlife Refuge lies to the south, but is outside RRWA. Urbanization of RRWA subject to Metro's Titles 3 and 13 will not cause significant adverse effects on refuge resources. Scattered rural residences with some tracts devoted to agriculture characterize the land use pattern of RRWA. Urbanization will not have a significant effect on agriculture in the region, but it will change the rural residential way of life of current residents. UGB Ord Rec 617-625;717. The Council concludes the environmental, energy, economic and social consequences of urbanization of RRWA are acceptable and less adverse than the consequences of urbanizing other areas considered for expansion. UGB Ord Rec 617-625;717.

- Factor 4: Compatibility of Proposed Uses with Nearby Agricultural and Forest Activities

There are significant blocks of agricultural land to the west of RRWA (across Roy Rogers Road). The road forms an edge between future urbanization and agriculture to the west, but it does not ensure compatibility with agricultural practices. Hence, the UGB ordinance applies a condition that requires Tigard to adopt measures to enhance compatibility when it completes planning to urbanize RRWA. UGB Ordinance, Exhibit B, UGB Rec Part 1; Staff Report, October 14, 2011, p. 6, UGB Ord Rec Part 1. The Council concludes that the RRWA performs as well as most areas studied under this compatibility factor.

- Factor 5: Equitable and Efficient Distribution of Housing and Employment Opportunities Throughout the Region

Expansions of the UGB made since 1998 added little residential capacity on the westside of the region.[22] Most residential capacity in that cycle was added to the east side (Damascus). In 2002 Metro added approximately 470 acres immediately east and north of RRWA to the UGB (Areas 63 and 64). These areas have been slow to urbanize and provide needed housing and employment due to their relative isolation from each other and distance from a city capable of providing urban services. On September 30, 2011, Tigard annexed 248 acres in Area 64 and has begun planning the extension of urban services to the area. The addition of RRWA will provide a service corridor between Tigard and Area 63, allowing the development of needed housing on an additional 219 acres of land already with the UGB. UGB Ord Rec 1080; 1228; Staff Report, October 14, 2011, p. 6, UGB Ord Rec Part 1. .

The addition of RRWA to the UGB to accommodate new housing will provide housing opportunities in a part of the region that has had little residential capacity added to the UGB since 1998. The Council concludes that addition of RRWA will lead to a more equitable and efficient distribution of housing on the westside of the region.

- Factor 6: Contribution to the Purposes of Centers and Corridors

New residential development in RRWA is unlikely to contribute in a significant way to the nearby town centers. The King City and Murray/Scholls Town Centers (1.5 and 2.5 miles, respectively, from RRWA) currently have low jobs to housing ratios. Addition of RRWA will

[22] Since 1998, 14,263 acres have been added to the Clackamas County part of the UGB. Only 6,102 acres have been added to the Washington County portion.

not improve the ratios. UGB Ord Rec 617-625. The Sherwood Town Center is more distant and is unlikely to be affected positively or negatively. The Council concludes that addition of RRWA is not likely to enhance the roles of the two centers closest to the area. This factor does not favor RRWA.

- Factor 7: Protection of Farmland Most Important to the Continuation of Commercial Agriculture in the Region

RRWA is a portion of an urban reserve, designated in part because it is less important for the long-term viability of commercial agriculture in the region than farmland designated rural reserve or left undesignated. The existing UGB borders RRWA on the north and east sides. UGB Ord Rec 617-625. The Council concludes that this portion of the Roy Rogers West Urban Reserve is less important to the region for its agricultural resources than for urbanization, particularly because addition of the area will facilitate efficient and economic urbanization of the South Cooper Mountain area.

- Factor 8: Avoidance of Conflict with Regionally Significant Fish and Wildlife Habitat

A stream with riparian vegetation passes through RRWA along its northern border with the UGB. The stream corridor is removed from the buildable land inventory as constrained. UGB Ord Rec 617-625; 717. Metro Titles 3 and 13 and Tigard's adopted Title 13 regulations will apply to the corridor. The Council concludes that RRWA can be urbanized with minimal adverse impacts to habitat in the area.

- Factor 9: Clear Transition Between Urban and Rural Lands

There are no natural or built features that make a clear transition between RRWA and rural lands to the south and west. Roy Rogers Road borders RRWA on the west and forms an edge. The buffering measures required to protect agricultural practices to the west and south will also provide some transition. The Council concludes that other areas studied have natural or built features at their perimeters than RRWA that would provide clearer transition between urban and rural lands.

Overall Conclusions for Roy Rogers West:

Urbanization of the RRWA portion (51.6 acres) of the Roy Rogers Urban Reserve (6C) will have fewer adverse effects on agriculture, habitat and other natural resources than other areas studied due to its small size and extensive border with the existing UGB. Because of the linkage it will provide between Areas 63 and 64, added to the UGB in 2002, it will perform an important role in the efficient urbanization of those areas and in the provision of urban services to the areas. RRWA itself will urbanize efficiently and at 15 units/new developable acre or better. For these reasons, the Council chooses this area above others considered.

2. Added Employment Capacity for Large-Lot Industrial Use

The Council added 330 acres in the North Hillsboro Analysis area to the UGB to meet the need for capacity for industries that seek large parcels. The addition will bring the capacity of the UGB to 300,000 new jobs, reflecting a 1.35 percent growth rate over the 20-year planning period. Staff Report, October 14, 2011, p. 7, UGB Ord Rec Part 1. With the conditions assigned to the area by the UGB ordinance, the area will provide one 100-acre tract and two 50-acre tracts.

Mindful of the characteristics of land that make it suitable to meet the need for large-lot industrial use (relatively large lots; relatively flat; proximate to transportation facilities capable of moving freight; adjacent on near the existing UGB), Metro eliminated from review the urban reserves without those characteristics.[23] Cap Ord Rec 4; 4102; 4274.

Of the 28,000 acres of urban reserves, the following areas have the characteristics, to one degree or another, that might make them suitable for large industrial users. and were considered for addition to meet this specific industrial need: Boring; Elligsen; Advance; Grahams Ferry; South Hillsboro; Forest Grove North; Cornelius South; Hillsboro North; Shute Road Interchange; Groveland Road and Bethany West.

The Council concludes that the Boring, Elligsen, Forest Grove North, Cornelius South and Bethany West areas fail to meet the site requirements. The large parcel in the Boring area lies 1.3 miles east of the UGB. The large parcels in the Elligsen area have slopes greater than 10 percent or lie more than two miles from an interchange (I-5). The Forest Grove North and Cornelius South areas lie more than three miles from an interchange (Hwy 26). The Bethany West area is distant from any city that could provide services (no city proposed addition of the area). The South Hillsboro, Advance, Grahams Ferry, and Groveland Road/Shute Road Interchange areas are discussed further, below.

North Hillsboro Analysis Area

- Factor 1: Efficient Accommodation of Identified Land Needs

The included portion of the North Hillsboro Analysis area (NHA) is relatively flat. UGB Ord Rec 1772 (map). It is composed of eight parcels, including two parcels between than 50 and 100 acres and three parcels between 20 and 50 acres in size. Little of the gross vacant buildable area is constrained. UGB Ord Rec 679-684; 717; Staff Report, October 14, 2011, p. 7, UGB Ord Rec Part 1. . This parcelization pattern makes consolidation of parcels to comprise 100-acre and 50-acre industrial sites feasible and achievable. UGB Ord Rec 977-979; 1675-1677. The city has agreements from the landowners to consolidate their parcels to comprise one 100-acre and two 50-acre tracts. UGB Ord Rec 754-760; 1239-1241; 1678-1681. The UGB ordinance requires consolidation to yield at least one 100-acre and two 50-acre tracts. UGB Ordinance, Exhibit B, UGB Ord Rec Part 1. The area lies along Highway 26 and within a mile from the Brookwood-Parkway interchange. NHAA also adjoins Hillsboro's "cluster" areas, all south of Highway 26. UGB Ord Rec 1646.

The Council concludes NHA can accommodate the full need (330 acres) determined by Metro more efficiently than any other area considered.

- Factor 2: Orderly and Economic Provision of Public Facilities and Services

The included portion of NHA has high suitability for public utilities and transportation connectivity. UGB Ord Rec 679-684; 715-716. The area lies west of Evergreen industrial area, within the UGB, added to the UGB in 2005.[24] The city of Hillsboro has planned and zoned the

[23] See Goal 14: "In determining need, local governments may specify characteristics, such as parcel size, topography or proximity, necessary for land to be suitable for an identified need." OAR 660-024-0060

[24] Metro Ordinance No. 05-1070A.

Evergreen area for industrial use and has adopted public facilities and services and transportation plans for it. The city also developed a pre-qualifying concept plan for NHA as part of its participation in the 2008-2010 reserves process. That plan shows the utility and transportation links between the Evergreen area and NHA. The services that will be established in that area can be extended to NHA. The city has demonstrated capacity and willingness to extend those services. UGB Ord Rec 1678-1681; 1641.

An analysis of the costs of public services and transportation done for Metro and Hillsboro indicates that the included portion of NHA compares favorably with the Groveland Road area and two other areas in the vicinity. NHA area would require 2.17 miles of new collector and arterial lane miles. The other three areas would require between 9.17 and 15.27 (Groveland Road area) new lane miles. UGB Ord Rec 1167-1170; Staff Report, October 14, 2011, p. 7, Attachments 10 and 11, UGB Ord Rec Part 1.

The Council concludes that public facilities and services can be provided to the NHA in an orderly and economic fashion. It is possible that services could be provided to the Shute Road Interchange area at lower public cost. But a comparison of service costs between these two areas must account for the fact that the Shute Road area will not fully satisfy the need for large parcels; Metro would have to add another area to meet the full need, with additional costs for public facilities and services.

- Factor 3: Comparative Environmental, Energy, Economic and Social Consequences

The included portion of NHA is largely devoted to agriculture. Hence, industrial uses will have few consequences for the natural resources in the area. UGB Ord Rec 679-684; 717. Industrial uses will displace agricultural uses. But the positive economic effect of industrial use and employment (the average annual 2009 payroll per employee in the existing North Hillsboro industrial area was $109,866 in 2009) will offset the loss of farmland base and farm employment. UGB Ord Rec 679-684;1662-1674. It is likely that industrial use will have adverse consequences for habitat in the area. But application and implementation of Titles 3 and 13, required by Title 11 of the UGMFP will minimize those consequences.

The Council concludes that the environmental, energy, economic and social consequences industrial uses in the NHA are acceptable given the beneficial consequences, and that the balance of consequences in the area are similar to those in other areas studied.

- Factor 4: Compatibility of Proposed Uses with Nearby Agricultural and Forest Activities

The included portion of NHA is separated from farmland to the north by Highway 26. The UGB (Evergreen industrial area) borders the area to the south. Between the area and the UGB on the east lies a pocket of rural residential development. Likewise, there are clusters of residential development to the west of the area, mixed among farm parcels. An extensive area of important farmland lies west of the pockets of development. The highway provides a significant edge and buffer that will reduce incompatibilities between industrial uses and farm practices to the north. The rural residential development will likewise separate industrial uses from much of the actively farmed land. The build features, together with measures required by the UGB ordinance, will reduce incompatibility with agricultural activities. UGB Ord Rec 679-684.

The Council concludes that industrial uses in NHA can be rendered generally compatible with nearby farm and forest practices, and that the level of compatibility would be similar to that achievable in other areas studied.

- Factor 5: Equitable and Efficient Distribution of Housing and Employment Opportunities Throughout the Region

In the previous capacity analysis and additions of capacity in response to it (2002-2005), Metro added land for industrial use east (Gresham, Damascus), south (Wilsonville, Tualatin/Sherwood) and west (Hillsboro) of the UGB. These expansions distributed industrial job opportunities equitably around the region. This UGB expansion adds only one area for employment, for those industries that demand large parcels. Given the characteristics needed for that particular part of the employment picture, addition of the 330 acres of NHA is the most efficient way to accommodate the demand. For a variety of reasons, recession included, the areas added for industrial use in 2002 to 2005 have been slow to develop. Given the factors described in these findings for NHA, the Council concludes that addition of NHA provides the best opportunity for this kind of employment in the relatively near future. Together with addition of housing capacity in the South Hillsboro area, NHA will contribute to equitable and efficient distribution of housing and employment to the west end of the region.

- Factor 6: Contribution to the Purposes of Centers and Corridors

Addition of the portion of NHA to the UGB will bring jobs to the area and the city of Hillsboro. New employment will probably induce demand for housing in the Hillsboro and Tanasbourne/Amberglen Regional Centers. But, given the distance from the centers and the already high ratio of jobs to housing in the Hillsboro Regional Center, it is doubtful that addition of NHAA will make a significant, direct contribution to either regional center. UGB Ord Rec 679-684. But the NHA will provide employment opportunities for the growing number of dwelling units in the Tanasbourne/Amberglen and Orenco Centers.

The Council concludes that industrial uses will have some positive effects on the Hillsboro and Tanasbourne/Amberglen Regional Centers by providing employment opportunities to residents in those centers, and by generating some employment in businesses in the centers that provide services to industries.

- Factor 7: Protection of Farmland Most Important to the Continuation of Commercial Agriculture in the Region

NHA is designated urban reserve, but it includes important agricultural land, and must be compared with other lands designated urban reserve. There are pockets of rural residential development in and at the perimeter of the area, and Highway 26 to its north that isolate it from the large block of farmland on the north side of the highway. UGB Ord Rec 679-684. Nonetheless, the Council concludes that the SCMA does not rate well under this factor.

- Factor 8: Avoidance of Conflict with Regionally Significant Fish and Wildlife Habitat

Although agricultural practices have disturbed habitat in most of NHA, there is riparian habitat associated with Waible Gulch. Even with the protection of land use regulations to implement titles 3 and 13 of Metro's UGMFP, urbanization of the area will likely have some adverse effects

on the habitat. UGB Ord Rec 679-684; 717. The Council concludes the NHA rates about average under this factor among other areas studied.

- Factor 9: Clear Transition between Urban and Rural Lands

Highway 26 provides an edge and clear transition from industrial use to the south and rural farmland to the north. Measures required by the UGB ordinance to reduce incompatibility with nearby agricultural activities will provide some transitional buffers from nearby farms. UGB Ordinance, Exhibit B, UGB Ord Rec Part 1; 679-684.

The Council concludes that opportunities for clear transitions between industrial uses in NHA and nearby rural lands are as good as opportunities in other areas studied.

Overall Conclusions for North Hillsboro Analysis Area

Compared to NHA, the Advance area has more constraints on efficient use for large industrial uses. Two streams and a BPA powerline and easement bisect the area, reducing the usable area and fragmenting it. The West Linn-Wilsonville School District owns several parcels (totaling 40 acres) in the area, one reason the city of Wilsonville proposes mixed use rather than industrial use for the Advance Area. The city has asked Metro to add the area for residential development to "balance" the high jobs to housing ratio. The area has lower suitabilities for public services and transportation improvements than NHA, and lower compatibility with nearby agricultural activities. UGB Ord Rec 679-684.

Compared to NHA, the Grahams Ferry area has fewer compatibility challenges with agricultural activities. But the area is more severely constrained by riparian habitat, wetlands and floodplain. The terrain is also more sloped than NHA, which reduces its suitability for infrastructure and transportation.

Compared to NHA, the South Hillsboro area is flat and contains large parcels. It has high suitability for public utilities and transportation. It fares just as well as NHA for its relatively small amount of constrained land and compatibility with agriculture. But it lies more than three miles from the nearest interchange, on Highway 26. Metro added the South Hillsboro area to the UGB for housing and mixed-use development because it is, among all the areas studied, the most suitable for compact, mixed-used, pedestrian and bicycle-friendly, transit-supportive development. For these reasons, the Council concludes that South Hillsboro is more important for mixed-use development than for large-lot industrial development.

Like the South Hillsboro area, the Groveland Road and the Shute Road Interchange areas are flat, have few ownerships and have high suitability for public utilities and transportation. UGB Ord Rec 698-714; Staff Report, October 14, 2011, p. 6, UGB Ord Rec Part 1. The Groveland Road area has fewer habitat and natural resource constraints than NHA, but the Shute Road area has constrained land that would fragment the developable area. UGB Ord Rec 698-701;706-711; 1678-1681. Six separate parcels, the largest of which is 39 acres, comprise the three ownerships. One owner has testified that he would be willing to combine his two lots to create a 69-acre tract. But 21 of these 69 acres lie within the floodplain of Waible Creek. UGB Ord Rec 1065. Through consolidation of parcels, the Shute Road Area could yield one tract of 50 acres of buildable land. UGB Ord Rec 1678-1681. But NHA included will yield one 100-acre and two

50-acre tracts and the entire need identified by Metro. Unlike with NHA, there is no signed agreement in the record that the owners will consolidate their parcels to create a single, large parcel.

The owners in the Shute Road area submitted a comparison of the costs of extending utilities and transportation to the two areas indicating that the costs for Shute Road are a fraction of the costs for NHA. Other information submitted, however casts doubt on the thoroughness of the owners' analysis. As noted by the city of Hillsboro, the owners' analysis does not distinguish between public and private costs. The city notes that the variance between the costs that will be borne by the public is smaller. Services to NHA serve a larger area (330 versus 139 acres). The city further notes that NHA can be served by an existing water reservoir; a new reservoir will be needed north of Highway 26. Also, the area north of Highway 26 would need a new sanitary sewer pump station. UGB Ord Rec 1678-1681.

NHA and Shute Road Interchange areas, with reference to the factors, share several advantages over other areas studied. Both are relatively flat and contain some large parcels. Both are close to an interchange on Highway 26. The Shute Road Interchange area rates higher for the orderly and economic provision of public facilities and services. NHA rates higher for the efficient accommodation of identified land needs. Owners in the Shute Road area emphasize that the area can be developed sooner than NHA because NHA must wait for development in the Evergreen area, added to the UGB for industrial use in 2005. But the Council and the city want the Evergreen area, already inside the UGB, to develop before any territory to be added to the UGB by this ordinance. Because the Council values the efficient use factor higher than the economic provision of services factor in this situation, the Council concludes NHA performs better overall than the Shute Road area.

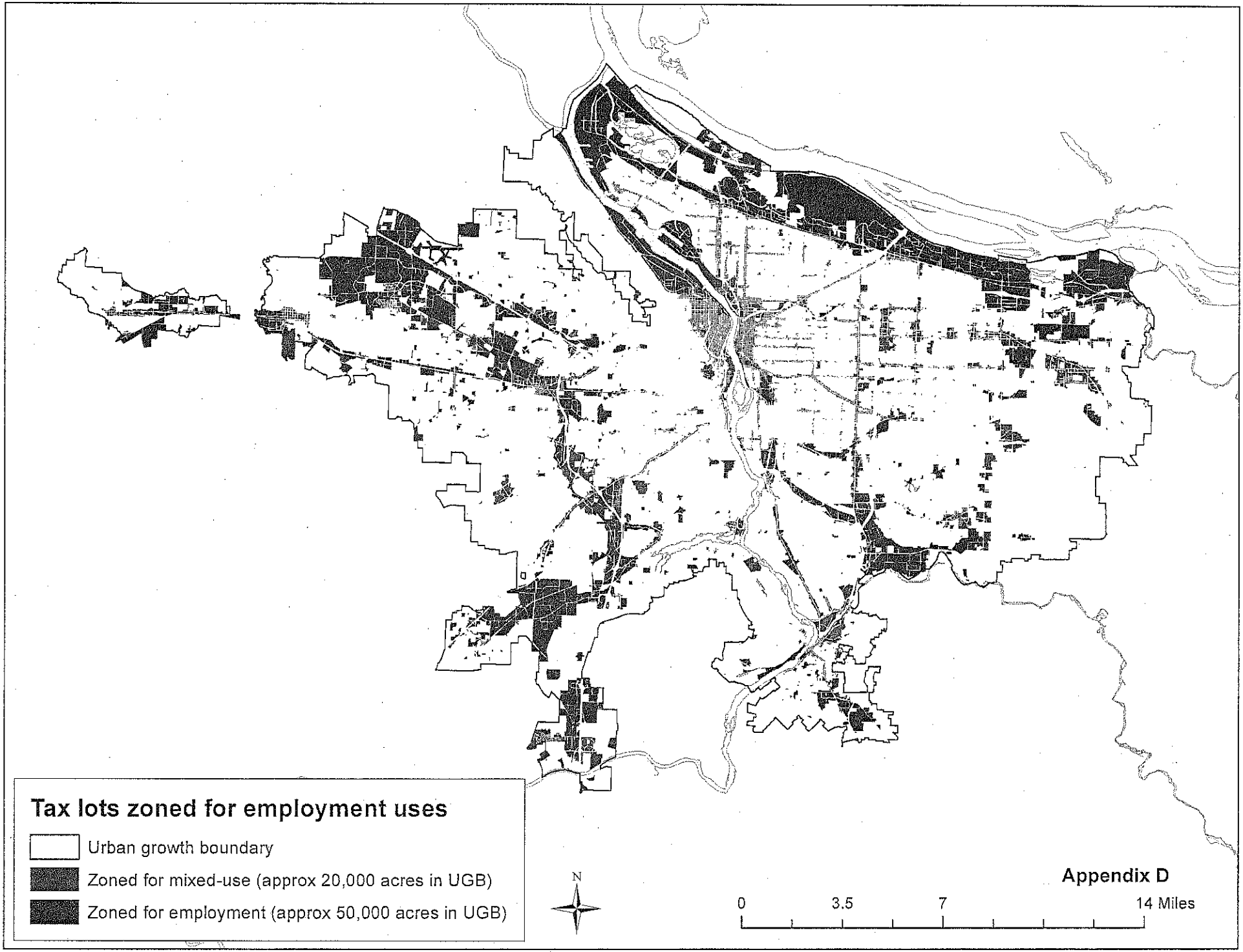
The Council concludes that the portion of the North Hillsboro Analysis Area (NHA) included measures up better under the applicable factors for providing large parcel employment capacity than any area studied.

Technical Amendment – City of Hillsboro
The UGB ordinance adds a small parcel (0.83 acres) to the UGB that, for reasons unknown, is an island within the existing UGB and is surrounded by the city of Hillsboro. The island was recently discovered during a Hillsboro annexation process involving land added to the UGB in 1981. Addition of this tract will allow Hillsboro to urbanize the area efficiently. Staff Report, October 14, 2011, p. 7, UGB Ord Rec Part 1.

III. Statewide Planning Goals (other than Goal 14)

Goal 1 (Citizen Involvement): See section IB, above.

Goal 2 (Adequate Factual Base): For coordination, see section IA, above. The Metro Council has concluded that the additions made to the UGB by this UGB ordinance comply with the statewide planning goals, the Regional Framework Plan and other land use laws. The Council's conclusions are based upon substantial evidence in the records of the capacity and UGB ordinances, as found in the Findings of Fact and Conclusions of Law supporting the two


Tax lots zoned for employment uses
Urban growth boundary
Zoned for mixed-use (approx 20,000 acres in UGB)
Zoned for employment (approx 50,000 acres in UGB)
N
Appendix D
0
3.5
7
14 Miles

Subject to Change

FY 2012-13 Council Budget Review
Key Dates and Deadlines
(REVISED as of April 30. 2012)

Monday April 9, 2012	Release Proposed Budget to Council electronically (no deliberations on budget allowed until public hearing in April)
Thursday April 19, 2012 2:00 p.m. (60 minutes)	**COUNCIL MEETING *(Public Hearing on budget)*** Chief Operating Officer acting as Budget Officer presents Proposed Budget and Budget Message to the Metro Council acting as Budget Committee *1st reading of Ordinance 12-1274*
Thursday April 26, 2012 2:00 p.m.	**COUNCIL MEETING *(Public Hearing on budget)*** Additional opportunity for public comment Adoption of rate ordinance *Additional reading of Ordinance 12-1274*
Thursday May 3, 2012 2:00 p.m.	**COUNCIL MEETING *(Public Hearing on budget)*** Approval of resolution setting tax rates and transmitting budget to TSCC *Additional readings to ordinance 12-1274* *Approval of resolution 12-4338*
Tuesday May 15, 2012	Deadline to file Approved Budget with TSCC
May 16 – June 6, 2012	TSCC public comment period (minimum 20 days)
Friday May 25, 2012 By close of business.	Deadline for submittal of Councilor amendments to the budget *Amendments after approval are subject to limitations of Oregon Budget Law*
Friday June 1, 2012 By 10:00 a.m..	Deadline for submittal of final department technical amendments *Amendments after approval are subject to limitations of Oregon Budget Law*
Thursday June 7, 2012 12:30 – 1:30	**TSCC Public Hearing** Metro Regional Center Council Annex
Friday June 8, 2012	Release packet of final department technical amendments and Councilor amendments
Tuesday June 12, 2012 2:00 p.m. (TBD)	**BUDGET WORK SESSION** Discussion of Councilor amendments Review of final technical amendments
Thursday June 14, 2012 2:00 p.m. (TBD)	**COUNCIL MEETING*: (Public Hearing on budget)*** Metro Council Chamber Consideration and vote on final amendments to budget *Additional reading/amendments to ordinance 12-1274*
Thursday, June 21, 2012 2:00 p.m. (TBD)	**COUNCIL MEETING: *(Public Hearing on budget)*** Metro Council Chamber Adoption of budget *Final reading/adoption of ordinance 12-1274*
Friday July 13, 2012	Deadline to file property tax information with TSCC and three counties

FY 2012-13 Council Proposals
For Budget Amendment Discussion

Councilor	#

Enter in the information under appropriate area. If you don't use all the space in an area, snug up unused lines. You can delete the descriptions under each header to save space.

Short Title

Concise Description

Please describe the proposal, sufficient in scope that the cost and/or level of effort can be evaluated.

Objective

Clear statement of what this proposal is intended to accomplish.
What is the desired outcome? How will you tell if the proposal reaches the desired outcome?

Duration (put an 'x' in the appropriate line, for specific length write in the length)

_____ One time Specific length: _____ _____On-going

Cost Estimate

How much are you willing to spend to achieve your desired outcome? What is the estimated cost or effort to implement this proposal? Give as much information about the cost as you can. Categories of expense (staffing, number of positions, outside services, necessary equipment) are helpful; line item detail is not required. Does this proposal generate revenue now? In some later period?

Funding Options

How will you fund this proposal? Sources might include:

a. Redeployment or elimination of existing effort by reassigning staff or eliminating an equivalent dollar amount from the proposed operating budget (be specific);
This option is cost neutral in FY 2011-12; depending on selection, it may or may not be 100 percent cost neutral in subsequent years.
b. Use of one-time money from Opportunity Fund ($500,000 total available);
The five-year plan anticipates that the Opportunity Fund will be funded each year. Committing the fund now may limit ability to respond to new opportunities that occur during the year.
c. Use of one-time money from a specified reserve.
This option follows the financial policies of using one-time money to fund one-time (not permanent) expenses. Funding for multi-year proposals would all come from this year's reserves. Depending on the chosen reserve, this may require replenishing the reserve next year under the "pay yourself first" principal for maintaining specified reserves.

Relationship to other programs

How does this proposal relate to, enhance or complement existing programs or projects?

Stakeholders

Who will be affected, positively or negatively, by this proposal? What known groups or coalitions will have interest in this?

For FP Use Only	
Org Unit	#

TECHNICAL AMENDMENT TO FY 2012-13 BUDGET

CENTER/SERVICE: _____ **DATE:** _____

DRAFTED BY : _____

Amendment to:		*Purpose:*		*Status:*	
Proposed Budget	☐	Operating	☐	Ongoing	☐
Approved Budget	☐	Capital Project	☐	One-time	☐
		Renewal & Replacement	☐		☐

Note: If the purpose of the amendment is for a capital or renewal and replacement project please attach a revised 5-year CIP sheet

PROPOSED AMENDMENT:

Org Unit	**Fund**	**Line Items**		
		Acct #	*Account Title*	*Amount*
Resources				
Requirements				

PROGRAM/STAFFING IMPACTS:

600 NE Grand Ave.
Portland, OR 97232-2736

Metro | *Memo*

Date: May 1, 2012
To: Martha Bennett, Chief Operating Officer
From: Margo Norton, Finance and Regulatory Services Director
Subject: Community Investment Initiative Staffing for FY 2012-13

You asked for a recap of the staffing proposed for the Community Investment Initiative for FY 2012-13.

The current budget funds 2.6 FTE and significant temporary staffing to provide administrative support. The proposed budget funds 3.5 FTE and includes these changes:

The policy advisor position leading the CII is proposed as a regular status position. There is no change in FTE or current cost. Continuation of the non-represented position after FY 2012-13 will be subject to the annual budgeting process.

A limited duration program analyst position continues without change until June 30, 2013.

A limited duration .6 GIS specialist, scheduled to end June 30, 2012, is continued for an additional year at .5 FTE, placed in the Research Center. It is combined in the Research Center with another part-time position and will perform work for the CII program.

A new 1.0 limited duration Program Analyst position is established to perform additional analytical work, offset in part by a reduction in temporary staffing,

A list of the limited duration positions can be found in Volume 2, Appendix, Limited duration positions (E8).

Council Office: (B28-29) (I am concerned that the council office budget has some large increases in expenses at a time we are reducing work force)

Please provide me with a description of and the purpose of the following expenditures:

Temporary Employees-$115,000

Travel-$49,300 (this has increase 4x over the 2008-9 budget. Why? For what purpose? I assume Councilor travel is accounted for in their personal accounts therefore this amount seems excessive.)

Council costs: $24,500 (councilor personal expenditure account add up to only $12,000, what is the additional $12,500 for?)

Staff Development: $38,700 (3x current year's, please detail)

Mobile communications allowance: $11,650 (what is this? I also see this in other department budgets, what are we buying and why is Metro paying for this expense in this way? Do Councilors get this allowance? (I'm not) and if so, why not included in personal accounts?)

Contracted Professional services-$429,000 (understand this includes CII (see below) what is additional $200,000 for?)

Response:

Response is provided by Ann Wawrukiewicz, Financial Planning Analyst.

	Council and Staff		COO's Office		GAPD		CII	
	2011-12	**2012-13**	**2011-12**	**2012-13**	**2011-12**	**2012-13**	**2011-12**	**2012-13**
Temp Employees	$82,000	$75,000	0	0	0	0	$55,000	$40,000
Council Accounts	$21,000	$24,500	N/A	N/A	N/A	N/A	N/A	N/A
Staff Development	$6,612	$6,700	0	$25,000	$5,050	$4,000	0	$3,000
Contracted Svcs	0	$45,000	$17,151	$112,000	$42,000	$42,000	$600,000	$230,000
	2008-09*	**2012-13**	**2008-09***	**2012-13**	**2008-09***	**2012-13**	**2008-09***	**2012-13**
Travel	$13,728	$32,000	$2,129	$4,300	N/A	$13,000	N/A	0

*The FY 2008-09 travel numbers shown are actual spending.

Temporary employees are reduced from the FY 2011-12 budget. The temporary staffing in the CII budget provides administrative support to the program; Council interns provide administrative and policy support.

The increase in travel from FY 2008-09 stems from three main sources:

The addition of the Government Affairs and Policy Development division. In FY 2008-09, these staff were in Communications and Planning. The GAPD travel budget in FY 2012-13 accounts for $13,000 of the FY 2012-13 total and includes travel to Salem for Randy Tucker.

An update of the COO budget. With the arrival of a new COO, the COO's materials and services budget was adjusted to more accurately reflect the travel and training needs of the office. In prior years the budget was maintained at a very low level, but actual spending had generally been higher than budget. The COO Office's travel budget is now $4,300.

The addition of a $25,000 general travel account. Councilors are expected to find funding sources for travel as much as possible, including Council accounts, sponsorships or direct funding from Metro departments, as relevant and appropriate.Beginning with the FY 2011-12 budget, this travel account was added to the budget to ensure that Councilors have a source for priority, Council-approved travel that would otherwise deplete Council account funds or department budgets. If the funds are not needed, they will drop to fund balance.

Council accounts were increased in FY 2008-09 from $3,000 to $3,500 per Councilor (including the Council President) and remained at that level in FY 2009-10. In FY 2010-11, as part of department-wide cuts, the Councilor accounts were cut back to $3,000 per Councilor, or a total of $21,000. In FY 2012-13, the accounts were again raised to $3,500 per Councilor, partially in response to concerns that in the geographically larger districts, local travel costs have increased in recent years.

The increase in staff development is due to the addition of $25,000 in the COO's Office to support diversity training for Metro staff.

The mobile communications allowance is available to those required to have a cell phone for Metro work; sign up is coordinated through payroll. Alternately, staff may choose to have a "Metro only" phone, with the bill paid directly as a utility charge. During FY 2011-12, it appears that about half of the Councilors are receiving this allowance, but for FY 2012-13, we have budgeted for 6 of 7 to receive it. A number of Council, COO and GAPD staff receives this allowance as well.

Contracted Professional Services: The $45,000 budgeted in Council and Staff includes $30,000 for the new closed captioning contract and $15,000 toward the De Lasalle internship program. The increase in the COO's Office is due to funding for translation and outreach support for the diversity program ($25,000), as well as placeholder funding for a local government strategy ($60,000). Other contract funding in the COO's Office also supports the diversity program. The decrease in the CII budget is due to funding for Communications-based work moving into the Communications budget (although at a lower level than in FY 2011-12). The $230,000 remaining in the CII budget is as follows:

Public Opinion Research	40,000
Strategic Communications	50,000
Materials and Events- Elected and Stakeholders	25,000
State Government Relations Contract	25,000
Facilitation and Technical Support	60,000
Development Consultant for Leadership Council	30,000
Total	**$230,000**

Community Investment Initiative (B34)
Please provide me with a description of and the purpose of the following expenditures:
Professional services-$230,000 (what is this buying? Explaining the current year's $600,000 expenditure would also be useful to me)

Response:

Response is provided by Ann Wawrukiewicz, Financial Planning Analyst.

Please see the table below for information about the $600,000 in contracted professional services budgeted in the CII/CIS budget in FY 2011-12. Actual total year-end spending for these items is expected to be approximately $450,000.

Public Opinion Research	75,000
Strategic Communications	50,000
Direct Marketing/PSAs	125,000
Web/Email/Social Media	30,000
State Govt Relations Contract	20,000
Facilitation Consultant for Leadership Council	135,000
Project List Development (consultant)	50,000
Carry forward in Communications Funding from FY 2010-11	115,000
Total	**$600,000**

On page 11 of the 2011-2012 line item budget there is $500,000 allocated to the Recovery Rate Stabilization Reserve. This is not apparent in the proposed budget. How are you accounting for over-collection of disposal fees? As you know, this was the source for the NIN non-capital grants in the past and Councilor Hosticka and I are considering using these revenues for that purpose again. I would like a history of the funds assigned to this account and would like to know where those funds are recognized in the proposed budget.

Response:

Response is provided by Margo Norton, Director of Finance and Regulatory Services.

You are correct, the FY 2011-12 budget did continue the use of the "Recovery Rate Stabilization Reserve" label which has now been retired because of changes in the excise tax code. We now refer to it as the "Reserve for Future One-time Expenditures." We report on this every quarter in the financial report on the excise tax page. In looking across this line item you can see that the actual accumulation in the prior two years was zero.

In the proposed budget you can find this $500,000 and the anticipated accumulation for FY 2011-12 in Volume 2, page B-13, General Fund resources at $1.313 million. This represents the prior balance which turned out to be not quite $500,000, only $457,000, and an addition of $813,000, the estimated accumulation of the FY 2011-12 (current) year based on the second quarter report. As you may recall, we will not know the actual accumulation until sometime after June 30 when we close the books. Our theoretical estimate for FY 2011-12 was $1.4 million and had fallen by nearly half at mid-year.

On the expenditure side, we have committed the $457,000 to pay most of the Eastside Street car assessment, a one-time payment of an estimated $500,000. Originally we had expected to pay it in June 2011, but the City of Portland advises that assessment bills will not be available until about November 2012.

The budget proposes to apply the current year's accumulation next year for one-time expenses which include:

$200,000	restore Nature in Neighborhoods small grants (the purpose you mention in your question)
$200,000	fund a portion of the $331,000 in urgent capital at Glendoveer
$200,000	leverage sustainability upgrades not eligible for renewal and replacement
Balance	reserve for one-time in FY 2013-14 (amount of balance will not be confirmed until after June 30

1. **Special Appropriations, Elections**
   Volume 1, Page C-93, and Volume 2 line items: I am not following the election expenses in this year's budget. I understand the 'Reserved for Future Elections' goes down to $0 with this proposed budge. The explanation for $75K proposed seem hidden. There are Council elections and at times bond measures, and potentially an operations serial levy. What are the practical assumptions that were used to set this level? (For example: Is it assuming that a region-wide May 2013, FY12-13, election would not be billed to Metro until FY13-14?)

Response:

Response is provided by Kathy Rutkowski, Budget Coordinator.

The proposed budget for FY 2012-13 includes only the anticipated cost of election for three Council districts. No other region-wide election cost has been budgeted at this time. The chart below provides information about the previous election cycles.

Election Cycle	May 2008 FY 2007-08	November 2008 FY 2008-09	May 2010 FY 2009-10	November 2010 FY 2010-11	May 2012 FY 2011-12
Budget expense	165,750	165,750	350,000	350,000	75,000
Actual expense	334,132	272,339	116,067	49,892	TBD
Over / (Short) of budget	**($168,382)**	**($106,589)**	**$233,933**	**$300,108**	

The budget provides for election expenses for the elected offices – Council President, Councilors, Metro Auditor – on the cyclical basis. In addition, if the Council has taken action to place a measure on the ballot or if a referred measure is known to be on the ballot, the budget will also include an estimated cost for that measure. The FY 2012-13 budget includes only an estimate for the cost of election expenses for three Council districts.

Note: In January 2010, the method by which election expenses were allocated by the Counties to local jurisdictions was modified. This resulted in significant savings to Metro in prior elections. However, the method is now truly based on the number of items on a ballot. Metro's costs can also significantly increase if more regional items are placed on any one ballot.

Reserve for Future Elections

The Reserve for Future Elections was exhausted in FY 2011-12. The history is provided below.

	FY 2007-08	FY 2008-09	FY 2009-10	FY 2010-11	FY 2011-12
Beginning Fund Balance	0	290,000	183,411	183,411	133,411
Ending Fund Balance	290,000	183,411	183,411	133,411	0
Amount used during FY	**n/a**	**$106,589**	**$0**	**$50,000**	**$133,411**

On September 27, 2007 the Council adopted ordinance 07-1160B allocating approximately $6 million in one-time only reserves to a series of projects to be funded over a three year period. Included in the series of allocations was $290,000 to be set aside for a November 2008 regional ballot measure on conversation education. This became known as the "Reserve for Future Elections." The specific purpose of the reserve – a ballot measure on conservation education – never materialized. The reserve funding was redirected over a period of years as follows:

1. The November 2008 ballot included a regional measure for the Oregon Zoo and Animal Welfare general obligation bond. The election expenses for this particular ballot were significantly greater than anticipated - $166,750 budgeted versus $272,339 actual expense. The unexpected expense was funded by a reduction in the "Reserve for Future Elections" leaving a balance of $183,411.

2. As a balancing action in preparing the FY 2010-11 budget, the Chief Operating Officer proposed funding a portion of the election expenses for that year through a reduction in the "Reserve for Future Election." It was

initially anticipated that election expenses for the year would be approximately $350,000. However, a State of Oregon change in the allocation method of election expenses to local jurisdictions significantly reduced Metro's charge to approximately $50,000. This amount was funded through a reduction in the reserve leaving a balance of $133,411.

3. In FY 2011-12, the COO again proposed funding the year's estimated $75,000 in election expenses through a reduction in the "Reserve for Future Elections." In addition, during the budget review, the Council approved several amendments to the budget. These amendments were funded, in part, with the remaining balance of the reserve leaving a zero balance in the "Reserve for Future Elections" at the end of FY 2011-12.

2. **Special Appropriations, First Stop & One Willamette River Coalition**
   I looked for explanatory text on each of the special appropriations. Some of the line items on Page C-93 are not addressed in the Volume 1 summary document. I went back to the fy11-12 adopted summary document to compare investment/expenditure levels as well.
   First Stop isn't listed in the fy11-12 adopted summary document. (I recall it being an item we help fund but can't find any explanation in this document and since not listed last year, I'm really wondering about it.) Is it an every-other-year payment or what? It would be helpful to indicate/footnote some timing information.
   One Willamette River Coalition, I could not find an explanation to go with this expenditure either – small that it is.

Response:

Response is provided by Ann Wawrukiewicz, Financial Planning Analyst.

Last year's special appropriations narrative included only the larger sponsorships, those of $25,000 or more; First Stop Portland was funded at $15,000. At this time, this sponsorship is expected to be annual, pending Council approval.

During the FY 2011-12 budget process, Financial Planning prepared a memo for Councilors that included detail on all special appropriations. Excerpted below are the paragraphs regarding First Stop Portland and the Willamette Falls Locks Coalition (referred to as the One Willamette River Coalition in the FY 2012-13 narrative).

<u>First Stop Portland: $15,000</u>

First Stop Portland, a Portland State University program, provides planning and logistical support for visiting delegations interested in learning about Portland's sustainable policies and practices. First Stop Portland hosts groups from around the world seeking to learn about sustainable, livable cities and urban development. During these visits, delegations see firsthand the impacts of Portland's commitment to central city vitality, transportation solutions, sustainable development, building diverse economies, and community engagement. Through Study Tours, mobile workshops and presentations, First Stop Portland connects visiting community leaders, national and international, with Portland's business, academic and political leaders. At one time staff in Communications and the Council Office performed these services. The shift of this service from staff to First Stop Portland has allowed us to reduce administrative staff needs over the past few years and also allows us to build relationships with the business community by serving on the board and participating in the visits.

<u>Willamette Falls Locks Consortium : $1,500 per year for three years</u>

Metro is asked to join the Willamette Falls Locks Consortium, an advisory group to the Willamette Falls Heritage Foundation. The purpose of the consortium is to work together to ensure the locks remain open to the public, to advocate for funding for various upgrades and repairs and to promote use of the locks with the public. There is a connection to Metro's interest from a transportation perspective for moving goods, from a recreation perspective for boating and kayaking and from a heritage perspective because of the significant Metro open space holding in the Willamette Falls vicinity. The agreement of the members is intended to provide a stable source of funding over the next three years for supporting the activities of the consortium. The agreement provides a budget of $18,000 per year for the next three years to maintain communications with the U.S. Army Corps of Engineers and other consortium members, convene an advisory board to address long-term policy and funding issues, coordinate interests of the consortium with state agencies and Congressional representatives and organize periodic promotions with the public.

3. **Opportunity Fund Expenditures FY11-12: What are the expenditures to date (aka what is the current run-rate?) In a time of reduction, I am asking myself the question 'Can we afford to maintain this level?' Last year at least we had discussion about federal grant opportunities (ex. Tiger, Regional Housing Strategy-HUD grant) – so what is the forward thinking for the $500K set-aside? Perhaps it is time to clearly appropriate but clearly not authorize?**

Response:

Response is provided by Kathy Rutkowski, Budget Coordinator.

History of Opportunity Account

	FY 2007-08	FY 2008-09	FY 2009-10	FY 2010-11	FY 2011-12
Proposed Budget Amount	500,000	500,000	500,000	0	500,000
Adopted Budget Amount	500,000	100,000	0	0	211,411
Amended Budget Amount	3,135	164,000	0	0	78,496
Amount used during FY	**$496,865**	**$336,000**	**$500,000**	**$0**	**$421,504**

FY 2007-08 (first year of Opportunity Account):

Mid-Year: Council adopted ordinance 07-1160B, which allocated approximately $6 million to a series of projects over a three year timeframe. The following projects were identified as funded by the Opportunity Account:

a. Transportation Speaker Series - $18,000
b. Nature Friendly Design Competition - $30,865
c. Earth Advantage Sponsorship - $50,000
d. Parks and Greenspaces priorities and implementation plan - $150,000
e. Conservation Education ballot measure research - $150,000
f. Regional Energy use mapping - $8,000
g. Bike Model Refinement - $50,000
h. Regional Affordable Housing Revolving Fund - $40,000

FY 2008-09:

During the Council budget review, the Council adopted an amendment to use up to $400,000 of the Opportunity Account as match for the diesel retrofit project.

Mid-Year: Council adopted ordinance 09-1209. The ordinance canceled the match for the diesel retrofit project returning it to the Account but made a new allocation of $336,000 for the integrated mobility strategy (now referred to as active transportation).

FY 2009-10:

During Council review of the proposed budget the Council made the following amendments using the Opportunity Account as the funding mechanism:

a. $45,000 for conservation education
b. $218,000 for regional system (connecting green)
c. $92,500 for Nature in Neighborhoods grants
d. $40,000 for Lone Fir maintenance/improvements
e. $67,000 for infrastructure financing limited duration position
f. $37,500 partial funding for climate change

FY 2010-11:

The Chief Operating Officer proposed eliminating the Opportunity Account to assist in balancing the budget.

FY 2011-12:

During Council review of the proposed budget the Council made the following amendments using the Opportunity Account as the funding mechanism:

a. $135,000 for climate preparedness
b. $100,000 for Phase 1 of Tualatin River Water Trail effort
c. $53,589 – balance needed to combine with Risk Management and elections savings to fund other approved Council amendments including Development Opportunity Fund, eco-employments, brownfields and parcelization.

Mid-Year: Ordinance 11-1266, $57,915 for Blue Lake Park disc golf project.

Reserved for future expense: The Council received a mid-year request to support the Metro Export Initiative through a participating membership of $25,000 per year for three years. The Chief Operating Officer has proposed to reserve $75,000 from the current Opportunity Account balance to fund a three year commitment, beginning in FY 2012-13, subject to Council budget approval.

4. **Debt Review:**
   a. **Table on page B-39 of Volume 1: I understand the debt schedules as documented in section D of Volume 2. Taking the info forward to the table on page B-39 of Volume 1... With the intention of issuances in 2015 for the remaining Natural Area and Zoo bond programs, I estimate that the level would just back up to $240M and the valuation curves would change. Can you show me what the estimated debt level would look like to include those possible issuances? I had been thinking about the possibility of a new regional investment bond in forward years (perhaps in 2015 or beyond) given the significant investment needs in the region. The current chart gives me a different picture than I think 2015 will actually look like given the intended new issuances.**

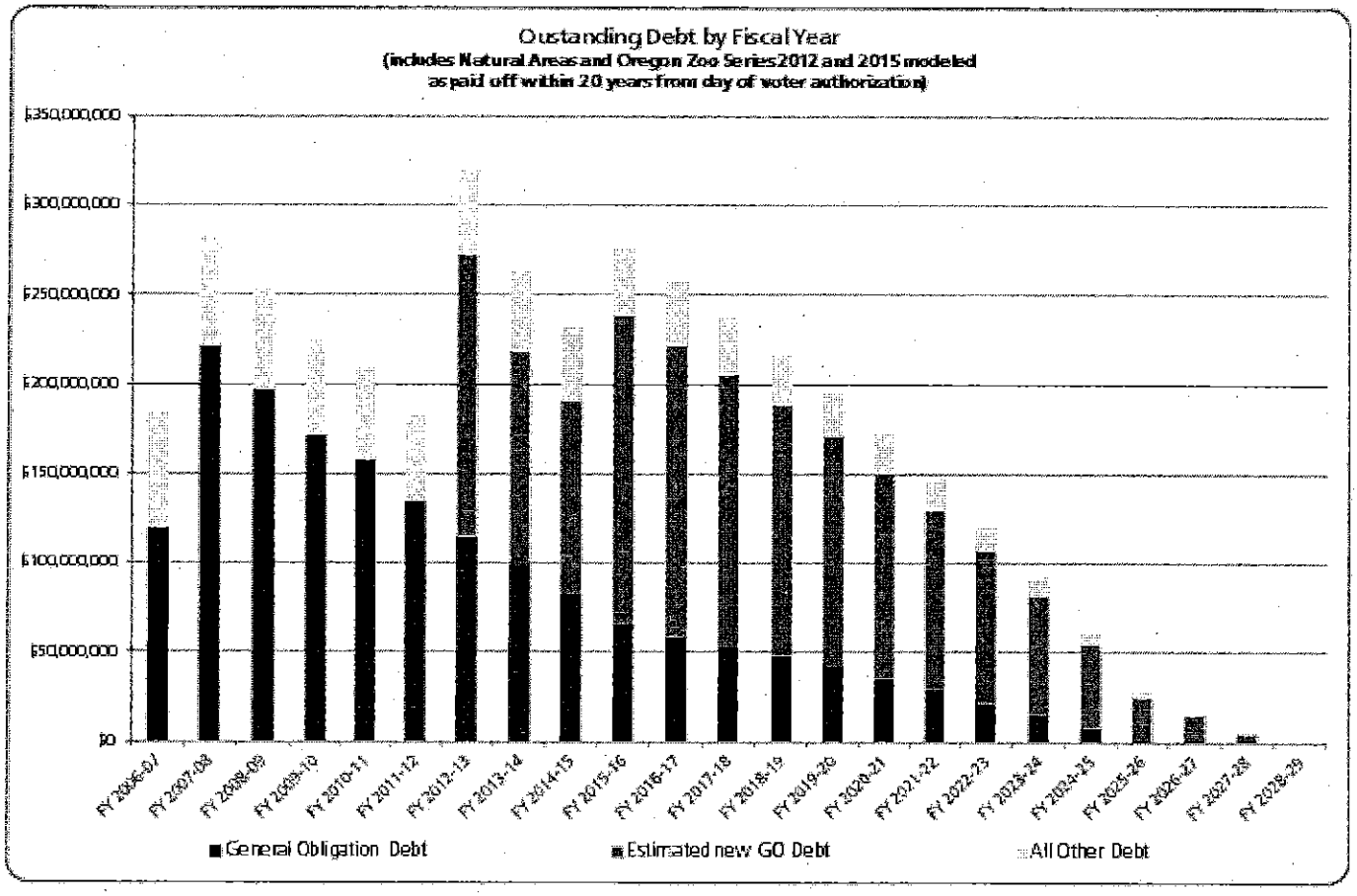
Response:

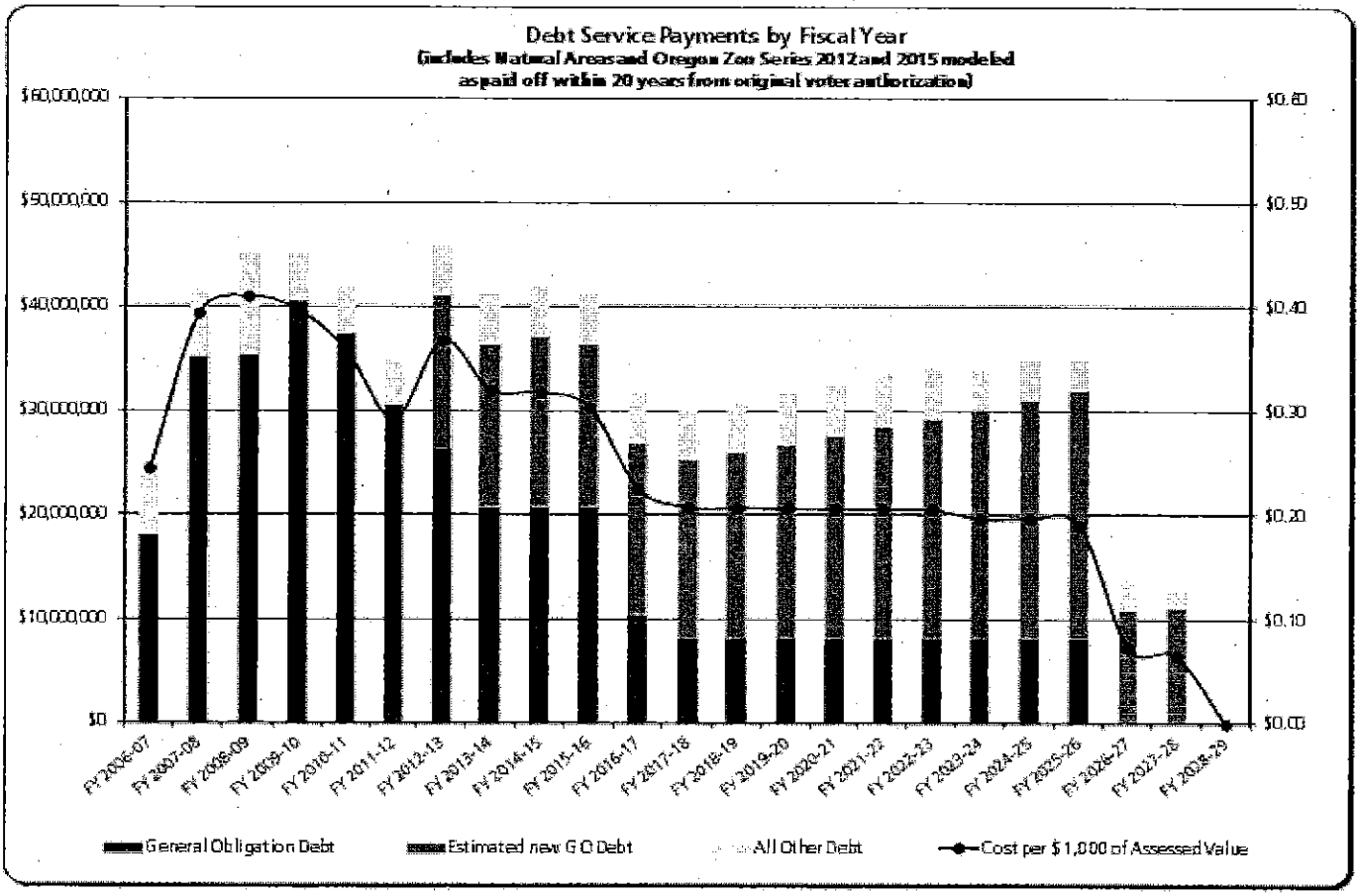
Response is provided by Kathy Rutkowski, Budget Coordinator.

When the Council, sitting as Budget Committee, approves the budget it takes two specific actions: 1) it sets the maximum property tax levy amount for the ensuing year, and 2) it directs the COO to transmit the approved budget to the Multnomah County TSCC. Once the property tax levy is set at the time of approval of the budget, it cannot be increased. However, the tax levy may always be decreased at the time of adoption in June.

When the proposed budget was being prepared we were still in discussions with our Financial Advisor about the structure of the upcoming bond sale. Given the limitations on increasing the tax levy after approval of the budget and the timing of the sale, Finance staff determined the best course of action was to provide maximum flexibility in the Proposed Budget to meet any structural contingencies, anticipating that a request to modify the levy amount would be presented to Council following the actual sale and prior to final budget adoption. The Proposed Budget provides for a levy equivalent to the maximum levy rate pledge to the voters - $0.19/$1,000 of assessed value for the Natural Areas bonds and $0.09/$1,000 of assessed value for the Oregon Zoo Infrastructure and Animal Welfare bonds. The tables on page B-39 and B-40 of Volume 1 of the Proposed Budget assume the Series 2012 bonds are paid off over a time-frame that uses the same maximum levy rate assumption. It does not include the impact of the issuance of the remaining balance of either authorization in 2015.

As we are now closer to the actual sale and after additional discussion with our Financial Advisor we are considering a modified approach to a traditional debt structure. A traditional structure would provide for either level dollar or level rate debt service repaid over twenty years from the date of issuance. We are recommending a level rate structure such that all bonds under the authorization, regardless of when sold, are paid off within twenty years from the date of the first issue. The following charts model total outstanding debt and outstanding debt service payments by fiscal year including both the 2012 and 2015 debt issues. The estimated levy rate would be $0.12/$1,000 of assessed value for the Natural Areas bonds and $0.06/$1,000 for the Oregon Zoo bonds. We are hopeful that the final sales price will be close to this model.


Outstanding Debt by Fiscal Year
(includes Natural Areas and Oregon Zoo Series 2012 and 2015 modeled as paid off within 20 years from day of voter authorization)
$350,000,000
$300,000,000
$250,000,000
$200,000,000
$150,000,000
$100,000,000
$50,000,000
$0
FY 2006-07
FY 2007-08
FY 2008-09
FY 2009-10
FY 2010-11
FY 2011-12
FY 2012-13
FY 2013-14
FY 2014-15
FY 2015-16
FY 2016-17
FY 2017-18
FY 2018-19
FY 2019-20
FY 2020-21
FY 2021-22
FY 2022-23
FY 2023-24
FY 2024-25
FY 2025-26
FY 2026-27
FY 2027-28
FY 2028-29
General Obligation Debt
Estimated new GO Debt
All Other Debt


Debt Service Payments by Fiscal Year
(includes Natural Areas and Oregon Zoo Series 2012 and 2015 modeled as paid off within 20 years from original voter authorization)
$60,000,000
$50,000,000
$40,000,000
$30,000,000
$20,000,000
$10,000,000
$0
$0.60
$0.50
$0.40
$0.30
$0.20
$0.10
$0.00
FY 2006-07
FY 2007-08
FY 2008-09
FY 2009-10
FY 2010-11
FY 2011-12
FY 2012-13
FY 2013-14
FY 2014-15
FY 2015-16
FY 2016-17
FY 2017-18
FY 2018-19
FY 2019-20
FY 2020-21
FY 2021-22
FY 2022-23
FY 2023-24
FY 2024-25
FY 2025-26
FY 2026-27
FY 2027-28
FY 2028-29
General Obligation Debt
Estimated new G O Debt
All Other Debt
Cost per $1,000 of Assessed Value

4. **Debt Review:**
   b. **MERC – Volume 2 page D-10 as a reference, got me thinking, is there a summary somewhere of what debt obligations Metro has just for the 3 venues of Expo, OCC and PCPA? I'm particularly curious about ratios of debt to operating revenue. Any info?**

Response:

Response is provided by Kathy Rutkowski, Budget Coordinator.

MERC Outstanding Debt – All of Metro's outstanding debt is disclosed in the budget document under the Debt Summary sections. Metro has two outstanding bond issues related to MERC venues:

- Oregon Convention Center general obligation bonds
  - o Source of debt payment = dedicated property tax levy
  - o Principal outstanding as of June 30, 2012 = $5,290,000
  - o Maturity Date = January 1, 2013
  - o Average annual debt service payment = $5,554,500
  - o Average operating revenue including TLT and VDI (last 4 years) = $26,490,000
  - o Ratio Average debt service to average operating revenue = not applicable*

  * this debt is paid by property taxes, not operating revenues.

- Full Faith & Credit obligation bonds for Expo Center Hall D
  - o Source of debt payment = Expo Center operating revenues with underlying pledge of Metro general revenues
  - o Principal outstanding as of June 30, 2012 = $11,560,000
  - o Maturity Date = December 1, 2024
  - o Average annual debt service payment = $1,180,000
  - o Average operating revenue (last 4 years) = $5,565,000
  - o Ratio Average debt service to average operating revenue = 21.2%

In addition, the Oregon Convention Center has committed to a ten year interfund loan from the General Fund to pay the City of Portland LID assessment for the Eastside Streetcar project. The interfund loan is in lieu of a 10-year or 20-year loan agreement with the City of Portland at much higher interest rates. The principal of the loan is estimated to be $2.2 million to be repaid in 10 equal installments beginning June 30, 2013. Interest will be repaid at an amount estimated to be the average monthly Metro pooled cash investment rate. The loan will be repaid by June 30, 2022.

Finally, all other debt for the Visitor Venues is held by and the obligation of the City of Portland. This includes the 2003 expansion of OCC and a small amount for renovations at PCPA. The obligation is not paid from the operating revenues of the facilities.

5. **Community Investment Initiative:**
   a. **We have invested a considerable amount of money in this one program in the last few years. While I remain hopeful that we will see some results soon, it has been too long without appreciable results and now this proposed budget has a significant ask of $639K in Fy12-13. I need a budget and spending review fo. this program. Perhaps this is an area where we appropriate but clearly not authorize without additional clear objectives, plans and review/scrutiny as we did in fall 2007 with various proposals for the 'Making a Great Place' program (both Planning-Development and Communications.) Yes I have gone through Volume 1 & 2 thoroughly and have been through numerous relationship oriented briefings. We also have different information for historical spending on CII with this budget than we have gotten with past budget decision-making/approval. In this budget, there are no clear program objectives and there is no Metro workplan that I know of, so it's seems too mysterious for such a significant level of expenditure. Specific questions include:**
      i. **I need to better understand what we are buying for this $639K level of investment.**

Response:

Response is provided by Ann Wawrukiewicz, Financial Planning Analyst.

	FY 2010-11		FY 2011-12		FY 2012-13
	Budget	**Actuals**	**Budget**	**Projected Spending**	**Budget**
Community Investment Initiative	3.85 FTE		2.6 FTE		3.5 FTE
Personnel Services (includes project management, admin and policy support, and GIS support from the Data Resource Center)	338,£84	290,000	302,812	300,500	390,545
Materials and Services					
Leadership Council Support and Meeting Expenses	65,000	22,300	60,000	26,000	15,000
Contracted Professional Services					
Public Opinion Research and Communications		11,000			115,000
State Govt Relations Contract	75,000		20,000		25,000
Facilitation Consultant (and program technical support in 12-13)		80,000	135,000	135,000	60,000
Project List Development (consultant)	50,000		50,000	15,000	30,000
Investment ROI Metrics	100,000				
Other, including printing, travel, training	10,000	15,000		20,000	3,000
Subtotal	**$638,884**	**$418,300**	**$567,812**	**$496,500**	**$638,545**
Community Investment Strategy (Communications)					
Personnel Services (incl. temps), to support Opt In work	-	35,000	-	62,500	
Materials and Services					
Contracted Professional Services					
Public Opinion Research	100,000		75,000		130,000 *
Strategic Communications	60,000		50,000		
Direct Marketing/PSAs	75,000	72,000	125,000	190,000	
Web/Email/Social Media	50,000		30,000		
Carryforward in Communications Funding (Opt In)			115,000		
Subtotal	**$285,000**	**$107,000**	**$395,000**	**$252,500**	**$130,000** *
Total	**$923,884**	**$525,300**	**$962,812**	**$749,000**	**$638,545** *

These line items ultimately were merged into the Opt In project

* Communications' Opt In work for FY 2012-13 is not funded by CII reserve

Estimated authorized funds remaining at June 30, 2013	
Subject to Council direction after receiving CII recommendations	**$393,455**

5. **Community Investment Initiative:**
   a. **Specific questions include:**
      ii. **Volume 1, page A-12 " The proposed budget includes the third year of a multi-year commitment to the Community Investment Initiative ($639,000) – This doesn't match up with the Volume 2 detail of $1,032,000 – please explain.**

Response:

Response is provided by Ann Wawrukiewicz, Financial Planning Analyst.

The $1,032,000 represents the remainder of the initial 3-year reserve for this project at the beginning of the year (Vol 2, B-13). Of this, $638,500 is budgeted in FY 2012-13, and $393,500 remains in the reserve, available for CII work in future years, pending Council approval (Vol 2, B-107).

5. **Community Investment Initiative:**
   b. **Volume 1, Page A-16 "In an effort to increase transparency, the Community Investment Initiative program budget includes only its direct costs." I don't believe that I am internalizing this the way you are hoping – because it causes me to be mindful of hidden 'indirect' expenditures. Please help me better understand.**

Response:

Response is provided by Ann Wawrukiewicz, Financial Planning Analyst.

As the Chief Operating Officer noted in her presentation to the Council on April 19, 2012, the use of the word "direct" is intended only to differentiate CII costs from Communications' Opt In costs. As part of the overall Community Investment Strategy, Opt In costs were included in the CII budget in FYs 2010-11 and 2011-12. For FY 2012-13, the COO has recommended that we be more transparent about Opt In. She has proposed separating it from the CII budget and moving it directly to Communications. The Communications budget will pay for the basic application and maintenance of the panel; user departments and groups, including CII, will pay the direct costs of the surveys from their individual budgets.

5. **Community Investment Initiative:**
   c. **Volume 1, page B-14, "The FY 2012-13 budget sets aside $1.03 million for completion of the Community Investment Initiative." Sets aside??? – I am not following this. Show me through Volumes 1 & Volume 2 detail please.**
   d. **Volume 2, detail:**

FY 10-11 Actual	**$2,821,907**	
FY 11-12 Adopted & Amended	**$1,838,699**	
Subtotal		**$4,660,606**
FY 12-13 Proposed	**$1,032,000**	
Grand Total		**$5,692,606**

Hmmmm: Different numbers than previous budget reports. I have no explanation to provide as a Councilor for what we have as result of $4.6M let alone what we might have with a total of $5.69M.

Response:

Response is provided by Ann Wawrukiewicz, Financial Planning Analyst.

The numbers you have noted in your question represent beginning fund balance in the CII reserve in each year. Fund balances do not represent actual spending, nor are they additive. The table below tracks the fund balances through each year, and includes a line showing actual spending:

	FY 2010-11	FY 2011-12	FY 2012-13
Adopted Beginning Fund Balance	$2,821,907	$1,838,699	$1,032,000
Project Spending	525,300	749,000*	638,545**
Underspending and reserves returned to General Fund balance via budget process.	457,908	57,699	
Next Year's Beginning Fund Balance	1,838,699	1,032,000	
Ending Fund Balance			393,455

*Projected spending at 6/30/2012

**Budgeted spending in FY 2012-13

6. **Reduction in force**
   The level of reduction in this budget is more significant than in past budgets. Given the environment this year, I practiced a different level of probing (changes year to year). I checked into increases in various proposed expenditure line items across all agency areas/department – specifically Staff increases, Travel, Staff Development, Contracted Professional Services, Other Purchased Services, Sponsorships. There are levels that I would like to better understand, best handled in a one on one Q&A session, versus type out here.

7. **Various – Trying to understand explanations:**
   a. **Direct costs versus fixed costs: Is there a definitions table someplace? (Volume 1, page A-15 "Metro has developed new fees to recover its direct costs and is proposing to recover a portion of the fixed costs in FY 2012-13."**

Response:

Response is provided by Margo Norton, Finance and Regulatory Services Director, and Doug Anderson, Solid Waste Policy and Compliance.

The budget message described fees that the Chief Operating Officer had been able to impose during the current year to recover the contract costs (direct costs) of handling the mixed yard debris and food waste coming through the transfer stations following the implementation of the City of Portland's residential composting program. Under current Metro Code the Chief Operating Officer can set rates for recoverable solid waste administratively only if she follows a specific formula set forth in code; rate making more generally is reserved for the Council. As the Council learned in the Solid Waste Rate presentation, for FY 2012-13 we are proposing to revise the code formula so that even when the rates are set administratively, they will be set to recover all costs, including transaction costs, and appropriate portions of fixed operating costs of the stations, and general and administrative costs.

7. **Various – Trying to understand explanations:**
   b. **MERC, Volume 1, A-18: "In addition the Commission recommended using $197,000 in strategic reserves to support the leadership transition while sales and marketing efforts are retooled." I'm not quite following… Is this specific to Expo is this related to all 4 venues?**

Response:

Response is provided by Cynthia Hill, MERC Budget Coordinator.

The MERC Commission is recommending use of $197,000 for Expo operations. The Expo Center, under new leadership, is taking an aggressive approach to generating new streams of revenue through a staff reorganization and increased investment in sales and marketing. The Commission approved the use of the Strategic Reserve for one year to support this leadership transition and sales marketing efforts, recognizing that these efforts will not generate immediate results and may take a year to see the direct benefits.

7. **Various – Trying to understand explanations:**
   c. **Volume 1, Page C-23 – First major bullet on page, starting "Better aligned… by:" the 'by' list seems to be missing.**

Response:

Response is provided by Ben Ruef, Planning and Development and Research Center Interim Finance Manager.

Good catch. We failed to delete fully this text left from the prior year's publication. At the time it related to completion of the urban and rural reserves and Regional Transportation Options (RTO) plans which are now complete. We will remove it in the adopted version.

7. **Various – Trying to understand explanations:**
   d. **Volume 1, Page C-23 (FY 11-12) and then C-24 (FY12-13), I know you try to be brief in this budget sections, but I am concerned that the budget explanations are not given credit to the level of work that Metro provides in participating in local planning efforts that are NOT Metro initiated. (You support a two way street not just a one-way of the locals partners doing work that Metro would like to see.) For example on the bullet "Partnered with Cities and Counties…" the TV Hwy Corridor Plan was local initiated (not regional and not Metro funded) yet the Metro participation supports the objective of "Making the most of what we've got." I know from a prior year conversation that at least 1 regional partner examined Metro budget docs for Planning & Dev department funding info – so my suggestion is to make sure they see the investment you make in supporting them too (the two way street.) (Besides there is unused white space on page C-25)**

Response:

Response is provided by Robin McArthur, Planning and Development Director.

This is a good suggestion. In the adopted budget we will plan to amend the text under the broader heading of Partnered with cities and counties : Partner with communities on locally initiated projects (e.g., TV Highway Corridor Plan, redesigning main streets) to offer financial and/or technical assistance as requested to foster great places around the region.

7. **Various – Trying to understand explanations:**
   e. **Volume 1, Page C-23-25: No mention of the Opportunity Mapping project with CLF (Equity Atlas)– which I think is a significant (deliverable) objective for reflection in either the Research Center or in Planning and Development given the information that I anticipate learning about equity and diversity throughout the region. I expect it will be published in September which is an accomplishment in of itself but getting a majority of us elected officials to understand what this tells us and what we might want to consider differently is a another potential significant accomplishment. Food for thought.**

Response:

Response is provided by John Williams, Deputy Planning Director.

Great point. We are excited about this work which will be completed this summer and unveiled for the public at the Equity Summit in October. We will amend the text of the Opportunity Mapping Project to reflect the need to do outreach with the Council and community partners to maximize the use of the products.

7. **Various – Trying to understand explanations:**
   f. **I need a MTOCA refresher (Metro Tourism Opportunity & Competitiveness Account) specifically where the revenue stream comes in and to make sure I follow the budget mechanics.**

Response:

Response is provided by Margo Norton, Finance and Regulatory Services Director; and Cynthia Hill, MERC Budget Coordinator.

MTOCA, the Metro Tourism Opportunity and Competitiveness Account, is an annual request from the Oregon Convention Center for Metro general fund support for a specific project or projects to enhance OCC's competitiveness. Its history began in 2004 with a 50 cent per ton dedication from excise tax collected on solid waste disposal (Ordinance No. 04-1052). The Council's enabling resolution (Resolution 04-3494A) identified three primary goals for MTOCA:

Goal #1: Targeted capital investments in the Oregon Convention Center's physical plant that yield demonstrable marketing advantages [a headquarters hotel was a specifically identified substrategy].

Goal #2: Assist the Visitor Development Fund with Oregon Convention Center facility costs.

Goal #3: Maintain the Oregon Convention Center in First Class condition.

The per-ton excise tax dedication was removed in 2006 (Ordinance No. 06-1116), distinguishing the Metro Code as the mechanism for collecting the money from the annual budget process as the mechanism for allocating the money. Following this uncoupling, Metro has continued to provide discretionary General Fund support to OCC as a general expense without regard to specific tonnage.

Requests are made by the MERC Commission and decided by the Metro Council. Past requests have supported capital projects and amenities designed to keep OCC refreshed, green and up to date. In 2008 and 2009 MTOCA money supported the Headquarters Hotel project. For FY 2012-13 the request ($518,633) is to support efforts to secure a dedicated room block.

The Chief Operating Officer identifies a specific MTOCA project in the proposed budget. For FY 2012-13 this was based on the Council's identification of a room block as a Council priority. The budget mechanics are a transfer from the General Fund to the MERC Fund where expenditures are restricted to the approved project.

7. **Various – Trying to understand explanations:**
   g. **Volume 2, Page B-67 & 68, Oregon Zoo (Volunteer Resources Division)**
   The personnel services $ subtotal for this division has increased 72% over the prior year with the total budget for this division increasing by 69.8%. I would like to have a better understanding of what this division does and the budget. (note: I am not asking for ROI level info, rather what is it that this division does and why the jump this budget year for this work?) The temporary employees in the volunteer division increased substantially – temps-volunteers... seems odd, please explain.

Response:

Response is provided by Kim Smith, Oregon Zoo Director; Joanne Ossanna, Oregon Zoo Finance Manager.

The large increase in the Volunteer Services personnel budget from FY 2011-12 to FY 2012-13 represents only a transfer of functions. It is related to moving the UNO (Urban Nature Overnights) and ZAP (Zoo Animal Presenters) programs and related budget from the Conservation division to Volunteer Services division. The details of this transfer include moving 2.0 FTE Education Specialist IIIs for the UNO Program Coordinator and ZAP Program Coordinator for a total of $121,674, moving $163,017 in temporary employee budget that includes $25,986 UNO program and $137,031 ZAP program and moving $23,000 in overtime for the ZAP and UNO programs.

What the Oregon Zoo Volunteer and Youth Programs (Volunteer Resources Division) does:

Zoo Animal Presenters (ZAP)

The Zoo Animal Presenter program is a paid, three-year internship program at the Oregon Zoo. Each year it trains about 30 low-income teenagers who head into the community to teach and serve. In the first year, ZAP members provide live animal presentations to low-income children and families. In the second year, they are the counselors in the Urban Nature Overnight Program (see below). In the third year, they conduct field work at Metro natural areas, waste reduction education at zoo camps and help in the zoo butterfly lab.

Urban Nature Overnights (UNO)

Staffed by second year ZAP members, the Urban Nature Overnights program partners with agencies who serve low-income youth to offer third to fifth graders a chance to experience the natural world, develop an appreciation of public lands and learn about wildlife conservation and stewardship issues. Of the 300 youth served in the school year and 100 in the summer, more than half have never been camping before.

Youth Volunteer Programs

- ZooTeens: 320 high school volunteers here in the summer to provide interpretation on zoo grounds.
- Leadership Corps: 100 ZooTeens who commit to more in-depth educational experiences at the zoo year-round, and who volunteer for hands-on conservation activities in the community.
- Family Farm: short- and long-term experiences in animal care and presentation for ZooTeens, Leadership Corps teens, and youth in the community. We also partner with several schools to provide school-to-work career development year round.

Adult Volunteer Programs

- ZooGuides: 400 regular, ongoing adult volunteers who serve in more than 50 programs
- Project volunteers: volunteer regularly in an area of expertise (e.g. divers)
- Interns: unpaid educational experiences for youth and adults
- Community volunteers: community members who support events at the zoo
- Group volunteers: corporate and community groups who do horticulture projects
- Mandate volunteers: help with specific projects
- ZooAmbassadors: an opportunity for families (accepts ages 10-110) to volunteer regularly at a seasonal zoo exhibit

Total volunteers in 2011: 1400. Total hours: 145,500. FTE equivalent: 70.

7. **Various – Trying to understand explanations:**
   h. **Volume 2, Page B-13, Line item 'Reserved for Future Planning Needs' is that where the Development Opportunity Fund $200K shows up? Where does it show up in organization detail?**

Response:

Response is provided by Kathy Rutkowski, Budget Coordinator; and Ben Ruef, Planning and Development and Research Center Interim Finance Manager.

The Reserved for Future Planning Needs is estimated carryover from FY 2011-12 of several projects:

- $6,940 for Parcelization
- $50,000 for Eco efficient employment
- $20,000 for Brownfields
- $425,546 for Development Opportunity Fund

In addition, another $200,000 in new funding from the General Fund has been provided for the Development Opportunity Fund for a total of approximately $625,000 in FY 2012-13. The entire amount is budgeted under line item 5240 – Contracted Professional Services in the Planning and Development budget.

8. **Look ahead type questions**
   a. **Once the HBA appeal to the OR Supreme Court is done (before end of FY12-13), I assume that the "Community Planning and Development Grants Review Committee" will need to be (re) convened by the COO, which involves some convening costs – though small. I assume FY13-14 timeframe, but it got me wondering, which detail line item does that sort of activity/work fall under?**

Response:

Response is provided by Margo Norton, Director of Finance and Regulatory Services, and John Williams, Deputy Planning Director.

Community Planning and Development Grants, funded by the construction excise tax, are budgeted in the General Fund in General Expense/Special Appropriations. The amount budgeted reflects the continuing payments for both grants funded by the original $6.3 million tax as well as the grants funded under the first round of Community Planning and Development Grants ($3.7 million).

Upon successful resolution of the litigation, we expect to reconvene the Community Planning and Development Grants Review Committee and do a variety of other work to support the next grants. The Land Use Planning section within the Community Development division staffs this as part of its ongoing work.

8. **Look ahead type questions**
   b. **UGR: The next UGR work will be 2009 + 4-5 years = 2013 or 2014; Do we have the performance model ready to evaluate against the 6 desired outcomes? Between Resource Center, page C-32, 2nd bullet and maybe something in Planning & Dev, this may be covered and I didn't internalize it.**

Response:

Response is provided by John Williams, Planning and Development Deputy Director.

The next Urban Growth Report will be due by the end of 2014, so we would anticipate work beginning in FY 2013-14. Our game plan has been to simplify this work in keeping with Council direction to focus on implementation, and to incorporate the UGR more fully into a comprehensive performance measurement program targeted at policy decisions we make. We will develop a work program for this once LCDC deliberations on the 2011 growth management decision are complete.

9. **Detail questions = later**
   I have a bunch of detail questions, points that I am not sure I understand what is written, but these questions are not necessary for the budget approval step in May. I'll ask my policy coordinator to help me get closure on this set.

CHAPTER 2

TRANSPORTATION: FITTER VEHICLES, SMARTER USE

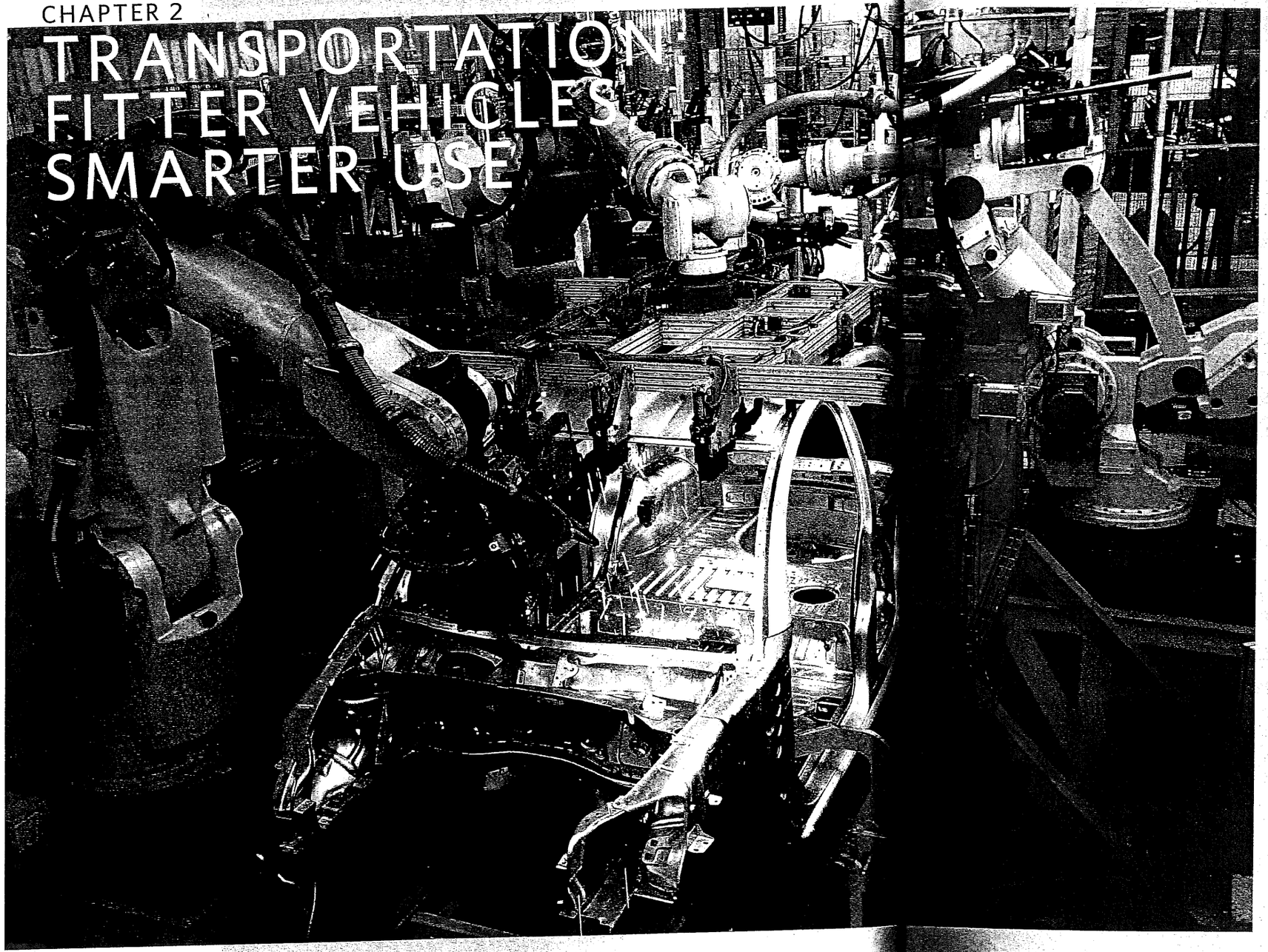


FIG. 2-1.

CHAPTER HIGHLIGHT

- In 2050, superefficient autos, trucks, and planes, far more productively used, need three-fourths less fuel and no oil and have less life-cycle cost than the vehicles of today. Yet they provide 90% more automobile-miles, 118% more truck-miles, and 61% more airplane seat-miles with uncompromised convenience, safety, and performance.
- Radical efficiency enables alternative propulsion and fuels, transforming vehicle manufacturing for breakthrough competitive advantage, while customers save money and mobility options expand. Society eliminates oil dependence, reducing many security and business risks.
- Oil not needed saves $3.8 trillion (in 2010 net preset value).
- Vehicle manufacturers and suppliers, chemical and electronics industries, fleet operators, entrepreneurs, real-estate developers, electric utilities, farmers and foresters.
- Innovative state, regional, or federal policies can remove barriers to buying superefficient vehicles and using them in smarter ways—without new federal taxes, subsidies, mandates, or laws (with a minor exception about truck weight limits[51]).

Whatever you can do, or dream you can, begin it. Boldness has genius, power, and magic in it.

—JOHN ANSTER, 1835, LOOSELY PARAPHRASING GOETHE'S FAUST, 214–30

The United States burns 13 million barrels of oil a day driving to work, shuttling kids to soccer games, hauling cargo, jetting to meetings and vacations, and keeping its vast transportation system humming. The costs of this use are huge and often hidden. They include oil spills, air pollution, climate risks, and a billion dollars a day plucked from Americans' pockets to buy petroleum from other countries, some of them unfriendly.

Yet burning that oil is simply unnecessary, and the money is largely misspent. We can imagine a world where spacious, peppy, ultrasafe autos sip fuel at 125–240 miles per gallon, but they need no gasoline; where heavy trucks haul goods along the interstates using a third the fuel they do now, but they need no diesel fuel; where planes use several-fold less fuel, but they need no oil either.

This isn't just a dream. It's a clear pathway that requires no technological miracles, only the continued development and adoption of innovations already well under way. Going down this pathway is not just an option but an imperative, because the transportation sector is in one of those rare periods of transformation. Now is the time when smart, light vehicles could take over the roads and skies, radically changing the world's biggest businesses.

The combination of better vehicles and smarter use would bring huge benefits to society—and to the companies that lead the way. Transportation is now America's number two consumer cost after housing, totaling $740 billion in 2009—17.6% of household expenditures. Yet the 13 million barrels of oil (fig. 2-2), roughly a billion dollars' worth, that keep America moving each day are mostly wasted.

Eliminating that waste is a multi-trillion-dollar business opportunity—not just for companies that manufacture vehicles, but also for suppliers innovating new materials and processes, and for investors who get in early and wisely.

If we do this right, we'll make America stronger and safer by keeping that billion-dollar-a-day oil-import cost at home. We'll be less buffeted by volatile oil prices and less anxious to defend access to oil. And if America, which put the world on wheels and wings, sets the pace and pattern for transport innovations in the next stage of global development, we could help head off the nightmare of an auto-choked but oil-starved world.

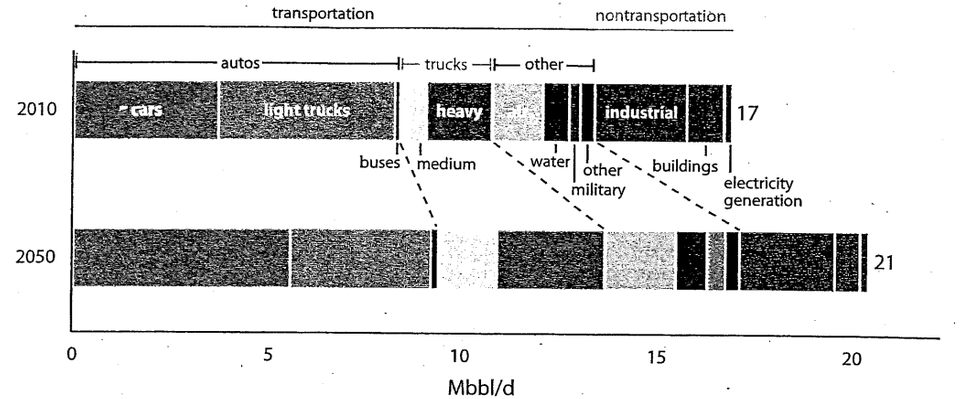


FIG. 2-2. U.S. oil use in 2010 and the U.S. Energy Information Administration's 2035 projection extrapolated to 2050 (our base case). (Only uses that burn oil are shown—not uses of oil as a raw material.) In 2010, transportation used 71% of U.S. oil and was 94% oil-fueled; the rest was 3% biofuels and 3% natural gas to run gas pipelines. Later chapters describe how to eliminate oil's nontransportation uses.[52]

This isn't to say that creating a better, oil-free world of transportation will be easy. For most auto buyers, and until lately some truck operators, fuel efficiency and fuel costs have historically been minor considerations. Up-front costs loom large for individuals, while individual benefits can be small: the fuel savings from switching even to an all-electric auto, though important over years, would barely buy a daily latte, inspiring little sense of urgency. Individual transportation modes often present advantages over public transit, as do road- and air-based shipping over rail- and water-based shipping. And the current pattern of sprawl and traffic congestion is firmly entrenched, thanks to subsidies, mandates, and Americans' own choices. That's why this transformation needs and merits both an extra initial nudge and fairer competition.

The ever graver consequences of our oil addiction leave us little choice. We must design and use our vehicles differently, transforming industries in the process. We can do it, because the technological path is clear, the business case is compelling, and we know new ways to use carefully crafted and light-handed public policies to bust barriers. If we do succeed, the benefits—to customers, to companies, and to society as a whole—will be vast and enduring.

DESIGNING AND BUILDING AUTOS DIFFERENTLY

The key innovation behind this transformation will be a shift to ultralight but ultrastrong autobodies, made of advanced materials. Not only will these bodies be simpler and cheaper to manufacture, they will also trigger snowballing weight savings. With drastically lighter platforms, propulsion systems can be smaller, lighter, cheaper, more efficient, and, for autos, electrified. Several major automakers (and airplane manufacturers) are already adopting or seriously considering this gamechanging strategy. And if the world is going to wean itself from fossil fuels, the rest of the world's vehicle makers need to adopt this strategy as well—or risk falling far behind.

TRANSPORTATION-SECTOR TERMINOLOGY

Mbbl/d is the abbreviation for "millions of barrels [of oil] per day," a common U.S. unit of oil production or use. An oil barrel contains 42 U.S. gallons. **Cost of saved energy (CSE)** is the cost of saving a unit of energy, directly comparable to the avoided cost of the saved energy.

The term **"autos"** is used in this book to refer to all **light-duty vehicles**, which comprise cars, light trucks (sport-utility vehicles [SUVs], pickup trucks, and vans), and **crossover** vehicles (SUVs with sedan attributes), with a gross vehicle weight up to 10,000 pounds (4,537 kg).

A **powertrain** generates an auto's propulsion and delivers it to the surface of the road. A **drivetrain** or **"driveline"** connects the source of torque (like an engine) to the driving axles.

Battery-electric vehicles (BEVs) are powered entirely by electricity. **Fuel-cell vehicles (FCVs)** are powered by a hydrogen fuel cell and electric motors. **Plug-in hybrid electric vehicles (PHEVs)** are powered by both an internal combustion engine **(ICE)** and batteries that can be recharged from an electrical outlet. **Electric vehicles (EVs)** comprise the three previous categories but do not include the popular **hybrid-electric vehicles** that use both a fueled engine and electric motor(s) but don't ever plug in.

A **ton-mile** is equivalent to a ton (in this book, 2,000 pounds) of freight moved one mile. A **seat-mile** refers to one commercial airline seat flown one mile and is used to measure performance standards in the aviation industry. The seat may be occupied or empty. **Vehicle-miles traveled (VMT)** refers to the total number of miles traveled by a vehicle over a given period of time, typically one year.

Physics at Work

By 2011, policies setting vehicle fuel consumption standards at roughly 30 mpg (miles per [U.S.] gallon) for 2016 were starting to shift the market, and 54.5 mpg standards—around 39 on the road—were agreed for 2025. Yet technology has far outrun policy: attractive 125–240 mpg autos can be achieved within a decade, with multi-trillion-dollar net benefits to society. How? The answer begins with the simple physics of automobiles.

Consider these two facts of automotive physics:

1. Less than 0.5% of the energy in the fuel of a typical modern auto actually moves the driver. Six-sevenths of the fuel energy is lost in the propulsion system, during idling while the vehicle is stopped or braking, and to run accessories like air-conditioning and lights. More than half of the remaining one-seventh of the fuel energy that reaches the wheels heats the air that the auto pushes aside or heats the tires and road. Only the last 5% of the fuel energy accelerates the auto. Depending on the type and size of vehicle and the weight of the driver, only about one-twentieth of the mass being accelerated is the driver—so only about 0.3%, and at most 0.5%, of the fuel energy accelerates the driver.

2. An auto's weight is responsible for more than two-thirds of the energy needed to move it. Heavy autos have more inertia, needing more force to accelerate. They also have more rolling resistance because more weight is pushing down on the tires, which therefore lose more energy. As a result, the energy needed to move the auto, called its "tractive load," increases about in proportion to its weight. Heavier autos also need proportionally more powerful engines for the same acceleration. U.S. autos' big engines use only 8% of their power in typical highway driving or just 5% in the city—and this mismatch to normal driving requirements halves their average efficiency.

A LITTLE AUTOMOTIVE HISTORY

The automotive industry is enormous and complex. Building autos is a $1.6-trillion-a-year global enterprise, producing every five seconds or so a shiny two-ton machine with more than 14,000 parts, mostly from a global web of suppliers. The automobile runs extremely reliably for 15 years in all kinds of harsh conditions, costs less per pound than a McDonald's quarter-pound hamburger, and meets conflicting requirements with immense skill honed over 120 years. Making major changes will be very hard.

However, radical change can occur quickly. America's changeovers from horses to cars, from bare automotive tailpipes to catalytic converters, and from steam to diesel-electric locomotives all went from 10% to 90% adoption (in the stock of devices in use, not merely in new units sold) in only 12 years. Airbags went from zero to 100% of the new vehicle market in seven years. Henry Ford sold 2.5 million Model Ts between 1908 and 1916 even though in 1908 the United States had almost no paved roads and affordable personal motorcars were so inconceivable that, as Ford quipped, if he'd asked his customers what they wanted, they'd have said, "Faster horses."

The industry can be responsive—if asked. Detroit proved its ability to respond to customer demand for efficiency during the years 1975–1985 (fig. 2-3), responding to President Gerald Ford's efficiency standards and fuel prices by raising rated efficiency 62%. The average new car shed nearly half a ton and, while becoming safer, far cleaner, and no less peppy, drove 1% fewer miles on 20% fewer gallons. Of that fuel saving, 96% came from smarter design, and 4% from smaller size. But the lost weight was more than regained by 2005. In the past decade, U.S. cars gained weight twice as fast as people did.

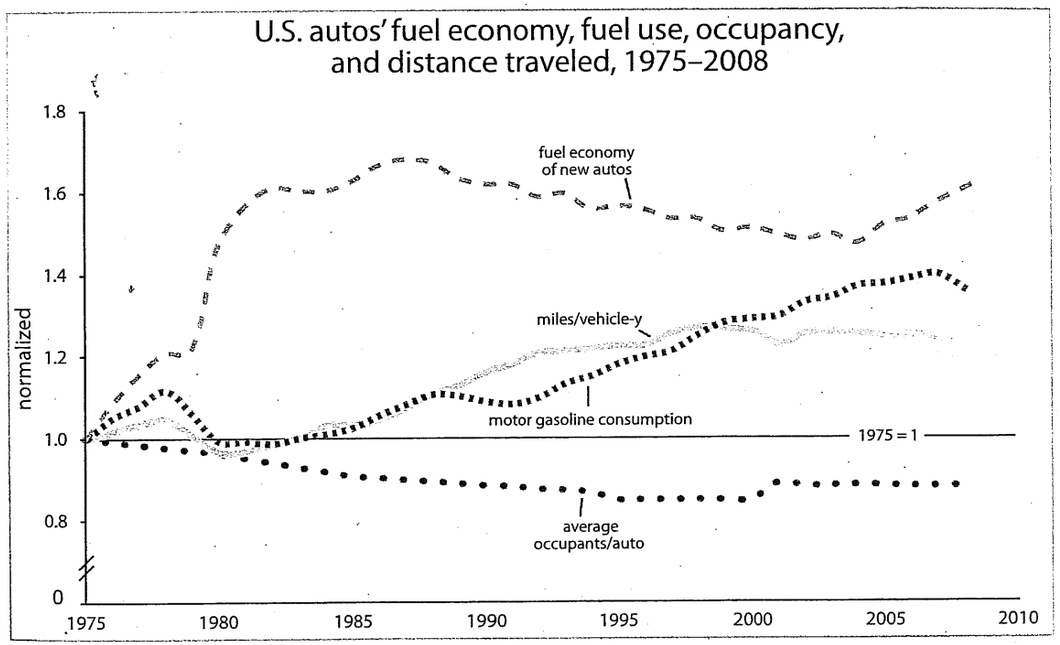


FIG. 2-3. Historic U.S. automotive fuel economy, vehicle-miles traveled, load factor, and fuel consumption. Automakers' big rise in fuel economy was driven mainly by 1975 federal CAFE (Corporate Average Fuel Economy) standards that took effect in 1978, and secondarily by fuel prices.[53]

From 1980 to 2004, automobile efficiency languished while the rest of the economy went to the moon, developed atomic power, and built the Internet.

The causes of the 30-year stagnation in vehicle efficiency are well understood. The combination of abundant oil supplies and efficiency's success crashed the world oil price in 1985–1986. In the U.S., heavy subsidies and light taxes helped keep it low for decades, ensuring that its price was one-half to one-third the price in almost all other countries. This boosted driving and sprawl and, as we'll see later, disadvantaged U.S. automakers against foreign ones. In the quarter century prior to 2008, global automaking's aftertax profits averaged just 1.26% of revenues; in the U.S., those profits were only 0.37% and more volatile. (Many brands were sustained by very few models, and by financing cars they sold at a loss.) As profit-starved Detroit kept on innovating, wringing more power from smaller engines while achieving remarkable improvements in emissions and safety, companies found they could make more money marketing acceleration, weight, and sheer size rather than efficiency. In 1998, a single factory, Ford's Michigan Truck Plant in Wayne, Michigan, earned $3.7 billion churning out giant 12 mpg Ford Expeditions and other SUVs, making it "the most profitable factory of any industry in the world," wrote Keith Bradsher in *High and Mighty*. To keep the SUV cash cow rolling, the auto industry's lobbyists blocked every effort to increase fuel economy standards (which by law were supposed to keep up with cost-effective technological advances). By 2008, new U.S. autos averaged a miserable 23 mpg on the road. No wonder America's best-selling vehicle in 2008, the Ford F150 pickup truck, got fewer miles per gallon than the groundbreaking Model T had a century earlier. But dependence on those highly profitable light trucks was risky, because their sales depended partly on oil prices staying low, while oil prices have actually been random since 1859. Inefficient autos in turn heightened pressure on world oil markets, making oil shocks more likely.

The industry is already responding to new conditions. Sure enough, the gasoline price spike of 2008, coinciding with recession and collapsing finance, led to a dramatic (if partly temporary) shift in customer preference from SUVs to more efficient vehicles. By 2010, the most popular SUV, for the first time in a quarter century, was outsold by a car—a Japanese compact—and GM couldn't even sell its Hummer business. The 2008–2009 Great Recession also sent U.S. auto sales plunging from nearly 17 million in 2005 to 10.4 million in 2009, helping push the U.S. industry to the brink of collapse. Concerns about climate change grew too. These trends, along with the waning clout of the crippled U.S. industry, emboldened Washington to enact the first higher fuel economy standards for cars in 35 years, raising new autos' minimum in 2016 to about 29.5 mpg—about where Europe was in 2008.

By 2011, efficiency was selling briskly and becoming good business. The emergence of plug-in hybrid and battery-electric vehicles such as the Chevrolet Volt, Tesla Roadster, and Nissan Leaf signalled a further shift in industry priorities.

These insights have a profound consequence: Making a conventional auto very light and smoothing its journey through the air and over the road has enormous leverage for saving fuel. By avoiding losses from tank to wheels, each unit of energy saved at the wheels saves seven units at the tank. A more efficient propulsion system wins no such leverage.

The logical goal, therefore, is achieving vehicle "fitness"—designing out weight, aerodynamic drag, and rolling resistance. Once autos are extremely light and efficient, *then* you can focus on the powertrain and change how autos are propelled and fueled.

Vehicle fitness is not news to automakers. They had compelling reasons not to pursue it seriously during the past few decades, but new conditions (see A Little Automotive History sidebar) are making the old rationale obsolete.

Boosting Efficiency, Step by Step: The Low-Hanging Fruit

Some improvements in automotive fitness are so straightforward with existing technology that they are considered, even now, the industry's quickest win.

Weight. The autos that will ultimately free us from oil will take the imperative for lightness as far as possible. Clever engineers are already working on the design, materials, and manufacturing innovations that will create ultralightweight autos with safety comparable to or better than today's heavier autos (as explained below). Automakers are taking the initial steps down that path, using conventional materials (see the There's a Lot of Life Left in Metals sidebar) and standard design and manufacturing techniques to wring weight out of existing vehicles, and doing so at little or no additional cost: a survey of 2010's new autos shows that across all models, lighter autos aren't priced higher.[54] Henry Ford said, "Weight may be desirable in a steam roller but nowhere else." In 2011, Ford CEO Alan Mulally called [light] weight "absolutely critical" and, reported Bloomberg, made lightweighting "the foundation of Ford's plan to meet rising fuel and safety mandates without scrapping the pickups and SUVs that generate most of the company's profits." Meanwhile, Nissan, Toyota, and Chinese automakers announced big weight cuts. Audi's aluminum concept version of its TT Roadster body got 35% lighter, twice as rigid, and a lot sportier—part of Audi's strategy to balance heavier electric propulsion components with lighter bodies.

Aerodynamics. Additional efficiency gains come from reducing the drag coefficient, the frontal area, or both. Smoothing the flow of air around an auto needn't constrain styling (it's often invisible, since much drag comes from airflow under the auto). One major automaker recently found that it could cut a popular model's aerodynamic drag by about 30%, which would boost fuel economy by 14%, at an extra manufacturing cost of around $100. Across all 2010 U.S. autos, there's no correlation between price and aerodynamic drag coefficient, which varies by nearly half among vehicles at any price level.

THERE'S A LOT OF LIFE LEFT IN METALS

The winner of the mainstream class of Progressive Insurance's 2010 Automotive X Prize for 100+ mpg designs, Edison2's Very Light Car, was made largely from steel and aluminum.

Nearly all modern autos are made mainly of steel, a strong, cheap, versatile material whose shaping technologies are exquisitely refined, and that is not nearly as heavy as it used to be. A study from a consortium of 35 steel producers shows that autobody structures could be made 25% lighter using advanced steels and manufacturing techniques, at no extra cost. How? Steel sheets can be made with varying thickness, putting strength only where needed. Hydraulic fluid can be used to shape metal in dies (a process called hydroforming), allowing larger and more complex shapes that add strength without weight. A follow-on project—"The Future Steel Vehicle 2020"—suggests that weight reductions of up to 35% are possible with steel.

Steel faces a challenge from aluminum, which is only one-third as dense for comparable strength. While aluminum is about five times as expensive per pound (thus about 1.5 times more expensive per part) and can be trickier to form and join, the metal is increasingly being used. Over the past three decades, the aluminum content of vehicles has increased from 2% to 8% as part of an effort to curb weight. Magnesium and even titanium are also increasingly used.

Rolling resistance. Another way to boost efficiency is by adding modern low-rolling-resistance tires. Again, highly efficient tires don't generally cost more. Shifting from the least to the most efficient in a common size boosts fuel economy by 8–12% but needn't cost more nor sacrifice performance, durability, or safety. Rolling resistance accounts for 9% of the world's oil use, worth a half-billion dollars a day, so innovation to cut that waste will continue.

Combined effects. These gains add up. Straightforward reductions in weight, drag, and tire losses could together boost fuel economy by about 50% with no electrification—not even the conventional hybrid drive now in millions of autos—at an attractive price. Watch your showrooms. Today, with rising oil prices, oil insecurity, and climate concerns, taking these evolutionary steps to boost efficiency sounds like a great idea. It is. But it captures only a part of the prize and won't get us off oil. We can be far bolder. Some automakers already sell autos with carbon-fiber composite parts or powered by electric motors. As we'll see next, these innovations are about to converge, not just to make a better, more efficient auto but to support the companies' long-term survival and success. So how can we make this revolutionary leap?

Revolutionary Autos: The Vision

The path to the answer began around 1992 behind the guarded doors of Lockheed Martin's legendary Skunk Works advanced research and development facility in Palmdale, California, where David F. Taggart, with a team of visionary engineers, led the development of an advanced airframe for the F-35 Joint Strike Fighter (JSF). It was 95% super-costly carbon-fiber composites, and hence one-third lighter than the benchmark 72%-metal JSF production design—yet it was two-thirds *cheaper*.[55]

How was that possible? Taggart's engineers began with a clean sheet of paper, reinventing the plane from scratch as a primarily composite airframe tailored for affordable manufacturing. For instance, novel snap-together joints would self-align large, complex composite shapes for bonding—a whole new way to make high-performance airplanes.

Taggart couldn't find a military customer for his radical fighter plane design, so he left Skunk Works, then joined Rocky Mountain Institute's Hypercar® Center in late 1998 to see if he could do for autos what he'd done for planes. In 2000, he and engineer David Cramer moved to England to build a development team with English and German Tier One auto-engineering firms expert in race cars, light structures, and advanced powertrains.

The team set out to design a midsize crossover sport-utility vehicle (SUV) that met a list of seemingly irreconcilable requirements: be as practical as a Ford Explorer, carrying five adults and their cargo in comfort and safety, with the driving dynamics of a BMW X5, at least three times the Explorer's fuel economy, and a mass-production extra price repaid by the first few years' savings at U.S. fuel prices.

Industry-standard performance, structural, and financial models and subsystem prototypes showed that the Hypercar team achieved these goals—in nine months and for a few million dollars. How did they do it? With integrative design.

Taggart and Cramer organized their people Skunk Works–style. The core team, initially seven engineers each leading a key vehicle subsystem, sat around the same table. Taggart deliberately set no requirements for each of these major systems, thus forcing the engineers to design the whole vehicle together from scratch. The only requirements were at the whole-vehicle level, so no subsystem could be optimized at the expense of another. They started from the wheels and worked back to the engine, giving each part exactly the needed size and strength. Perhaps most importantly, Taggart's engineers took to heart the central lesson from auto physics, relentlessly striving for lighter weight.

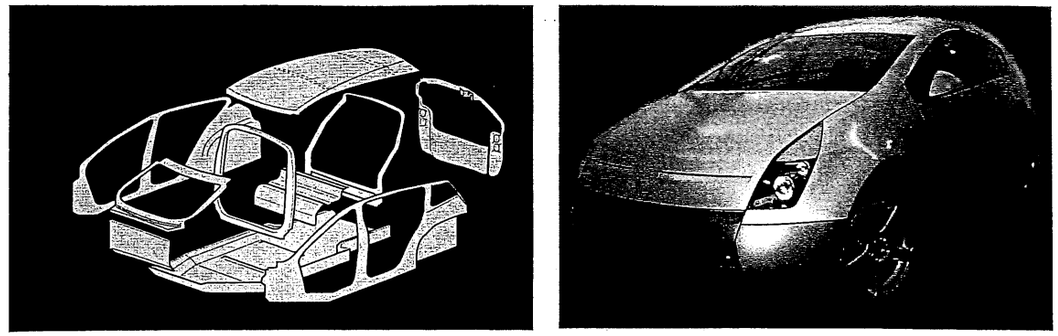


FIG. 2-4. The Hypercar (2000) SUV design's airframe-inspired ultralight carbon-fiber-composite body (left)—suspended from rings, not built up from a tub—and a full-scale physical mockup of the complete virtual design (right). It won the 2003 World Technology Award.

They designed the composite structure in a novel way[56] that enhanced crashworthiness and eased assembly, while putting strength and stiffness only where they were needed. At each key design milestone, leveraging further efficiencies in both cost and weight made the vehicle still lighter and cheaper. The final body had just 14 main parts (fig. 2-4, left), each liftable without a hoist, and designed for mass-production techniques devised specifically for making carbon-fiber autos, including parts that snap precisely into position for bonding.

The designers integrated parts and functions so that many parts each did multiple tasks, substituted software for hardware, replaced mechanical and hydraulic with electrical and electronic components, and trimmed superfluous features. For example, Taggart's team made the interior and trim 72% lighter by exposing the body structures to the interior and making their components simultaneously vibration-damping, crash-absorbing, heat-insulating, good-looking, and therefore fewer.

With the size of a Ford Edge, the final Hypercar SUV design (fig. 2-4, right) was 53% lighter and simulated to be 3.6 times more efficient on gasoline (6.3 times on hydrogen) than the most comparable steel SUV, the 2000 Audi Allroad 2.7T. The Hypercar SUV could cruise at 55 mph on the same power to the wheels that a normal SUV uses on a hot afternoon to run its air conditioner. (The Hypercar design had an air conditioner too, but with seven times normal efficiency.) Hypercar, Inc., was unable to raise production capital in the late-2000 capital-market crash, but the design[57] continued to influence industry thinking in ways that are now moving toward the market. Both Toyota (fig. 2-5) and Volkswagen (fig. 2-6) have

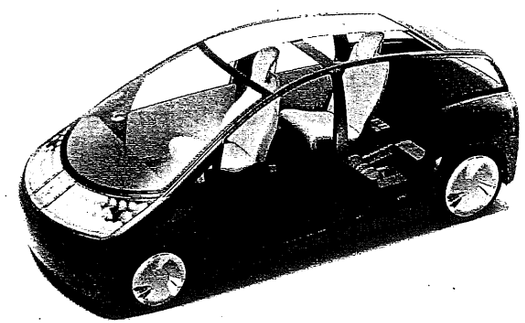


FIG. 2-5. Toyota's 2007 1/X concept car—a carbon-fiber-monocoque four-seat plug-in hybrid with half the fuel use and one-third the weight of an equally spacious Prius. It weighs just 926 pounds (and would weigh only 880 pounds if it were an ordinary hybrid) and reportedly gets about 108 mpg on the European test cycle. Its half-liter flex-fuel backup engine is tucked under the rear seat.

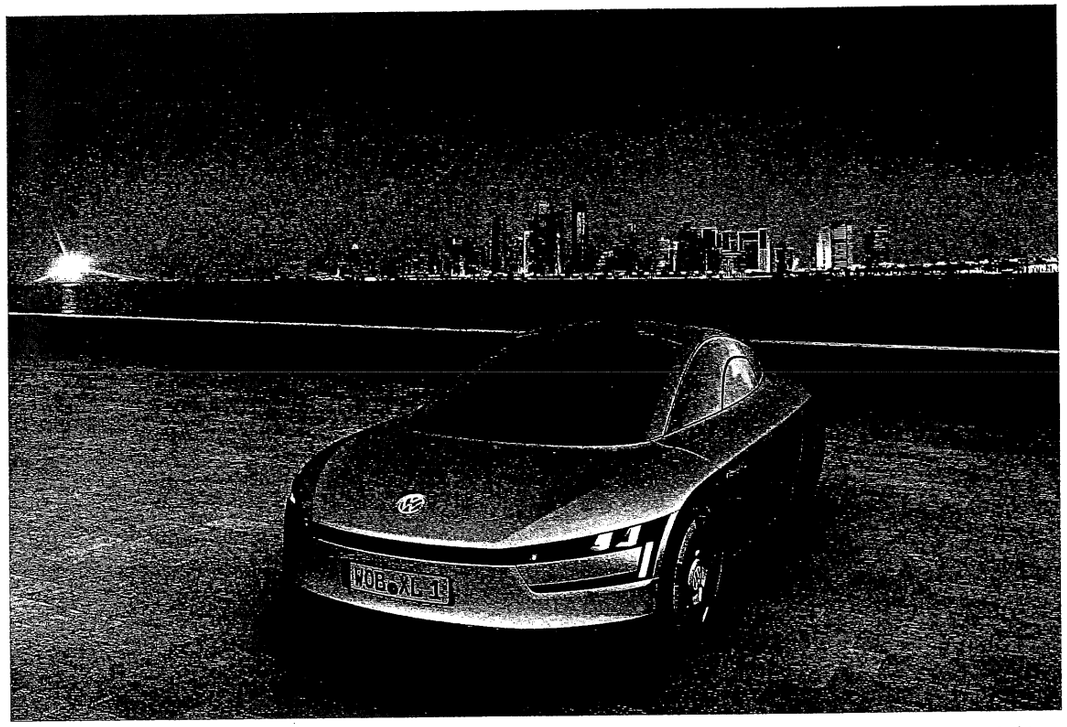


FIG. 2-6. Volkswagen's 230-mpg-gasoline-equivalent XL1 concept car (2011)—a carbon-fiber two-seat plug-in hybrid. Its 0.8-liter 48 hp diesel engine is hybridized with a 27 hp electric motor, and its drag coefficient is an industry-leading 0.186. The car has a top speed of 99 mph and 0–62 mph time of 11.9 seconds, weighs just 1,752 pounds, and is slated to enter limited production in 2013.

shown Hypercar-class carbon-fiber sedans, the latter—like the BMW and Audi sedans mentioned below—with announced imminent production intent.

Revolutionary+ Vehicles: Key Enablers

The key enablers to vehicles of such breakthrough efficiency, which we'll call "Revolutionary," are (1) integrative, whole-system design optimized for (2) ultralight materials, particularly advanced composites. Adding (3) an electrified powertrain creates what we'll call the "Revolutionary+" auto—the key to getting autos off oil by 2050.

Each of the three successive Revolutionary+ enablers unlocks the effectiveness of the next, yielding benefits that multiply. The first two, integrative design and advanced materials, not only save energy directly but also make it more practical and affordable to move to the third—super-efficient electrified powertrains (fig. 2-7).

Revolutionary+ Enabler 1: Whole-System Design

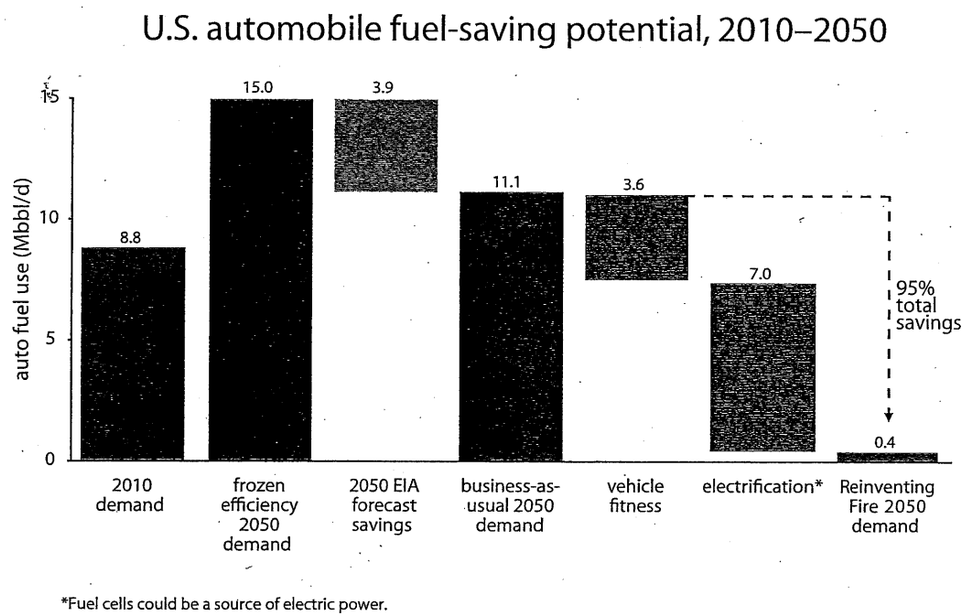
This requires new ways of thinking. Changing a design, Taggart explains, is like stretching a rubber band. The farther you stretch it from its current norm, the greater the resistance. Stretch too far from the comfort zone and the rubber band breaks. Breakthrough design therefore requires shifting to what engineers call a whole new "design space" with its own brand-new rubber band. If technology can't yet reliably deliver the performance you need, you can stretch back toward today's norms, but as the technology matures, the rubber band will relax toward your goal and pull you into the future.

Instead of assuming that an auto needs all the traditional parts and designing each part separately, why not think of the design as one integrated whole? The biggest benefits emerge when engineers repeatedly revise the whole design to exploit each gain they just made in its parts. This recursive "design cycle" exploits how lightness snowballs. The less weight you have, the less weight you need.

A lighter auto needs less power, so its powertrain can be smaller and simpler. That makes the auto even lighter, so in the next design go-round, the engine can be made yet smaller and lighter. The weight savings multiply with each component, from brakes to suspension parts, and with each turn around the design cycle. Parts and systems can even disappear entirely: put an electric motor in each wheel, for instance, and suddenly there's no need for a transmission, clutch, driveshaft, axles, universal joints, or differentials. Their disappearance in turn triggers still more weight savings. Lightness multiplies.

Revolutionary+ Enabler 2: Advanced Composites

By combining two or more materials with complementary properties, composites can maximize the



*Fuel cells could be a source of electric power.

FIG. 2-7. Vehicle fitness (via integrative design and advanced materials) reduces normally projected automotive fuel consumption by one-third while enabling efficient and affordable electrification, the source of even larger fuel savings and the most crucial step toward getting U.S. autos completely off oil. The oil use remaining in 2050 to run surviving gasoline-engined vehicles is displaced by biofuels.[58]

benefits of each material. Like wood—cellulose fibers in a lignin matrix—carbon-fiber composites embed long strands of carbon atoms, with excellent tensile strength, in a tough plastic resin to yield a new material stronger and stiffer than steel but only one-third as dense. Modern methods can make it reparable and recyclable. It doesn't rust or fatigue. It could allow the chemical industry to muscle in on metalmakers. And such ultralighting of U.S. autos could cut up to two-thirds of their weight and half their fuel usage, make their electrification affordable, and thus ultimately save an amount of annual oil nearly comparable to finding a Saudi Arabia under Detroit.

Revolutionary+ vehicles will combine a mixture of materials. Composites aren't appropriate for all applications: advanced and even standard versions of today's conventional metals are sure to play a significant role in lightweight autos, just as they do in Boeing's half-composite 787. Designing with composites creates a new realm of lightweight possibilities, enabling Revolutionary+ vehicles and bringing drivers far lower fuel costs for the same or better performance. However, the currently high price of ultralight materials, their traditionally slow manufacturing processes, and the investment needed to retool factories all challenge automakers to manufacture such featherweights affordably. Are there ways to unlock lightweight materials' benefits without breaking the bank?

Mass-Producing Composite Structures

Building Formula One carbon-fiber autobodies is like crafting a handmade Italian suit. Bundles, sheets, tapes, or woven cloth made of stiff, finer-than-hair carbon fibers are laid by hand in precise patterns aligned for maximum strength. This "layup" is embedded in a costly thermoset resin like epoxy and then baked in big ovens to cure—a finicky process that takes hours per part. Much of the expensive fiber gets trimmed away as scrap. No wonder the automakers long considered carbon fiber prohibitive: they'd need a process roughly a thousandfold higher-volume and lower-cost, and a hundredfold faster.

A typical 250,000-units-a-year auto plant must make a vehicle every two minutes or less, for two main reasons. First, only half of a typical auto's retail price is manufacturing cost; the other half is fixed overhead. If production volume drops, overhead costs per auto rise and profits plunge. Second, production must keep pace with the $0.3 billion paint shop, whose huge scale spreads the cost of controlling its air pollution and protecting workers. Automakers would therefore need composite parts made in a minute, not hours.

But what if you could invent a rapid automated layup process and switch from thermosets to thermoplastics—tougher, cheaper, needing no curing, and quickly reshapable simply by melting, molding, and cooling? David Cramer and other Hypercar engineers tried that and it worked. Hypercar developed automated equipment that if scaled and matured could meet automotive speed and cost goals, and it became Fiberforge Corporation. Now its third-generation equipment is making high-performance composite parts for aerospace, military, and other customers, in competition with such firms as Electroimpact, Forest-Liné, Ingersoll Machine Tools, MTorres, and MAG Cincinnati.

Automakers are also partnering to develop their own large-scale manufacturing processes, already at several-minute cycle times—initially with thermosets but moving toward thermoplastics. Toray, the world's largest carbon-fiber supplier, announced the day before Toyota showed the 1/X—a clear signal of both firms' strategic intent—a $0.3 billion factory to "mass-produce carbon-fiber auto parts for Toyota," then added Honda, Nissan, Subaru, Daimler, and others, seeking "billion-dollar automotive sales." Arch-rival Teijin announced a sub-minute thermoplastic forming process. Toray and U.S. rival Zoltek

each opened an automotive advanced-composite application center; so, in 2010, did the Japanese government, to accelerate private-sector composite technology. A half-dozen automakers know that, as VW said in 2011, large-scale manufacture of carbon-fiber automotive structures, "simply not viable" in 2002, "is now possible." The *Wall Street Journal*, surveying lightweighting progress from Lamborghini to Land Rover, concluded: "Deftly trimming the weight from cars . . . will be vital to the competitiveness of every auto maker. . . . Soon, a luxury car made only of steel and plastic could be as déclassé as a cinder-block sized cellphone."[59] And meanwhile, Toyota and Honda have entered the carbon-fiber airplane business, doubtless aiming to cross-pollinate new materials skills back to their core automotive businesses.

Transforming Automaking

Though at least two firms' technologies can already achieve one-minute cycle times, that may still be slower than steel-stamping. But plants can compensate for any initially longer composite cycle times by setting up parallel lines in the floorspace previously needed for one steel-based production line. The new equipment's drastically lower cost and size could shift production economics profoundly, since costlier but fewer parts with far cheaper assembly can help offset the costlier materials.

Consider first that composites can reduce by approximately tenfold the 100 to 200 parts needed for a typical autobody.[60] The roughly $0.3 billion tooling cost to stamp them would fall far more, because molding each part takes a single dieset with composites, versus about four progressive diesets to stamp steel. Fewer parts also mean fewer assembly stations and fewer robots. Lighter parts mean less powerful, less costly equipment. Bonded or induction-welded joints can replace thousands of spot welds.

Composites may also prove able to slash auto plants' biggest investment and toughest operation—the paint shop. A shiny, flawless Class A finish costs about $400 per auto. With composites, it may be possible to use "paint-in-mold" techniques to prime or color a part while forming it, greatly simplifying the paint shop or eliminating it altogether.

Studies show that Revolutionary autos' manufacturing fixed costs can be reduced by 80% (fig. 2-8), cutting total manufacturing cost by about 35% in a 250,000-a-year plant.[61] Other savings in variable nonmaterial costs, such as factory energy, are a useful bonus. Manufacturing with composites may thus shift the longstanding automaking business model toward lower investment, smaller plants, faster product cycles, and hence a more diverse, agile, and rapidly evolving product portfolio—all helpful in managing uncertainty.

Right now, the raw material for a carbon-fiber composite is 15–30 times more expensive per pound than steel. So an unfinished autobody made of composite parts 60% lighter than their steel equivalents would be roughly 300 pounds lighter and $1,000 to $3,000 costlier. But only 4–8% of the manufacturing cost of a typical steel car is the steel, so shaping, finishing, and all the rest of the car's manufacture drive far more cost. The composites' material-cost premium gets partly offset by simpler manufacturing, smaller powertrain, snowballing weight savings that make other parts smaller, and such valuable performance benefits as more stiffness, better handling and ride quality, faster acceleration, and fuel savings.

Making Carbon Fiber Cheaper

Composite autobodies' extra materials cost is wide-ranging because carbon fiber comes in different types with differing prices. In non-cosmetic applications, substituting cheaper, often recycled carbon fiber scrap with strength comparable to that of high-grade fiber can save up to one third of material cost. Further savings result

from placing carbon fiber only in areas where its exceptional properties are required and filling the remaining space with lighter, cheaper glass fiber or core material. Carbon fiber's price will also fall as the industry first equilibrates and then matures.

Carbon fiber was long a boutique product with global tonnage comparable to U.S. gourmet chocolate sales. Its price then soared with sudden demand for making airplanes and wind-turbine blades (as well as spiking oil prices), but it will ease—even without cheap new precursors—as suppliers catch up and move down the learning curve[62] to compellingly low prices.[63]

About half today's production cost is for precursor material—96% of which is polyacrylonitrile made from oil (propylene) or natural gas (propane), both of which have volatile prices. Carbon-fiber manufacturers are starting to make their own precursors and expect to cut their costs by about 20%. But much cheaper precursors are emerging. Their strands of carbon atoms are commonplace; the trick is removing the other elements and forming the remaining carbon skeleton into long, pure strands. Solve those problems, and carbon fiber could be made from biomaterials like plant fibers, or even from recycled plastic trash. Oak Ridge National Laboratory (ORNL) believes these alternatives could potentially cut carbon-fiber costs by up to 90%, matching or even beating steel prices on a direct dollar-per-pound comparison[64]—not that anyone buys autos by the pound.

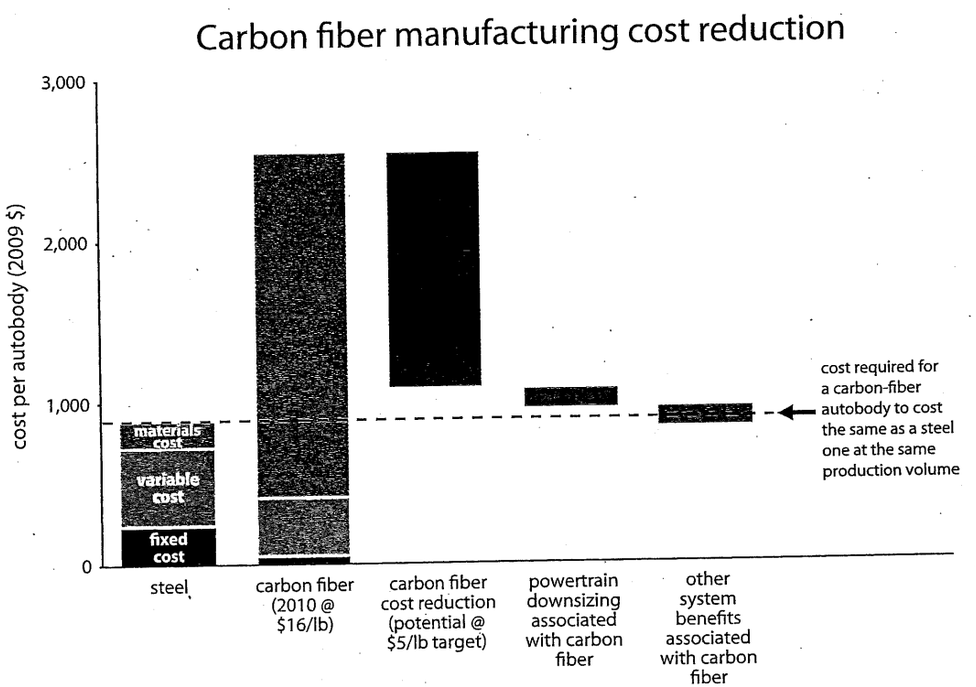


FIG. 2-8. Manufacturing with composites can cut the fixed costs of making an autobody by 80% and its variable nonmaterials costs by 25%. Both reductions are currently overshadowed by raw material costs, but those are likely to fall as the composites industry matures and are partly offset by other factors (as described in the text).[65]

Ultralight but Ultrastrong

What about the safety of composites-based vehicles? Until recently, the prevailing view in the U.S. auto industry was that efficient autos are small, unsafe, sluggish, costly, or otherwise so undesirable that customers would buy them only if the government required or subsidized them. However, the physics of autos shows that light weight and efficiency can actually mean spacious, safer (see Crash Safety with Composites sidebar), peppier, and cost-competitive. People will buy such autos because they're *better*, not just because they're more efficient, much as most of us switched from vinyl phonograph records to CDs and then to iPods.

CRASH SAFETY WITH COMPOSITES

The perception that safety requires weight stems mainly from flawed studies done between 1977 and 2004 by the National Highway Traffic Safety Administration (NHTSA). Analyzing U.S. crashes, NHTSA concluded that making autos 100 pounds lighter would kill an extra 400–1,300 Americans per year.[66] NHTSA therefore encouraged heavier autos by letting them be less efficient. At the same time, big autos got more popular and profitable, while materials and design choices made big autos heavy. The combined effect was a frenzied "mass arms race" in which, trying to protect your kids, you drive an Expedition, your neighbor drives a Hummer, and the guy down the street drives an 18-wheeler.

But NHTSA's analysis had erred by conflating weight with size. Careful reanalysis of the data showed that making all autos 100 pounds lighter would *save* 1,500 lives, because what increases crash safety is not weight but size.[67] Buyers were right about larger autos being safer—they have more crush space to absorb impacts. But larger autos needn't be heavy. NHTSA has since switched to regulating autos by size, not weight. The goal, explains University of Michigan physics professor Marc Ross, should be to make "heavy vehicles lighter (but not smaller) and . . . lighter cars larger (but not heavier)."[68] We can thus make autos big, and hence comfortable and protective, without making them heavy, and hence hostile and inefficient. By decoupling size from weight, ultralight materials can save lives, oil, and money simultaneously.[69]

At any weight, using any materials, design for safety is vital: it's why, across all cars on U.S. roads, observed crash death rates vary by about threefold between different models of the same weight. But lighter, stronger materials magnify the design opportunity. Aluminum absorbs about twice as much crash energy per pound as steel, while carbon-fiber composites are up to six times better than aluminum. Such materials' strength, combined with good design, helps explain why Formula One race-car drivers usually suffer only minor injuries in horrific 200 mph crashes. It also explains how ORNL's and Hypercar's designs halved vehicle weight without reducing safety. And it explains why your sports safety helmet is probably made of carbon fiber, not steel.

Also, as part of a clean-sheet design approach, integrating the latest active safety features could enhance safety while allowing further weight savings. MIT's *Reinventing the Automobile* shows how features based on wireless technology and electronic sensing could help make accidents less likely and less severe even with smaller autos.[70]

A fleet of lightweight, well-designed autos would be a triple play on safety. They'd protect their own drivers and passengers better. They'd cause less damage if they hit other vehicles, structures, or pedestrians, thus protecting others better. And they'd protect us all against the dangers of buying and burning oil.

REVOLUTIONARY+ ENABLER 3: ELECTRIFIED POWERTRAINS

So far we've seen the alluring benefits of designing autos to be as light as possible, maximizing their overall vehicle fitness while maintaining or improving safety. We've also identified a path to reducing the cost of manufacturing these ultralight autos so that they offer a compelling business case.

Yet there's still a trump card to be played. While vehicle fitness alone accounts for a third of autos' 2050 fuel reduction, it more importantly enables the essential element that finally liberates us from oil. That final ingredient is powertrain

electrification, which unlocks a further 63% reduction of 2050 fuel consumption (fig. 2-7).

An electric motor both drives the wheels and acts as a generator to convert unwanted motion back into useful electricity. That electric motor can be run on battery power or fuel cells, or it can be augmented with a small onboard fueled engine, as in hybrid and plug-in hybrid autos. Batteries store far less energy per pound than gasoline but convert it more efficiently into motion, helping to justify their higher cost.

Do we really need to go to electric propulsion? After all, several innovations are under way with internal combustion engines (ICEs) that could boost efficiency by as much as 50% (see New Engine Technologies sidebar).

Despite such advances, some simple math shows that electrification is a better answer. If the best ICE technology were combined with 30% lighter vehicle weight, U.S. autos would still burn about six million barrels of biofuels a day (8.5 times 2010 production), far exceeding the country's projected supply of inedible biofeedstocks (see Pumping Biofuels on page 65). Those biofuels would be better used by aviation and heavy trucking, for which electric power is not a viable option.

The saga of JB Straubel further illuminates the advantages of electric propulsion. Earning Stanford engineering degrees, he built a gasoline reformer and fuel cell (they worked and didn't blow up) and then electrified his Porsche. He worked with ultralight airplane pioneer Burt Rutan and then designed hybrid powertrains at Rosen Motors. When PayPal cofounder and commercial-space-rocket mogul Elon Musk decided to build a breakthrough battery-electric car, founding Tesla Motors in Silicon Valley, Straubel was the perfect choice to lead the design.

Straubel already knew that electric motors are lighter, smaller, cheaper, quieter, cleaner, more rugged and reliable, and severalfold more efficient than modern fueled engines, as well as enabling sizzling acceleration. And electric drive can automatically recover for storage and reuse (accelerating the auto) up to about 70% of the energy otherwise wasted as heat by the brakes.

Could autos fully capture those advantages? Straubel's first task was to design a powerful but affordable battery. He bought consumer-electronics lithium cells that look like drugstore AAs—but slightly older models to cut cost. He figured out how to arrange 6,831 of them safely in flatpacks that Tesla now sells to other automakers. He married a light, low-drag Lotus body with an advanced watermelon-size motor and inverter previously used in GM's EV-1 electric car. The resulting Roadster EV costs $109,000 to buy but one cent per mile to run—and its acceleration is on par with that of the world's fastest sports cars.

But a problem appeared: the car's original two-speed gearbox kept breaking. Two top suppliers couldn't meet both the acceleration and top-speed specifications. Straubel's novel solution: eliminate the gearbox and let his *electrical* engineers solve the problem by wringing more torque from the electric motor and helping it shed heat better. The result was 40 more horsepower, 10-mile longer range, 14-pound lighter weight, less noise and maintenance, less warranty cost, and lower manufacturing costs.

This story offers an important lesson for automakers. The world of power electronics, microchips, software, and systems integration is at a far earlier stage than 120-odd-year-old engine-and-gears designs, so it offers far more scope for innovation, scaling, and cost reduction (see Electric-Powertrain Learning Curves sidebar). Early-generation, low-volume electric traction systems can compete *today* against mechanical systems

NEW ENGINE TECHNOLOGIES

In the 1960s, Israeli engineering genius Eddie Sturman designed digitally controlled valves for NASA's huge rocket engines. His valves' energy frugality helped the crippled *Apollo 13* return to Earth. Now his Colorado firm and its larger collaborators are trying to revolutionize the diesel engine, operating the valves with tiny electric actuators instead of mechanically driven camshafts.

A diesel engine's piston compresses the air in a heavy metal cylinder to extremely high pressures, making the air so hot that sprayed-in fuel oil explodes, pushing back the piston to turn a crankshaft. Modern diesel engines in autos and trucks get peak efficiencies in the 40s of percent, versus the 30s for nondiesel car engines.

Fast, small, light, and cheap, Sturman's retrofittable valves permit very precise fuel and air injection under closed-loop digital control. This could boost the efficiency of a diesel engine by half (to around 60%), increase torque by more than half, and make the engine at least one-third smaller and lighter, more than a tenth cheaper, and able to burn any fuel so cleanly it would need no emission-control equipment.

Digital valves also permit unusual event sequences. How about first injecting the fuel into leftover exhaust gas, so it's vaporized and mixed for free, then adding the air through a separate digital valve? Or switching the engine on the fly between two-, four-, six-, and eight-stroke operation? Or better yet, since the piston has the least leverage when trying to push the crankshaft from the top of its stroke, how about eliminating the crankshaft? Simple: Let the back of the piston directly compress hydraulic fluid into a separate vessel, then later turn that stored pressure back into mechanical work exactly when and at the force required. This system, Sturman believes, could push the engine well past 60% efficiency and offer many advantages for propulsion, as well as for stationary engines.

Another brilliant engine innovation to watch is the opposed piston–opposed cylinder (OPOC) design developed for DARPA (Defense Advanced Research Projects Agency, a military research agency) to make very light and efficient portable generators. OPOC is very compact because it balances and integrates the forces of two aligned pistons moving in opposite directions. EcoMotors International, led by Don Runkle (formerly GM's head of advanced engineering), is commercializing it. The firm claims its engine is 30% lighter, 75% smaller, and 50% more efficient than today's state-of-the-art turbocharged diesel engines. It needs no valves. An electricity-generating version could even eliminate the crankshaft by using magnet-containing free pistons, nonmagnetic cylinder walls, and surrounding copper coils.

ELECTRIC-POWERTRAIN LEARNING CURVES

Our manufacturing-cost learning curves for battery packs and fuel-cell systems are based on a 2007 MIT study on electric powertrains (Kromer and Heywood 2007) and informed by extensive industry data.[71] The cost decrease is very steep for the first half-million vehicles, supporting rapid takeoff to higher volume.

Lithium batteries are similarly getting cheaper as more are made, but batteries' underlying science and technology are driven less by new automotive markets than by consumer-electronics buyers' willingness to pay a premium for longer operating time from smaller batteries. To get a marketing edge, electronics manufacturers therefore pay suppliers about twice the price for a battery that safely packs the same energy into half the volume. The battery-maker's incentive is even bigger because such an innovation typically sells twice as well, quadrupling revenues. Battery packs for propelling autos have very different requirements (cycle life and depth, temperature, ruggedness, safety, et cetera), but fundamentally they're made from many small batteries. In time, the basic battery innovations driven by the consumer-electronics market do tend to trickle down from cellphones and laptops to autos.

Much government effort now goes into making batteries cheaper, and used to go into making vehicular fuel cells cheaper. Yet investing R&D effort in vehicle fitness (which got about 100-fold less in U.S. research budgets through 2010) will yield the same result with less cost, time, and risk. First making batteries *fewer* (fit vehicles need two- to threefold less energy per mile) makes them affordable; that sells more electric autos; that volume makes batteries cheaper. Smaller *and* cheaper batteries then hit the jackpot.

that sweated out most potential cost reductions decades ago. Imagine how far electric traction will jump ahead with greater experience and higher volume. And the advantage may as easily go to small, agile firms as to big, rich ones.

Contrary to some recent reports, electrification won't be constrained by critical materials (see The Rare-Earth Conundrum sidebar); rather, they're vibrant business opportunities to displace scarce elements and to use them more productively, durably, and recoverably.

The Transition to Revolutionary+ Autos

As we have seen so far, incremental efficiency gains can apply to any auto. The real automotive magic—and the best hope for eliminating oil—happens when electric traction is combined with Revolutionary vehicle fitness, making any advanced powertrain more affordable and providing the range buyers have come to expect. So how can automakers best make this transition to Revolutionary+ vehicles? Producing these designs at scale is the next and most difficult step, one that no auto manufacturer has yet taken.

As with any breakthrough technology, however, there are "first movers" who have already begun the transition. Some begin with a substitution phase in which a few standard parts on an existing auto model are replaced with lightweight composite parts, enabling a manufacturer to build analysis and design prowess for composites while working out the raw-material supply chain and gaining a head start on tooling. This advances all four elements of automotive innovation—plant, people, product, and process—with due deliberate speed but not all at once, which would create undue risk.

The experience thus gained can then be applied to manufacturing an all-new, clean-sheet, integrative design that takes full advantage of advanced materials. BMW, for instance, announced in 2010 a $748 million investment to mass-produce what it described as "the world's first volume-produced vehicle with a passenger cell made of carbon" (fig. 2-9)—and in 2011, confirmed that "The smaller battery pack required by a lighter car offsets the cost of the carbon fiber body."[76]

Audi announced production of a carbon-fiber electrified auto for 2012, a year before VW's and BMW's releases. These three companies are presumably counting on strong initial sales to early adopters to increase their market share as production expansion and the gains from mutually reinforcing technologies make these models more affordable. There are also signs that Japan's automakers have significant, though shrouded, ultralighting efforts under way.

So far, such first movers as Audi, BMW, Volkswagen, and Toyota have pursued the compound benefits of lightweighting plus electrification. But what about introducing electrification *before* full vehicle fitness? Chevrolet's Volt and Nissan's Leaf did just that, pioneering emerging powertrain technologies in 2010. The Volt, a midsize plug-in hybrid, goes 35 miles on electric power alone before a gasoline engine kicks in and generates enough electricity to carry it more than 300 additional miles on a single charge. But it weighs in at a hefty 3,781 pounds. The Leaf, a midsize battery-electric vehicle, goes 73 miles on a charge, at 99 mpg equivalent, but it's also relatively heavy at 3,366 pounds. Meanwhile Honda, with a long lightweighting heritage, broke new ground with

FIG. 2-9. July 2011 preliminary version of BMW's i3 (originally Megacity) carbon-and-aluminum battery-electric car announced in 2010 for 2013 mass production—the same year as VW's XL-1 (fig. 2-6). BMW's 2,756-lb, 4-seat flat-floor city hatchback is agile, compact, airy, and spacious. Its range is about 100 miles without an optional "REx" range-extending gasoline engine so small it fits alongside the drive-motor above the rear axle. The 170-hp electric motor delivers 184 lb-ft from a standstill and accelerates 0–62 mph in 7.9 seconds, rivaling a BMW 120i, though top speed is governed to 93 mph. The carbon-fiber passenger cell, with replaceable plastic exterior panels, is more crashworthy and durable than steel but half the weight. Initial production is reportedly planned for 30,000 a year but is rapidly scalable upwards.

THE RARE-EARTH CONUNDRUM: ARE CRITICAL MATERIALS FOR ELECTRIFIED VEHICLES REALLY IN SHORT SUPPLY?

Much has lately been written about supposed shortages of critical materials for electric vehicles (and for renewable energy and even energy efficiency), notably "rare earth" elements. The U.S. Department of Energy has set up a special group to examine these issues, though the Pentagon found they're not important to national security. On closer examination, such serious critical-materials issues aren't likely, especially for autos.[72] (The U.S. Geological Survey in 2010 reported 1,300 years' worth of U.S. rare-earth deposits.[73])

Lithium, currently the best battery material, is relatively abundant and is readily recoverable from old batteries, much as 97% of the lead in today's auto batteries is recovered for reuse: you must often turn in your old battery to buy a new one or reclaim a deposit. Rare-earth elements like neodymium, mined mainly in China and currently in the midst of a market bubble[74] hyped by stock promoters, are part of the recoverable superstrong magnets in certain compact and powerful electric motors and generators: a Prius's main motor contains nearly half a pound of neodymium and dysprosium, and the world makes about 50,000 tonnes of such magnets per year. (Another and commoner rare-earth element, lanthanum, is in recyclable nickel-metal-hydride batteries, but virtually all automakers, now including Toyota, have switched new models to lighter-weight lithium batteries.) However, there's no necessity nor good reason to use permanent-magnet motors. Induction (asynchronous) motors like Tesla's have no magnets, nor do switched-reluctance motors that match or beat permanent-magnet motors in all respects including cost.[75] And of course the need for all these special materials remains small—both before Revolutionary+ autos, because electrification's cost severely limits its market, and after, because their tractive loads and powertrains are two to three times smaller.

its FCX Clarity fuel-cell car—a hydrogen-fueled sedan with a 240-mile range—but it weighs 3,582 pounds.

These cars are already impressive. But think how much more amazing they would be at half or one-third the weight, if their manufacturers also made the investments in advanced materials and clean-sheet design to turn them into Revolutionary+ vehicles. For example, Bright Automotive's nominally 80 mpg commercial van (fig. 2-10) is aluminum-intensive yet weighs less with a ton of payload than its competitors weigh empty. Even that partial gain in fitness eliminated 40% of the costly batteries needed to make it a plug-in hybrid. That in turn made its business case compelling to fleet buyers (who take a longer view on fuel savings than do private auto buyers), without the subsidy that all other plug-in hybrids currently need. A future carbon-fiber general-market version could then attract individual car buyers.

Making electrified vehicles light would cost more for structural materials but less for batteries. A fit Nissan Leaf, for example, could save $3,000 in battery costs for the same range and cut the charge time on a standard home outlet from 20 to just over 13 hours; or it could keep the current battery pack while increasing range 50%. Revolutionary fitness could similarly extend the range or reduce the price of fuel-cell electric vehicles like Honda's FCX Clarity.

Seasoned automakers that have become first movers are mainly interested in a stepwise manufacturing transition to reduce risk and ease losses of legacy investments in equipment and tooling. But start-ups like Tesla and rapidly emerging Asian competitors (see New Asian Competitors sidebar) can adopt the latest manufacturing technology from scratch. Start-ups nonetheless face their own barriers linked mainly to economies of scale. They start at low production volumes not to minimize risk

FIG. 2-10. Bright Automotive—a 2009 RMI spinoff that in 2010 entered a strategic partnership with General Motors—showed in 2009 a driving prototype of this commercial utility/service/delivery van, the Bright IDEA, with 3- to 12-fold higher fuel economy depending on driving cycle. It carries 5 cubic meters of cargo, two people, and their fold-down front-seat office for 30 miles electric-only or 430 miles total, and gets 100 mpg on a 50-mile-a-day urban route. This vehicle segment is 7% of U.S. auto sales but uses about 20% of their fuel.

but rather because of limited capacity and high barriers to market entry. Like incumbent manufacturers, they sell initially to an early-adopter market willing to pay for new technology, hoping then to descend learning curves, cut prices, and broaden sales.

But is becoming a first mover the only way to get a piece of this emerging market? Not if followers move swiftly. "Fast followers" are mindful that often "the pioneers get the arrows, the settlers get the land." They believe there may be little intellectual property advantage for first movers, since manufacturing innovation could lie within the supply chain, so all competitors would ultimately pay to license it. If not—if first movers own the intellectual property themselves—fast followers believe it can be affordably licensed from them. In either case, the strategy is to offset the brand value of their pioneering competitors by starting further down the learning curve and piggybacking on an increasingly commoditized supply chain, perhaps aided by better understanding of the market.

Whether first mover or fast follower, existing manufacturer or start-up, the first and most important step is to establish the goal by *designing* an ultralight vehicle that takes full advantage of advanced materials to enable a smaller, cheaper powertrain. The sooner the better: Integrative design could require major organizational change, which isn't easily emulated. Those with

NEW ASIAN COMPETITORS

The California phenomenon of smart, hungry, unknown engineers tinkering in the garage, hatching the next Apple or HP or Xerox, still lives on, but now it's happening worldwide, from Shenzhen to Bangalore and São Paulo to St. Petersburg.

Despite China's many challenges, its industry is dynamic, capable, and supported by nearly free and almost unlimited state capital and determined central policy. Automaking is now a pillar of the nation's growth strategy. The same intensity and drive that created the world's largest-ever construction boom to serve an increasingly affluent and urbanized 1.4 billion people is joining with Chinese leaders' aversion to the oil trap, commitment to electrification and fuel cells, strong interest in advanced lightweight materials, and strategic goal of becoming a formidable advanced-vehicle exporter. China plans a carbon-fiber plant as big as Toray, the world's top producer. In 2010, China became the world's largest auto maker and buyer; Zhejiang Geely bought Volvo; and GM sold half of its India operations to its Chinese 51% partner, Shanghai Automotive, which will now coinvest in GM's Indian expansion. China's auto market, after a sevenfold surge from 2000 to 2009, shows few signs of flagging. And the pattern of turning Western partnership into competition, as in high-speed rail and wind turbines, may well repeat with road vehicles, especially lightweight electric ones.[77] As journalist Thomas L. Friedman recently told a U.S. audience, "The bad news is we'll buy all this stuff from China; the good news is it'll cost less than your tennis shoes." The more China exercises its potentially vast market power, the faster it will drive—even lead—the global automotive transformation.

India is another emerging force in the world automotive market. Capable, aggressive conglomerates like Mahindra and Tata have already snapped up Land Rover and Jaguar. In 2009 Tata launched the Nano, a decent four-seat family car more efficient than a Prius, and in late 2010 priced at $2,900—less than half Ford's fast-selling $7,700 Figo four-seat subcompact hatchback. It's crammed with clever, deeply frugal "Gandhian engineering." Indian quality has improved at least as fast as Korea's: seven years ago, Tata exported 20,000 cars to Britain under the MG Rover badge. India's auto market in 2009 was still only one-sixth that of China but growing briskly. India's 1.2 billion people, including an educated elite as populous as France, have vast innovation potential that's already transformed industries from prosthetics to software. India still lags behind China in overall development and coherent central policy, but the country could be ahead of China in other key institutional factors. It'll be quite a horserace—not to mention Brazil, Korea, maybe Russia, and more.

an established Revolutionary+ design will be best positioned to produce it quickly, whether to win or defend market share.

The Enabling Role of New Policies

The nirvana of autos that use little or no oil is in sight. Mutually reinforcing technologies, economies of scale, and manufacturing innovation, in both raw materials and finished products, will make Revolutionary+ autos affordable; the question is when. In 2030, both battery-electric and fuel-cell vehicles would still be priced a few thousand dollars higher than the Energy Information Administration projects for comparable business-as-usual models, but their higher price would be more than repaid from fuel savings within three years. By 2050, ever-cheaper batteries and fuel cells would bring the vehicles' price down to $29,000—about $500 more than business-as-usual autos (fig. 2-11). Attractive, safe, sporty, fuel-sipping, and eminently affordable, such autos should fly out of showrooms.

But that still leaves a huge problem. How do we jump-start the rapid development of Revolutionary+ vehicles today, so that their prices will drop to economically compelling levels by 2030? Their early price premium would be so high that they'd sell only to a high-end niche market of early adopters.

Fortunately, there are ways to ensure the widespread adoption of Revolutionary+ autos by 2050. Smart policies can unlock and accelerate this transition by changing buyers' price signals to favor advanced-technology vehicles, and speeding retooling to make them. Non-fiscal, light-handed policies—fresher and more effective than fuel taxes or CAFE standards—could boost innovation and speed retooling even better than standards without picking technology winners, mandating specific solutions, or raising subsidies or taxes. Then government can steer the transition while

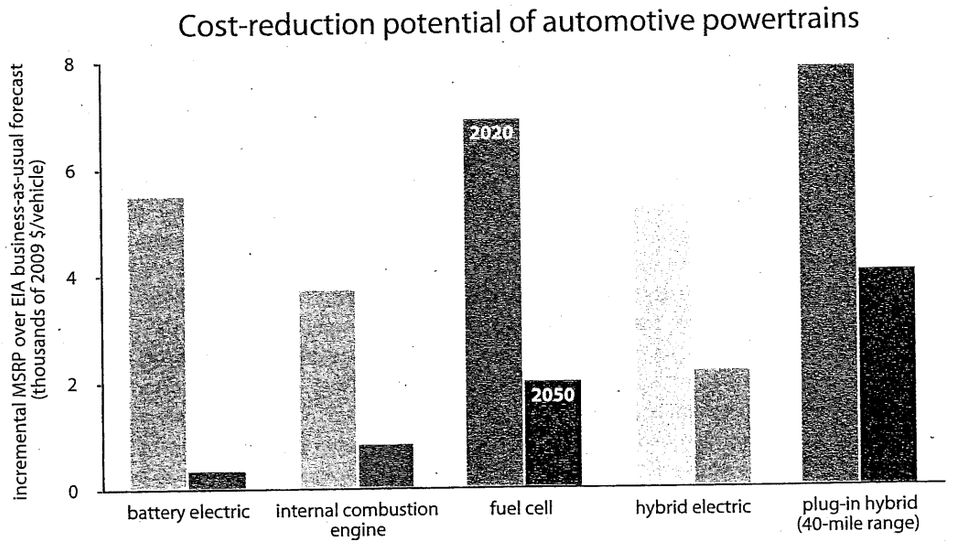


FIG. 2-11. By 2050, the sticker-price premium for Revolutionary vehicles, compared to EIA's projected business-as-usual autos, would drop dramatically.[78]

free enterprise does the rowing. To cross the finish line first, one adjustment to the tiller has unique strategic value: the "feebate."

Feebates

Feebates make efficient autos cheaper to buy and inefficient autos costlier.[79] Buy a fuel hog and you'd pay an up-front fee, right on the price sticker, that climbs as its fuel economy declines. But choose a fuel sipper instead and you'd get a rebate funded by others' fees: the more efficient the auto, the bigger the rebate. Crucially, this is not a wealth transfer scheme. Feebates offer buyers an incentive to buy more of a good thing for themselves and for society—efficient autos—and less of a bad one—inefficient autos. Nor is it a tax: just choose an efficient model and you get an on-the-spot rebate. The Treasury's revenues don't change. And setting feebates separately for each size class would reward you for buying a more efficient model of the size you want.

Feebates provide a powerful price signal that influences auto-buying decisions at the instant they're made. Feebates also maintain a continuous incentive for automakers to innovate. In contrast, government standards may stagnate for decades and give automakers no incentive to beat the standard, while gasoline price spikes only temporarily and unpredictably change consumers' preferences.

Feebates work. The biggest program, in France (fig. 2-12), began at the start of 2008. It charges up to €2,600 or gives out up to €1,000 across seven classes of auto efficiency. The result? Market share for the more efficient models nearly doubled. Market share for fuel hogs fell threefold. While high fuel taxes and CO_2 standards also helped, feebates tripled the speed of efficiency gains, through periods of both high and low fuel prices. Countries with high fuel taxes and CO_2 standards, but without feebates, did not see the same shift, nor did they achieve the same rate of carbon emission

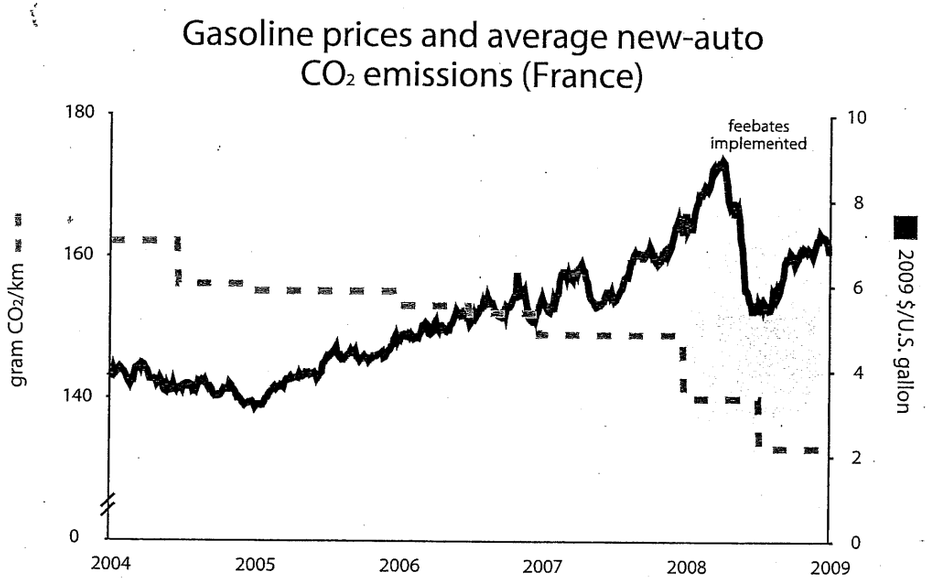


FIG. 2-12. France's spectacularly successful feebates tripled the speed of auto efficiency gains, even when fuel prices were low. Details are adjusted annually. Other feebate programs have succeeded in Denmark, Norway, Holland, and Austria.[80]

reduction. The French program was such a howling success that the rebates totaled far more than the fees, running up a €710 million deficit in 2010. A revenue-neutral design, adjusted each year, would avoid such deficits.

So are U.S. feebates politically feasible? Inside-the-Beltway mutter says no, but the evidence says yes. If a federal feebate bill (introduced in 2009) didn't pass, states or regions could fill the gap: California and its 16 state partners on auto-efficiency rules are two-fifths of the U.S. auto market, enough to swing the whole market. The California legislature passed a feebate by a seven-to-one margin in 1980 (though outgoing governor George Deukmejian pocket-vetoed it because automakers, who hadn't been properly engaged in its design, were uncertain or divided). Now the state is considering a feebate again, and a late-2009 politically balanced survey of 3,000 California households found 76% support.[81] Some automakers, too, already believe well-crafted feebates would help them make more money at less risk and speed innovation. Dealers could support feebates to boost sales and margins. Such industry support, plus national-security and environmental constituencies, could be politically potent.

So what could feebates achieve? Large rebates and avoided fees—totaling perhaps up to $4,000–$5,000 per auto, comparable to manufacturers' SUV rebates of the mid-2000s, and lower than the current $7,500 credit for electrified vehicles—would trigger a virtuous cycle. People would buy enough Revolutionary+ autos to propel automakers down the three mutually reinforcing learning curves that together can achieve three-year or shorter paybacks before 2030 (fig. 2-13). Feebates could even be conditional on electrification in order to speed the journey beyond oil, replacing

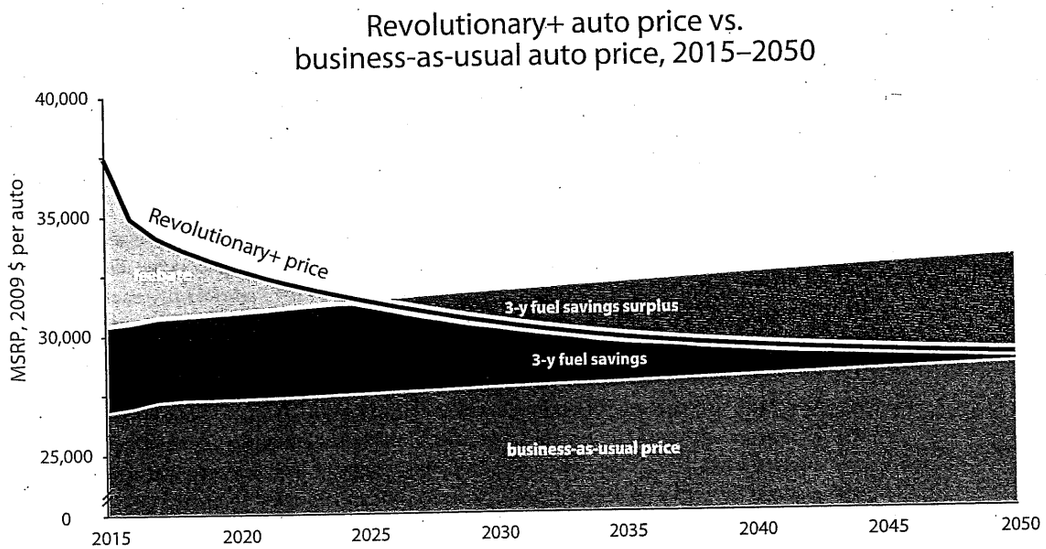


FIG. 2-13. The first three years' total cost of ownership[82] starts higher for Revolutionary+ autos. An initial revenue-neutral feebate covers the premium as up-front cost falls with production volume. By about 2030, fuel savings pay back that premium in three years, so no feebate is needed. Soon thereafter, the autos are creating a societal surplus totaling $2 trillion in 2010 net present value (assuming government-forecast gasoline prices). The curve for fuel-cell autos is very similar, lagging by a few years the battery-electrics shown here.[83]

federal tax credits with self-financing feebates and eliminating current perverse incentives that favor big batteries over fitter autos.

The autos then would rapidly become cheaper, further accelerating their success, which would stimulate more innovation and bring even lower prices. As a result, feebates could be phased out entirely by 2030, when Revolutionary+ autos will pay back in about three years at reasonable fuel prices. Further improvements would then continue, cutting autos' mobility-fuel needs 84% by 2050.

Could we do even better? Besides feebates, there's a host of clever ideas that could further offset the initial price premium of Revolutionary+ autos, in turn accelerating manufacturers' retooling to build them, and sooner achieving their benefits.

Fleet Procurement

Fleets, including rental fleets, employ about 7% of U.S. autos and light trucks, drive their vehicles about twice as much as private owners, and resell them about twice as fast, so they can strongly influence the whole auto market. If governments or big fleet owners, perhaps encouraged by feebates, bought the most efficient vehicles available that are cost-effective on a life-cycle basis (as federal rules require), that investment could jumpstart learning curves, driving down everyone's costs quickly. This would be a boon for manufacturers because fleets have such strong purchasing power. Just three officials in the U.S. General Services Administration, the Department of Defense, and the Postal Service together control more than 650,000 autos and buy about 70,000 annually.[84] If they could commit to future purchases of highly efficient autos and all commercial fleets followed suit, this would slash manufacturers' risk and accelerate Revolutionary+ retooling.[85] And when big buyers are prepared to commit to buys at certain specifications and prices, a proven "golden carrot" program that shares this intention with automakers would encourage them to offer such vehicles without worrying about whether they'll have timely customers.

New York City's taxi fleet is currently one-third hybrid-electric. Mayor Bloomberg's plan to mandate the conversion of the entire fleet to hybrids was struck down by the U.S. Supreme Court because city governments can't regulate emissions and efficiency—only Washington can. Efforts are under way to revise the federal law on which the ruling was based, so local officials can enact laws to improve emissions and efficiency. But meanwhile, absent federal regulations, they can adopt policies that reasonably influence (but don't mandate) fleet choices—for example, by focusing just on life-cycle cost to minimize taxi fares.[86] Cities and states remain free to mandate changes in public fleets too, so Massachusetts governor Mitt Romney in 2004 ordered 5,600 hybrids for state use and ordered state agencies to buy vehicles with a 20 mpg rating or higher.

Cash for Clunkers

Another approach: speed the retirement of old, inefficient vehicles to save oil and speed turnover of the automotive stock. A recent example is the "cash for clunkers" Consumer Assistance to Recycle and Save Act of 2009. CARS got nearly 700,000 "clunkers" off the road and replaced them at an unexpectedly high average gain of 9.1 mpg. The $3 billion allocated was committed in probably the first week of the program, which boosted GDP by an estimated $3.8–$6.8 billion and created or saved 60,000 jobs. The program could have been improved by pegging the size of the award to the efficiency gain; by paying for clunkers without requiring a new replacement be bought; by encouraging carsharing and other modes of mobility; and by financing low-income Americans' purchase of efficient autos so they can afford to drive to work. Making efficient autos affordable to these households, when combined with accelerated scrappage

of inefficient autos, would also offer Detroit a new million-autos-a-year market from customers who otherwise couldn't qualify to buy a new auto.[87]

Affordable Government Financing

There's already a long and successful history of using federal dollars to jump-start innovation and new industries, from microchips to the Global Positioning System. Now, taxpayer dollars could be loaned to automakers, with appropriate accountability and safeguards, to convert or build production capacity and retrain workers for Revolutionary+ vehicles, as is already being done for ordinary autos' efficiency improvements.[88]

Prize Competitions

Lindbergh flew the Atlantic to win a prize. Longitude became measurable because of a prize. The $10 million Progressive Automotive X Prize motivated private teams to build safe, affordable, two- and four-seat cars that achieved at least the equivalent of 100 mpg with a 200-mile range. Future prizes, private or public, could be larger and based on autos sold. These policies all have the same effect: by boosting demand, guaranteeing purchases, or funding development, they help automakers spread production cost and reduce their sales risk for new superefficient vehicles.

Modernizing Old Policies That Hobble U.S. Automakers

Finally, to compete fairly and fully in tough global markets, U.S. automakers and suppliers need not just these new policies but also changes in some old ones (see U.S. Automakers' Three Handicaps sidebar) that make fast followership riskier for them than for their competitors. They're talented enough to overcome that risk by extraordinary effort—but why make their path so much harder?

The Risks and Rewards

For the whole value chain from suppliers through automakers to dealers (see Implications for Auto Dealers sidebar), a new automotive strategy is emerging: (1) Using feebates to vault initial price barriers, quickly introduce Revolutionary vehicle fitness, and use it to enable electrification. Such Revolutionary+ autos tightly integrate three game-changing technologies—advanced ultralight materials, their rapid structural manufacturing, and electric powertrains. (2) Drive and exploit the rapidly falling costs of all three to build volume, gain share, and cut costs even more. While legacy manufacturers are wringing pennies out of the nearly flat learning curves of century-old steel stamping and engines, these three learning curves are fresh and steep, savings thousands of dollars per car—and all three powerfully reinforce each other.

This strategy could be as transformational as jumping from tiny refinements in mechanical typewriters to the dramatic Moore's Law–driven gains in computers. IT and electronics are now America's biggest industrial sector; typewriter makers are gone. The CEO of BMW, pushing the carbon-fiber-and-electrified auto frontier, gets it: his speeches announce that his firm does not intend to be a typewriter maker.

For the companies in the highly competitive auto industry, however, the challenges are both exhilarating and terrifying. Executives must decide which of many types of vehicles to build, what materials and manufacturing processes to use, and how quickly to invest in revolutionary advances. They must make these choices without knowing whether the coming decades will bring recessions or prosperity, spiky or stable oil prices, high or low interest rates, helpful or crippling regulations, even war or peace. The industry has long lead times: typically four years' research and eight years' development to design and start mass-producing a new vehicle, followed by roughly eight-year cycles of cosmetic freshening, reskinning, restyling, reengineering, and redesign. Wrong bets can be fatal. Look how many automakers, from Duesenberg to Hudson to Nash, have vanished, or how close GM and Chrysler came to disappearing in 2008.

Fundamental to a durable automotive sector, therefore, is a strategy of systematic derisking by cutting capital intensity, lead times, oil dependence, borrowing needs, complexity, inflexibility,

U.S. AUTOMAKERS' THREE HANDICAPS

The Big Three automakers, besides being in an inherently tough industry,[89] labor under three handicaps imposed by public policy and national politics. First, U.S. auto efficiency standards and offerings still lag those abroad. Ten leading countries beat the efficiency of U.S. autos now on the road by an average of about 30% and aim to stay ahead. The new 54.5 U.S. standard for 2025 is one-sixth weaker than Europe's for 2020, and may be leapfrogged again—even by China, whose current standards flunk most U.S. SUVs.

Second, historically cheap gasoline makes America the only automaking country where such inefficient cars can be affordably fueled. European autos are about 30% more efficient, and driven 60+% less per capita,[90] not because their designers are more capable, but largely because a gallon there is taxed to cost $6–$9, not $2–$4. This affects auto design. Saving a pound by shifting from steel to aluminum costs about a dollar and saves about a gallon of gasoline over 12 years' driving, so if that gallon is worth, say, $3, the lightweighting pays back in four years, longer than most buyers want. U.S. automakers' unusually cheap domestic gasoline makes domestic buyers less eager than foreign ones to buy efficient autos. This mismatch between home and export markets' preferences is a competitive weakness in a global industry.

Third, gridlocked federal policy hasn't helped. For more than two decades, oil companies have called for stiffer auto-efficiency standards, and automakers for higher gasoline taxes. Many environmentalists want both; many politicians want neither. These titanic lobbies fought each other to a debilitating standoff until a brief interlude of federal policy coherence, and a wave of reform as the automakers surveyed the wreckage in 2008–2009, began to break the logjam. Yet the same conflict between domestic and foreign market expectations for this global industry is now being replayed in climate policy.

IMPLICATIONS FOR AUTO DEALERS

The shift to Revolutionary+ autos is important to auto dealers, who as a whole are a powerful force that provides a tenth of many American communities' sales-tax revenues. During 1999–2009, the average U.S. dealership made only about $50 net profit selling each new auto, or $40,000 per year, but cleared $94,000 on used-auto sales and $279,000 on service and parts. Ultrareliable, extra-durable, radically simplified autos could threaten this model. Even oil changes could become a tale to tell the grandkids.

However, new software and hardware upgrade opportunities would abound, creating new businesses that could rival providers of smartphone apps. Dealers could become the center for customizing increasingly software-based autos and for add-ons, ranging from extra range and pep modules to integrated entertainment and security options. Dealers have always found ways to exploit their customer relationships and skills when technologies changed. Mr. Goodwrench is becoming Ms. Goodchip, but life goes on.

The smarter dealers are already eager to get their hands on Revolutionary+ autos because of their powerful potential to create value and engage customers. Dealers could well find that early adoption and expertise could make them as popular as iPhone distributors with precious stocks of the latest hot model. When oil prices spiked in 2008, high demand and short supply drove up the prices of hybrids like the Toyota Prius and Ford Escape, often to thousands of dollars above list price. Prius had earlier doubled dealers' average margins for a considerable time. Supply-constrained introduction of Revolutionary+ autos could well repeat this happy (for dealers) history, but repeatedly and in short model cycles more akin to those of consumer electronics.

and societal impacts (especially carbon emissions). Revolutionary+ vehicles, once mature, could potentially do *all* these things.

Of course, they'd introduce new, nontrivial risks of their own. Manufacturers will need to change cherished perceptions of value, selling light weight and acceleration instead of heft and horsepower, and beating their own legacy products before competitors do. The perception of a safety problem can kill a model or tarnish an entire brand. Yet with Revolutionary+ autos, consumers will be asked to believe in the safety of a number of new technologies. Will they be convinced, for instance, that ultralight autos are safe on roads filled with 18-wheelers? Or that the featherweight vehicles made of the same light, super-tough, noncorroding materials now familiar from sporting goods will last for 15 years or perhaps much longer? Even clever marketing campaigns may not be enough to overturn deeply held beliefs that only weight brings safety and durability.

So there's no question that leading on this path to an oil-free future is risky. But here's the surprising twist: lagging can be still riskier. The cheapest and fastest ways to save oil and carbon, and to meet automakers' other seemingly conflicting requirements, are also the best ways to manage business risks and exploit new business opportunities.

That's because Revolutionary+ automobiles are potentially simpler, cleaner, higher performance, safer, more reliable, and more durable than today's autos. They permit mass customization because most functionality is in software—they're more like computers with wheels than cars with chips. They enable production with shorter cycles and more flexible scale. They offer more potential for further cost reduction and simplification as even better materials, manufacturing methods, and powertrain components emerge and converge. They make cheaper *any* of the four innovative powertrains now extant—battery-electric, fuel cell, plug-in hybrid, or advanced-biofuel advanced-engine hybrid—driving vibrant competition and rapid improvement in all four (and perhaps others not yet thought of). They need less capital investment. And the learning curves behind their three advanced technologies will give pioneering companies lower manufacturing costs than slower competitors, bringing the first movers and fast followers most of the spoils and the laggards most of the spills. This makes incrementalism the *high*-risk strategy.

Consider how Toyota's boldly accelerated 1997 Japan launch of Prius is still challenging competitors 14 years later to catch up to the company's overwhelming dominance of the hybrid marketplace. Being a pioneer let Toyota "green" and pep up its luxury models and hybridize Camry, one of the world's most popular sedans. Nissan now seems to be seeking similarly to capture the market lead for battery-electric vehicles. The first automaker to jump to Revolutionary+ autos will move much faster by exploiting three simultaneous and synergistic technologies, not just one—the hybrid powertrain—as Toyota did.

The risk of lagging is equally great for automakers' suppliers. A switch to electric traction would make obsolete nearly 30% of sales in Japan's $430-billion-a-year automotive supply chain.[91] But as Hiroshi Tsuda, a former Suzuki president, says: "This is not a crisis. It's a big opportunity." As always when technologies undergo tectonic shifts, innovators find ways to stay ahead—and to reap even greater profits. That will be true not only for autos but for all other vehicles.

USING AUTOS MORE PRODUCTIVELY

As we've seen, better designs and materials can enormously increase the efficiency of automobiles. Now we come to the second big part of the efficiency story: *using* autos more productively. We can eliminate the need for many trips entirely, and we can use vehicles in smarter ways, improving access to places or goods with fewer, shorter, or faster trips. America's real cost of driving (see The Real Cost of Driving sidebar) makes this an economic as well as a national-security imperative.

First, though, we must explode a deeply held myth—that efforts to reduce travel inevitably take away cherished freedoms, choices, and mobility. This myth is so powerful because such fears are real. After all, one effective way to take autos off the road is to simply decree that you can't drive. China, for instance, has yanked hundreds of thousands of autos off Beijing's streets to cut pollution. No wonder taking steps to reduce miles traveled raises the ominous specter of Big Brother or intrusive government.

The efforts we advocate don't curtail freedom or choice. On the contrary, they'd provide wider choice, greater freedom, and more mobility through diverse alternatives to individual autos. But will those alternatives still be attractive as we adopt Revolutionary+ vehicles that drastically reduce the cost of driving? (There are compelling reasons why this won't materially increase driving and cause fuel use to "rebound."[92])

Changing how we use autos doesn't just save oil; it also creates new business opportunities. And it can change a core function from chore to joy. Imagine waking up and having options: Do I feel like jumping into an electric sports car from my carsharing program, and getting on a road that is

THE REAL COST OF DRIVING

Most Americans have only one real transportation option and one option for fueling it; you can "choose" among several vendors of almost-identical gasoline. Due to our lack of other mobility choices, we're powerless when gasoline prices soar. Shrinking government coffers can't sustain our aging transportation infrastructure, let alone significantly expand it. Road accidents, though declining, still kill about as many Americans as breast cancer or diabetes and injure five million a year. Throw in pollution and climate change, and the hidden societal costs of oil-powered U.S. automobiles add up to $820 billion a year (fig. 2-14).[93] That analysis seriously understates energy security costs that by themselves are probably upwards of a half-trillion dollars per year (chapter 1), 40% of which is attributable to fueling autos.

These results are not necessarily surprising. Decades of dedicated road and parking-lot building with little or no proper pricing, competition, information, or opportunity have created socialism for drivers and free enterprise for most other modes of transportation—not a level playing field with honest prices and open choices. But we can fix these distortions by applying some smart market thinking to changing how, when, where, and why we use our vehicles. Along the way, we'll save millions of barrels of oil every day, adding to the savings from Revolutionary+ autos.

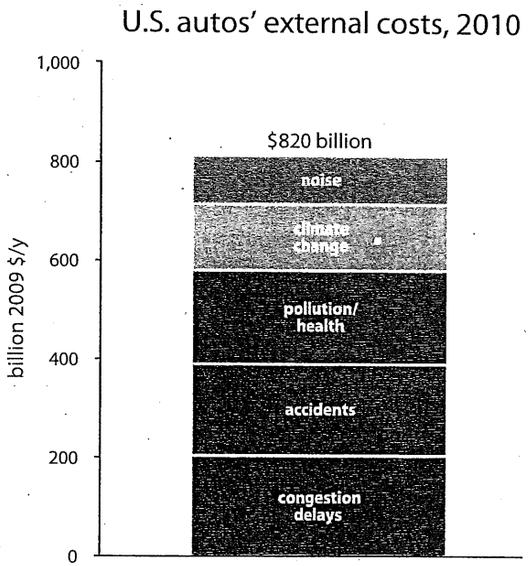


Fig. 2-14. The hidden costs of U.S. automobiles, all paid not at the pump but in ill health, delay, and loss of well-being. Not included are costs to national security and costs of roads parking, policing, et cetera, paid through general taxation.[94]

fast and clear of congestion because of intelligent pricing and better management? Will I fund and enliven my ride by accessing a social network and offering to share it with a friend or stranger headed the same way? Or should I swipe my universal transit card, jump on a readily available bus, get some work done on the free Wi-Fi, then take a bikeshare for the last few blocks to get some exercise? Or do I want to work from home and attend the day's important meetings via my computer's or smartphone's virtual-presence features?

Providing all these options won't always be easy. Americans cherish the freedom to hop into their private autos and drive wherever they please. To some, trying to increase the use of buses or carpools or adding tolls to roads seems like intrusive government at its worst (though building those taxpayer-funded roads was a major imposition, especially on displaced residents and nondrivers). So the key is showing people that these wider choices improve their lives. We can make better use of existing roads, save time, build better communities, and expand options in everything from types of transport to insurance policies. Moreover, we can create a more equitable society where the poor, young, elderly, and disabled enjoy better access.

So how can we achieve these benefits? The most obvious solution is reducing the need to commute to work. Why fight traffic and burn fuel if you can do the same work from home? Telecommuting reduces an average worker's miles traveled by about 40%, saves more energy in avoided office space than the extra energy it uses in the home, and can bring important side benefits, such as more family time and improved morale, retention, and productivity—by 81% among British Telecommunications' telecommuting employees.[95]

Beyond telecommuting, the solutions fall into four main categories (fig. 2-15): innovative pricing, alternative commuting, smart growth, and system-wide transportation efficiency improvements. The basic idea is to make driving and parking bear their true costs at the time of use, foster

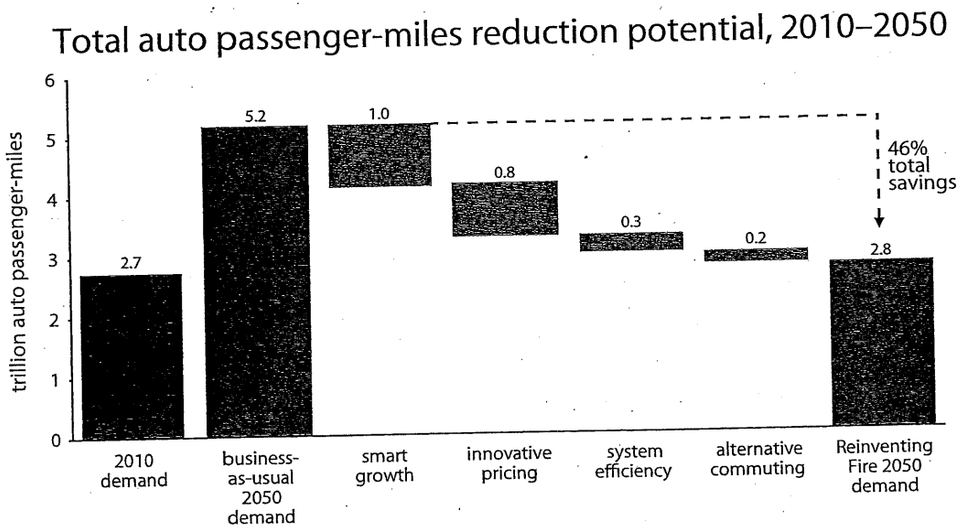


FIG. 2-15. Four ways of using autos more productively can provide the same or better access services at lower cost with 46–84% less driving in 2050.[96]

genuine competition between different modes of transportation (or between transportation and its substitutes), and integrate land-use choices with personal mobility options. Together, based on empirically observed U.S. performance in specific implementation experiments, *these opportunities can by themselves, without making vehicles any more efficient, save 46–84% of U.S. automotive fuel* by allowing us to travel fewer passenger-miles to do the same tasks, thus offsetting the entire projected growth in passenger-miles to 2050.[97]

Innovative Pricing

Reducing vehicle-miles traveled (VMT) can lead to another reboundlike effect: induced demand. If highways become less congested because more people are carpooling or not driving to work, why wouldn't we drive more to take advantage of a newly available, uncongested roadway? The solution is well-designed pricing to achieve the balancing act of decongesting roadways *and* discouraging driving during peak travel hours.

We must do this anyway, because as we adopt efficient autos that use far less fuel, little or none of it gasoline, the fuel-tax revenues that keep up our roads and bridges will dwindle and ultimately vanish. (It would be hard to tax car-charging electricity—a ubiquitous and fungible commodity—or hydrogen; even biofuels can be homebrewed.) The federal gasoline tax isn't indexed for inflation and hasn't risen since 1993 despite enormous increases in the cost and scale of highway construction and maintenance. Real highway spending per mile traveled has shrunk by nearly 50% since the Highway Trust Fund was established in the 1950s, and scary deficits loom: $400 billion by 2015, $2.3 trillion by 2035. So we must pay for our driving infrastructure differently—but how?

Driving imposes social costs like oil dependence and pollution. Autos take up space. Both driving and autos contribute to congestion. Weight also causes road wear, bridge fatigue, and fuel waste (hence pollution).[98] But probably a lot more of driving's societal cost comes from driving than from autos, so it'd be smart to fill the road-funding gap mainly by charging for vehicle-miles driven, by switching from a gasoline tax to a VMT tax.[99]

In 2005, Oregon tested this fundamental change in the way people pay to drive. GPS units recorded how many miles volunteers' autos drove. At the pump, instead of paying the state gasoline tax, the volunteers paid a fee (higher in peak travel periods) based on how many miles they'd driven. Compared to a control group, these Oregon drivers reduced their total mileage by 15% and their rush-hour mileage by 22%.[100]

Suspicions of Big Brother snooping could be eased by offering an array of choices, such as using odometer readings at regular inspection visits to record vehicle-miles, installing on-board diagnostic logs (OBDs), ensuring that GPS location data would be kept private, or simply using GPS, as Oregon did, to store and transmit only mileage, not position.

Pricing mechanisms that reduce peak driving also avoid the need for costly new infrastructure so we can focus on fixing the roads we already have. And congestion pricing can work even without a VMT tax. Just charge drivers a fee to drive when roads are clogged. After Singapore started charging to drive downtown during rush hour, the number of autos coming into town dropped 44% (and solo trips plunged 60%), speeding traffic by 20%. London's fee, now a hefty $16 per day, has cut average traffic inside the central city 15%, sped it up 30%, and greatly expanded bus and bicycle ridership—a special boon to low-income citizens.

Insurance companies are also starting to use a creative new approach that rewards both driving less and using efficient vehicles: pay-as-you-drive (PAYD) insurance. Paying casualty insurance by the mile makes the premium roughly proportional

to the risk, so low-mileage drivers needn't subsidize high-mileage drivers. PAYD insurance has been observed to cut driving about 8%[101] and accidents even more.[102]

Still another way to reduce driving harnesses market-savvy parking policies. A typical city has three times as many parking spaces as autos, yet cruising for a spot is thought to cause a third of major cities' downtown traffic and even more congestion. All those spaces eat up a vast area of land—81% of the Los Angeles Central Business District, 31% of San Francisco, and 18% of New York. Where charged, parking fees rarely cover the true cost of building and maintaining each space, which totals tens of thousands of dollars per spot (just building the parking at Los Angeles' Disney Concert Hall cost $50,000 per space). In all, parking gets $151 billion worth of annual subsidies—perhaps the greatest single cause of excessive urban driving.[103] Yet much of that overbuilt parking capacity is required by zoning and building rules mandating as much parking as drivers might conceivably use if it were all free.

The alternative? Frankfurt, Germany, actually forbids developers of workplaces to provide parking. Britain plans to tax firms that provide free or below-market employee parking. Metro Sydney taxes nonresidential parking spaces and uses the revenue to fund transit improvements. In Tokyo, you can't even buy an auto without proving you own or rent a parking place.

Such policies would be a hard sell in the U.S., where cheap parking is viewed as almost a sacred right. But we can, as companies in smog-prone parts of California are required to do, pay employees the fair market value of the parking at their companies' lots and charge them that rate when they do park there. Workers can use the allowance to pay for parking, or they can leave their autos at home, get to work by other means, and pocket the money. That's an incentive for real competition and wider, smarter choices.

Charging drivers for the costs their driving incurs and imposes is fundamentally fairer than socializing their costs to all taxpayers, a third of whom, though they benefit from road haulage, are too old, young, poor, or infirm to drive themselves—a potentially potent coalition once they realize how they're subsidizing drivers. They'll argue that drivers should get what they pay for—but also pay for what they get. And if the gasoline-tax system isn't fixed, the already-broke Highway Trust Fund will become unable to keep America's traffic moving. Inaction is not an option.

Alternative Commuting

About 77% of U.S. job commuting is by single-person auto. Almost all autos are meant to carry at least four adults, yet for daily commutes, single-occupant drivers outnumber more than tenfold the *combined* total of all Americans who carpool, ride public transit, walk, bike, or telecommute. That lone driver may be the traditional American way, but it doesn't have to be our future. Coaxing more people into each auto, sharing autos, or eliminating trips can together reduce work-related VMT by 6–12%.

Carpooling and Ridesharing

The most direct way to reduce VMT is carpooling. For many years, metropolitan areas from Washington DC to Los Angeles and San Francisco have offered special highway lanes for high-occupancy vehicles (HOVs). Some regions have seen considerable success. In San Francisco, about 3,000 three-person carpools spontaneously form daily at East Bay pickup points, saving about $30 million a year in fuel, time, and transit subsidies. Most riders take the bus home. Similar "slug lines," like taxi lines for carpoolers, form in Washington DC and Houston. In the District, two million rides per year save more than two million gallons of gasoline.

Such ridesharing could get a boost from social networking. New applications with names like Avego and NuRide link drivers with riders, eliminating the uncertainty of depending on slug lines. Even without such tools, ridesharing programs typically displace 5–15% of single-auto commutes—more when incentives are offered, which in the Puget Sound area attracted 10–30% of commute trips into vanpooling.

Carsharing

Ten years ago, Robin Chase and Antje Danielson were sitting in a Cambridge café. Danielson had just returned from Berlin, where she'd seen a branded shared car on the street. The women launched Zipcar—now the largest U.S. commercial carsharing company, with three-fourths of the market.

The business model was simple: Americans now each pay about $8,000 per year for a vehicle that stands idle 96% of the time. For people who don't need an auto to get to work, this makes little sense. People could save money (and Zipcar could make money) if they paid for an auto just when they needed one. As German climatologist Hans-Joachim Schellnhuber quips, "Buying a car to get mobility is like buying a three-star restaurant to get a good meal."

Zipcar now owns more than 8,000 autos in 30 diverse models, parked in 1,200 locations in cities and university towns across the United States, Canada, and the United Kingdom. Its members pay an annual fee plus an hourly rate, fuel and insurance included. Zipcar says each of its autos takes 15–20 personally owned autos off the road. Similar programs in Europe have resulted in a 30–70% drop in VMT. *The Economist* in 2010 reported carsharing models emerging in over a thousand cities worldwide; U.S. membership is projected to approach 4.5 million and revenue $3 billion by 2016.

A new take on the carsharing business model even allows individual auto owners to get in on the action via person-to-person ("P2P") business models. In Boston and San Francisco, owners can register their vehicles with companies like Spride and RelayRides that rent out their vehicles by the hour, day, or week.

Why limit such sharing schemes to autos? In some bike-friendly major cities in Europe, 30–40% of commuters walk or bike. Paris has had enormous success with its Vélib' (*vélo libre*) free public bicycles, now numbering 17,000 in 1,200 self-service stations throughout the city center. Washington DC recently expanded its own bikeshare program, which charges an annual fee and a small usage fee. Having bikes available can remove one of the major disincentives to use transit—that it doesn't go exactly where you want.

Getting people out of their autos sometimes requires new laws and policies. Some businesses can't eliminate costly parking places, for example, because zoning laws demand a certain number of spaces. Auto insurance policies often don't cover ridesharers or P2P (except in California), raising the financial risk when accidents happen. And states and cities impose auto rental taxes on carsharing, increasing the costs of the service.[104]

Smart Growth

For decades, Atlanta's inhabitants pursued the American Dream—moving to a nice house in the suburbs. But the resulting sprawl has dimmed the dream. Atlantans drive more miles than most other Americans and suffer crippling congestion. But in 1999, one developer in the sprawling city chose to build a dense community of residences, shops, and offices on an abandoned steel-mill site in the heart of Atlanta, rather than scattering them across three suburbs. The 130-acre Atlantic Station offered homes for 10,000 people, employment for 30,000, recreational opportunities for millions, and easy access to public transit. For auto-choked Atlanta, the results have been revelatory: area VMT dropped by 30%.[105]

Shifting 60% of new U.S. growth to become more "smart" and compact, like Atlantic Station, would save as much fuel as a 28% rise in the efficiency of new vehicles by 2020. Far from raising costs (to pay for transit), these smart-growth developments typically *de*crease buyers' costs, and later their tax bills. New Jersey found that each new homeowner in a sprawl development pays about $10,000 more for extra roads and extended infrastructure.[106] Most compact development avoids those costs, increases household savings rates, enhances real-estate values, holds value much better in market slumps, and boosts developers' profits.[107]

Smart growth also greatly improves quality of life. "Most people believe the alternative to autos is better transit—in truth, it's better neighborhoods," explains Alan Durning of the Sightline Group. Such neighborhoods, he adds, make the automobile "an accessory of life rather than its central organizing principle." This rebuilds community by reversing decades of what architect Andres Duany calls "meeting our neighbors only through windshields."

It's easy to see why smart growth commonly cuts the length and number of trips by auto by half, and in the best recent designs by three-fourths.[108] Such developments are dense, putting the dry cleaner, bagel shop, gym, or even office a short walk or bike ride away (while also facilitating local delivery and online shopping for heavy or bulky items[109]). They're typically built in underused urban neighborhoods, bringing people nearer jobs and kids nearer schools. They avoid the repetitive "dead-worm" cul-de-sacs of many suburbs, where visiting a neighbor on the next street may mean jumping in an auto and driving to a main road before dipping back into the neighborhood. They can also improve public health through exercise by making walking and biking safe again. And they make buses and light-rail systems more effective, especially in communities like Arlington, Virginia, where dense mixed-use development is encouraged to cluster around Metro stops.

Pricier urban housing can often *decrease* a household's *total* costs.[110] Why? Because suburban transportation costs—gasoline, congestion, accidents, et cetera—are higher. Traditionally, housing is deemed "affordable" if it consumes no more than 30% of income; on that basis, 69% of U.S. communities have affordable housing. But including transportation costs cuts the affordable fraction of communities to 39%.

That's why Fannie Mae offers—if you can get one—"locationally efficient mortgages" with easier qualification for households near work or transit, reflecting their better cash flow and lower default risk. How much lower? Natural Resources Defense Council scientist Dr. David Goldstein, who pioneered that concept, notes that an average location-inefficient homeowner, over a 30-year mortgage life, pays about $300,000 for car commuting and $75,000 for home utilities—in all, twice the $175,000 median price of the house. An energy-retrofitted, locationally efficient home saves at least 63% of that total, or one-third more than the price of the house. No wonder high-driving regions have lately had by far the highest mortgage default rates while smart-growth, compact, transit-served areas have had the lowest. The differences in default rate were as high as 40-fold after controlling for other variables like credit scores and income. If this were more widely appreciated, smart growth might help inoculate our economy against another mortgage-induced financial meltdown, protecting capital markets and cutting interest rates.[111]

Together, then, smart growth is important not just to the developers whose property values, margins, absorption, and appreciation it enhances, but to all business. Workers who spend less time commuting, arrive less stressed, can better balance work with family life, and have more time with their kids are more valuable and productive. Businesses in a smart-growth area can better recruit and retain the best workers yet needn't pay them so much to offset their high commuting costs. Less traffic and perhaps more exercise also mean safer and healthier people, cutting healthcare costs and sick time. Smart growth is just another part of smart business.

Boosting Efficiency in Transportation Systems

What's the most frustrating part of taking public transport? Often it's not knowing when the next bus or train will arrive.

Plenty of entrepreneurs are stepping into this breach. Transit systems like the Massachusetts Bay Transit Authority already broadcast real-time bus locations. NextBus uses GPS to provide accurate vehicle arrival and departure information and real-time maps to any passenger with Internet access. More innovation is brewing. Anna Jaffe's Mobi team at MIT is working on an ambitious integration: you enter your destination into your smartphone (which already knows where you are), and up pops a list and map of all the ways to get there—transit, ridesharing, Zipcar, free or rental bikes, whatever—with their cost, location, and real-time-savvy estimated arrival time.

Such "intelligent transportation systems" (ITS) can make traffic flow more smoothly by controlling traffic lights to match changing conditions, advising drivers about hazards or jams ahead, using ramp meters to smoothly insert autos into the traffic, or charging tolls on the fly electronically, to name just a few. Taking all these steps would cut fuel use by 5% and prevent 308 million person-hours of delay per year, worth $6.5 billion.[112]

That leaves one more "system" that can be tweaked to save fuel—drivers themselves. Changing *how* we drive can significantly boost efficiency in any auto, on any road.

Just bringing tire pressures up to recommended levels and using improved synthetic engine oil would cut U.S. gasoline use by 1–3%. Once on the road, the key to fuel efficiency is a light touch on the accelerator and brakes, coasting up to red lights or traffic jams, avoiding jackrabbit starts (except in many hybrids where brisk acceleration can *save* fuel), and driving slower. Hybrid autos, and some nonhybrids, also turn off their engines automatically when stopped. We can remove unused heavy junk from the trunk, open windows at low speeds instead of using air-conditioning, and put shades in the windshield when parked to keep auto interiors cooler.

The most effective way to encourage these changes in driver behavior, it turns out, is to give drivers more information about how they're doing. Real-time mpg indicators on the dashboard can turn driving into a contest to see who can get the best mileage. A British government report estimates that efforts to promote "eco-driving" can save 10–15% of fuel in the long run—and the cost is nearly zero.

Together, all these ways to use autos more productively can save a 2010 net present value of about $0.4 trillion, deliver the same or better access to where we want to be, and improve the quality of our lives and the strength of our families and communities. Far from losing convenient access, we'll improve it. We'll unclog traffic, save time and tension, cut pollution and noise, save lives now lost to traffic accidents, reclaim land from roads and parking lots, reduce tax burdens—and take another giant step toward getting off oil.

THE REST OF THE STORY: BEYOND AUTOMOBILES

Automobiles use 60% of U.S. transportation's oil—by far the biggest leverage point in the transportation sector's energy use. But what about all the

other vehicles we rely on? What opportunities lie in their smarter design and use?

Heavy Trucks

Jimmy Ray is a straight-talking, charismatic veteran of the U.S. trucking industry with decades of experience maintaining, driving, and managing Class 8 trucks.[113] He runs Mesilla Valley Transportation, a large, highly successful, locally owned freight service provider based in western Texas and southern New Mexico. One secret to his success: efficiency. The big rigs in Jimmy's 800-tractor fleet are sleeker than typical 18-wheelers, since two-thirds of the energy needed to move trucks over the road is caused by aerodynamic drag. Many of his trucks sport wide tires in place of the usual two adjacent narrow ones, further reducing aerodynamic drag and cutting the rolling resistance that accounts for the remaining third of tractive load. Jimmy also offers quarterly rewards to the most efficient drivers (and every year, the most efficient driver wins a Harley-Davidson motorcycle). U.S. heavy trucks are officially projected to average 7.8 mpg by 2050. Yet in 2010, forty years early, Jimmy's fleet averaged 8.5 mpg.

His innovations are but the tip of an iceberg of technical, operational, and logistical improvements for trucks that can save about a tenth of U.S. oil, help insulate the trucking industry and its customers from high oil prices, and keep the U.S. economy humming. Moving goods, not people, burns upwards of 28% of the fuel used for transportation. Despite a sophisticated industry whose trucks use highly efficient diesel engines, most of that fuel is wasted. This doesn't have to happen. Focusing on design and operational changes can cut total U.S. big-rig diesel fuel consumption 41% by 2050 despite 88% more heavy-truck-miles.[114]

As with autos, the solution starts with physics. Modern aerodynamic improvements (fig. 2-16) and today's better, wider tires can take the typical 2010 Class 8 tractor-trailer rigs dramatically beyond their average of 6 miles per gallon of diesel fuel.

Another tweak connects fewer axles to the engine, cutting hundreds of pounds in driveshafts, gears, and differentials. The unpowered "tag axles" tag along behind the powered ones. Saved weight is usually taken up in more payload—a valuable feature.[115] Saved drag often permits an engine that is one size smaller, and hence lighter and cheaper. Electronic active suspensions can recover some of the energy of bouncing over bumps and potholes. Combining all these technologies could yield a competitively priced 8.9 mpg truck.[116]

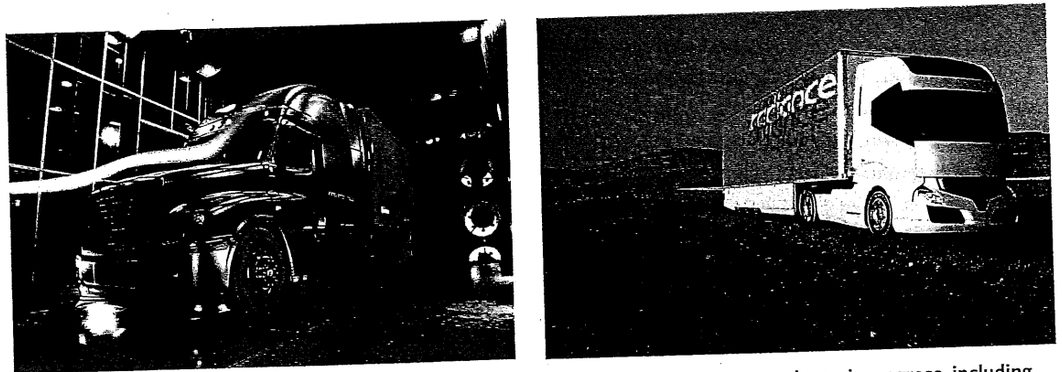


FIG. 2-16. The Daimler Innovation Truck (left) and Renault Radiance (right) illustrate aerodynamic progress, including fairings, underbody panels, and side-view cameras replacing mirrors.

Adding some simple hardware brings another leap. To understand why, look at the typical truck stop, where dozens of trucks are parked with their engines running to power the air conditioner, lights, and electronics during drivers' mandated breaks (which must last 10 hours after 11 hours of driving). These idling engines eat up 12% of typical heavy trucks' fuel. Two-thirds of this idling waste can be saved with an auxiliary power unit (APU) such as a small diesel generator, fuel cell, or battery. Plugging into an electrified parking space (EPS), as moored ships and parked airplanes do, saves all of it.

A huge South Bronx truck depot handling most of greater New York's produce offers a glimpse of what's possible. Community activist Majora Carter persuaded the operators to double the overnight parking fee from $10 to $20, but also to include an EPS to eliminate idling. Drivers come out ahead by saving more than $10 worth of fuel plus engine wear and tear, while the neighborhood benefits from big drops in its extraordinary levels of diesel-particulate-induced asthma.

Such straightforward design improvements would save 1.7 million barrels of diesel fuel each day (fig. 2-17). Even assuming 2009's low diesel price of $2.47 a gallon, this translates to savings of $64 billion per year.

Fuel savings per ton-mile of cargo improve further when trucks hitch a second or third long trailer behind the first on highways, on which most cargo moves. Such mammoth rigs are controversial because of their size and weight, which rises from 80,000 to as much as 120,000 pounds. But the number of axles rises even more, from five to nine, so weight per axle—the key to road wear—*decreases* by one-sixth. Smarter links between trailers and active electronic safety aids

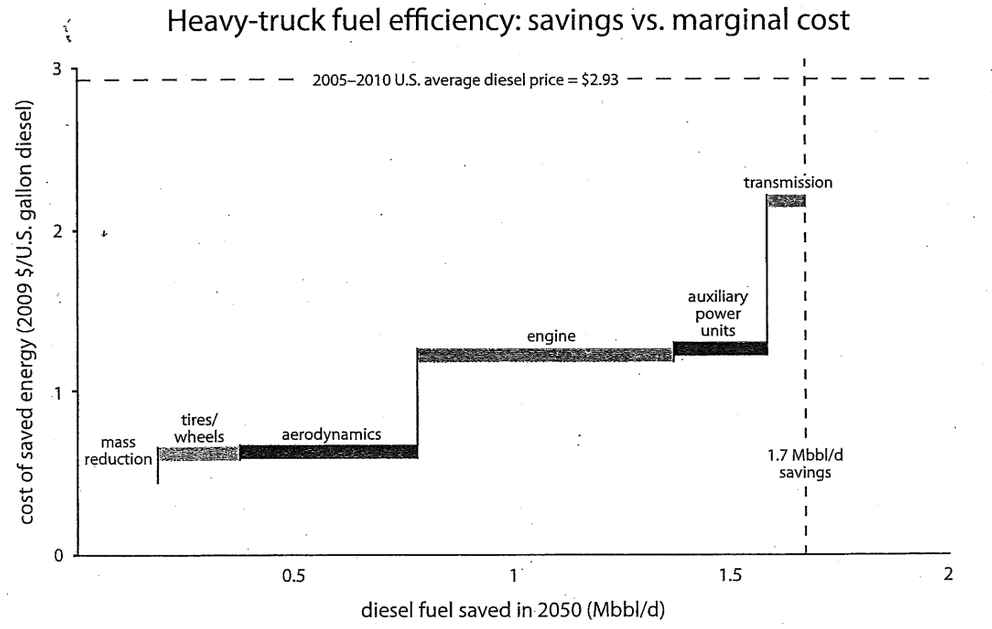


FIG. 2-17. Better design of single-trailer Class 8 trucks could save the U.S. 1.7 million barrels of diesel fuel per day at a fraction of the cost of diesel fuel.[117]

make the long trailers of such turnpike doubles, as they're known, inherently more stable than today's short double trailers, and much safer than today's triple trailers. Turnpike doubles can boost nationwide heavy truck efficiency by 7% (beyond the design changes cited in figure 2-17) because of their doubled cargo capacity. Shifting to these long combination vehicles can also cut congestion by reducing the total number of trucks on the road and cut cost by saving tractors and skilled drivers (of whom there's a worrisome shortage).[118]

To reap these benefits fully, the allowable trailer length should be increased nationwide—as some states have already done—from 53 to 59 feet. Furthermore, the maximum allowable gross vehicle weight rating (GVWR) should be increased to 97,000 pounds (which is still less than Britain's current limit of 110,000 pounds).[119]

With such big, technologically advanced rigs humming along the highways, the U.S. could haul its cargo with an amazing 41% less fuel than today's 6 mpg average. Further improvements could come from more efficient truck refrigeration and advanced emissions controls, superefficient engines, hybrids on some routes, and closer attention to auxiliary and accessory loads.

The even better news is that all these reductions would be relatively cheap: a fit, aerodynamic truck with wide single tires and a superefficient engine would pay back in just over three years with diesel at $3.00 a gallon. As Jimmy Ray likes to say, "We get our tires for free"—that is, the small incremental cost of superefficient tires pays back almost immediately.

Overcoming Obstacles to Heavy-Truck Innovation

The bad news is that this dramatic cut in trucking fuel faces more hurdles than just the cost of the technologies. Higher maintenance costs, such as for add-on aerodynamic features, sometimes cut into the fuel savings. Tractors and trailers are usually made and often owned by different companies, making it hard to integrate the design of the whole rig to achieve the best aerodynamics.

Industry standards, vertical integration, new business models that share the savings, and the demands of big customers can help solve these problems. For instance, in just five years Walmart was able to reduce by 60% its heavy-truck fuel use per ton-mile from its 2005 level (handily beating its 2005 goal of a 50% reduction by 2015) and is looking for more gains.[120] With one of the world's largest civilian heavy-truck fleets—6,400 tractors—Walmart could compel truck, and indeed tractor and trailer, manufacturers to work together to boost efficiencies.

Another problem is the structure of the trucking business. Only about 20% of truck ton-miles get moved by the private fleets of companies like Walmart, where increased fuel efficiency makes clear economic sense. Most of the rest is moved by for-hire firms that, in turn, rely on the services of more than 540,000 independent contractors. The companies hiring these truckers have little incentive to invest in efficiency because the drivers buy their own fuel. And while independent truckers typically drive older, inefficient rigs and would benefit greatly from fuel efficiency, they simply can't afford fuel-saving technologies or newer, more-efficient trucks.

However, clever entrepreneurs are figuring out how to get fuel-saving improvements into the hands of the small operators. Jon Gustafson at Cascade Sierra Solutions has set up a series of trucker-to-trucker kiosks at West Coast truck stops to advise on technologies and best operational practices. In 2004, his colleague Sharon Banks launched "Everybody Wins," a program that finances APUs with lease-to-own contracts along with grants and tax credits. It has since financed 350 mainly small operators' upgrades, saving more than 0.7 million gallons of fuel per year and much pollution.

More broadly, capitalizing the fuel savings of doubled- and tripled-efficiency heavy trucks into a lease could enable small operators to buy a new rig before big competitors who first buy those breakthrough trucks have put them out of business—a great opportunity for leasing and financial companies.[121]

Trucks can also save fuel when drivers are trained in efficiency. Highway cruising at 65 mph instead of 70 boosts fuel economy by more than 8%. Route optimization can more than make up for the slower speed and help operators deliver on or ahead of schedule. Still lower speeds further reduce air drag, since drag increases as the *cube* of speed.

Picking the right gear (out of as many as 18 on a big rig) saves as much as 10% of fuel, so driver training or dashboard up- and downshift lights help. So can innovative cruise control systems: Daimler's new Predictive Cruise Control plans optimal gearshifts a mile in advance.

Jimmy Ray trains his drivers to accelerate slowly and cruise efficiently with the aid of electronic controls and displays that show real-time mpg. He also limits their speed with a 63-mph governor and monitors their performance with an onboard tracking system. The result? A 6% gain in mpg.

These reforms aren't always easy to implement. Drivers paid by the haul have a powerful incentive to drive faster. Shippers and carriers are often not well coordinated, even internally. But we can take effective steps. Paying drivers by the hour would encourage efficiency and could save more fuel than the extra labor cost. So would regulations, electronic logs, GPS uplinks, and speed governors that keep drivers from driving too long and too fast. Compound trailers can be loaded in tandem, or their drivers paid to wait for loading—it's cheaper than needing an extra tractor and its driver for the second trailer's whole route.

Using Trucks More Productively

We needn't stop with doubled-efficiency trucks. We can also be much smarter about how we use trucks in the first place. We can reduce the number and length of trips, or figure out how to ship fewer goods, or make sure our trucks are full.

Here are the key areas for improvement.

Logistics

Both independent truckers and big fleets abhor "empty" miles—trips made with no cargo (which currently typically make up 10–28% of a heavy trucking fleet's total miles).[122] The solution is consolidating shipments across carriers, shippers, and platforms via third-party logistics (3PL) firms, IT companies, and initiatives like the Empty Miles Service. This boost in truck productivity per mile saves 5–15% of heavy-truck fuel at a profit. One European retailer raised the average load per truck from 85% to 93% of full capacity, saving 10,000 outbound loads per year. Carrefour's Demeter Environment and Logistics Club helps companies coordinate their shipments to reduce backhauls; one of its retailers has even reported that only 5% of its fleet's miles are empty.

Fewer Miles

Another way to cut fuel and cost is to drive more efficient routes. Coca-Cola's Simply Orange Juice shipments used to stop at Minute Maid's Florida distribution center to pick up juice for delivery. Now the product travels straight from factory to regional distribution centers. Eliminating the extra stop saves 144,000 gallons of diesel fuel each year while stretching product shelf life by up to six days.

Making products or growing food closer to customers can also shorten routes. Certain soft-drink producers are moving toward in-store or home-fountain production; Walmart makes bottled water at its distribution centers, not a remote factory. (Better yet: use tapwater.) Some

medium- and light-duty commercial fleets are consolidating home deliveries into secure, insulated giant mailboxes, further reducing hauls.

Less Wasted Space

Surprisingly, empty air still makes up the biggest volume shipped in many firms' supply chains. IKEA, famous for making its bulky furniture products collapsible, even employs "air hunters" who design products to stack more densely and completely fill each truck while balancing denser with fluffier cargoes.[123] Big retailers are pushing their suppliers to cut packaging, redesign products to fit more in a truck, and fine-tune pallet designs to minimize empty space at the top of the truck.

Fewer Tons

We can also save large amounts of fuel by shipping less cargo. Rapid innovation and improvement are shrinking countless products, from industrial equipment to consumer goods like music players. Look at Proctor & Gamble's concentrated detergents. The large volume of water formerly in the bottle, which had to be shipped from afar, is instead added from the user's tap. Products are lasting longer and being designed for repair, remanufacturing, reuse, and recycling. Superfluous packaging is being driven out of the market by higher hydrocarbon and fiber prices, consumer rejection, and pressure from companies that don't want to pay for unneeded packaging, let alone twice—once to buy it and once more to discard it. And those bulky marine and rail shipping containers themselves are becoming radically lighter (even before advanced composites) and more foldable, making them far handier to store and return: by folding to one-fourth its volume in just four steps, Holland Container Innovations' container can save up to 25% of shipping lines' operational cost.[124]

U.S. freight energy use and share of ton-miles by platform, 2010

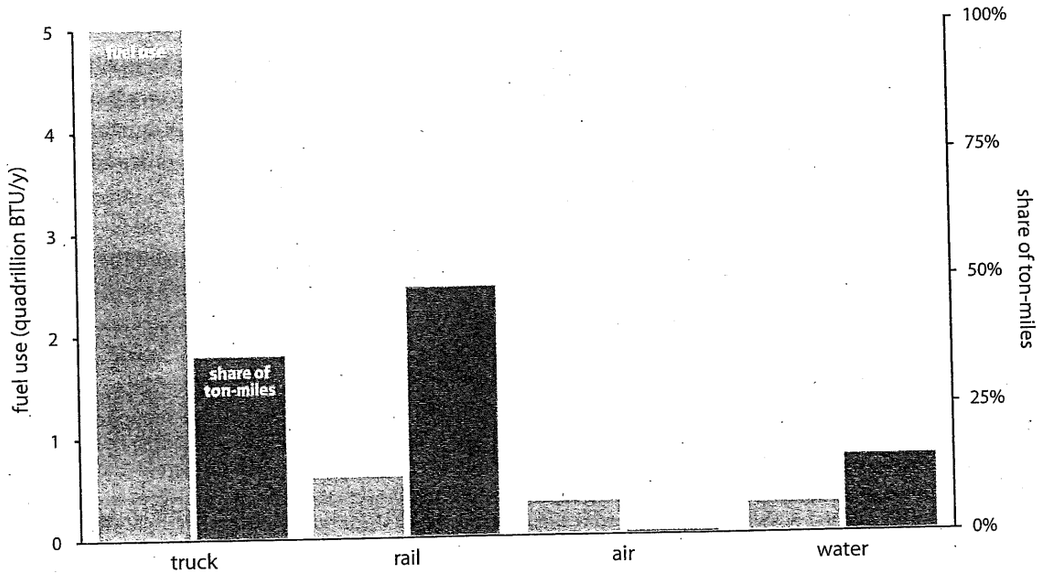


FIG. 2-18. Trucks haul less U.S. freight than railways but use more than twice as much fuel per ton-mile.[125]

Intermodal Freight: Merging Truck, Sea, and Rail Transport

The two oldest means of moving heavy goods—ships and trains—are still the most energy-efficient. Rail moves 49% of U.S. freight but uses only 9% of freight-sector fuel (fig. 2-18). Shifting from truck to rail nearly halves cost per ton-mile and cuts fuel use by nearly fivefold. The trick is to use each mode to do what it does best.

Both rail and ships also beat trucks in capacity, cost, and safety. This permits major gains from shipping goods most of the distance by rail or ship, shifting them to or from trucks for a few dozen miles on each end—so-called intermodal transport. The net energy saving, plus packaging improvements and reduced need to haul oil and coal, can total 33% of total heavy-truck fuel[126]—*beyond* the major potential for hauling fewer tons, cubes, and miles.

Intermodal transport has become so popular that it yields 21% of U.S. railway revenues—the second-biggest segment after coal hauling (which used 48% of 2009 U.S. ton-miles). As chapters 4 and 5 will describe, coal burning could be eliminated, effectively doubling rail capacity. Greater rail capacity could drastically reduce road congestion and deterioration, saving more truck and auto fuel too.

Shifting one-third of our freight to intermodality won't happen overnight. Both rail and ships are usually slower than trucks and can't deliver point-to-point. Current rail infrastructure is stressed and aging, while seaports have their own infrastructure challenges and often impose high harbor maintenance taxes.

However, advances in rail and port design are boosting intermodalism. Thruport terminals reduce the number of interchanges for rail-based freight from 13 steps to one. They improve terminal efficiency 97% by eliminating unneeded drayage between rail terminals, allowing crane transfers from rail to rail, and eliminating the need to store freight overnight outside the terminal. And some ports are shifting from diesel equipment to all-electric to save cost and pollution.

U.S. heavy-truck fuel-saving potential, 2010–2050

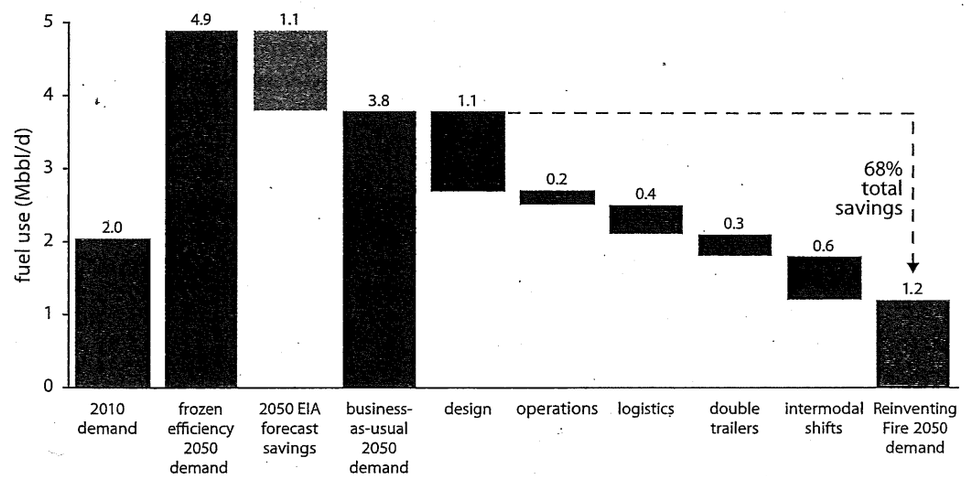


FIG. 2-19. A portfolio approach to enhanced efficiency in the U.S. domestic freight sector cuts the 2050 need for heavy-truck fuel to just 1.2 Mbbl/d—none of which need be oil.[127]

Combined Truck Savings

The Energy Information Administration predicts that Class 8 trucks will improve from 6.1 mpg in 2010 to 7 mpg by 2035, which we extrapolate to 7.8 mpg by 2050—29% better than 2010. But figure 2-19 shows how combining improvements in design (including idle reduction), improved operations and logistics, long compound rigs, and intermodalism can cut 2050 fuel use to one-third of projected demand.

Next, let's look to America's third-biggest oil user—in the skies.

Airplanes

Thanks to the marvel of flight, we can leave the U.S. and meet with Chinese clients within a day's time, pop over to Paris for a romantic weekend, or travel around the world in two days. But flying burns fuel—lots of it. Even after decades of improvements in airplane design and airline logistics, which slashed the fuel burned per seat-mile by 82% from 1958 to 2010, U.S. air transportation of people and freight uses 1.3 million barrels of oil per day and is projected to climb to 1.8 million by 2050. But efficiency continues to improve, thanks to many of the same technological advances that make Revolutionary+ vehicles possible—and to bold moves by companies like Boeing, Airbus, and their smaller competitors.

Faced with a critical development decision in 2000, Boeing initially favored a high-speed jet it called the Sonic Cruiser, but airline customers wanted efficiency. Even without changing the plane's basic form, this bore risks. Weight would clearly be the key: each pound removed from a typical midsize jet saves 124 pounds of fuel a year,[128] with a 30-year present value approaching a thousand dollars. The lightweight, high-performance design Boeing envisaged and airlines wanted would have to comprise 50% carbon fiber composites by weight (80% by volume). It'd also need to electrify more systems and depend on a global supply chain. But Boeing plunged ahead with what became the 787 Dreamliner. Some of the development risks proved all too real: design- and production-related delays of over three years diverted focus from the company's next all-new airplane, probably a replacement for the mainstay 737 to compete with new offerings from Airbus and China. But the risk seems to have been worth it: the 787 became the fastest-selling new jetliner ever, giving Boeing a leg up on archrival Airbus. It's expected to use 20% less fuel than a comparable 767-300, proving the market appetite for efficiency just as Prius did for autos.

Moreover, Boeing is turning that technological leapfrog into a breakthrough competitive strategy, using its head start to move technologies developed for the 787 rapidly into existing platforms. The coming 747-8, for example, uses a 787-style composite wing with the same supercritical airfoil shape to cut high-speed drag and, like the 787, electrifies energy-sapping pneumatic systems. The updated 747-8 will use 16% less fuel than its predecessor.

As airplane makers come down the learning curve of making advanced composite structures, they've discovered that the new manufacturing methods, when combined with lean principles gleaned from the Japanese automotive industry in the 1990s, are actually cheaper than those for making metal airplanes.[129] Now automakers stand to benefit in turn from composite airplanes' process advances.[130]

Next-Generation Efficiency

Are further efficiency gains possible? Beyond weight reduction enabled by advanced materials, the most critical airplane performance levers are engine efficiency, aerodynamics, and integrative design that maximizes snowballing weight savings.

The next jump in efficiency, therefore, will come from new designs that improve aerodynamics while making the engines and airframe work better together. Three such state-of-the-art designs offer the potential to reduce fuel use by 59–80%. The first (fig. 2-20, at left) braces the wing with a strut or a truss, making it much longer, lighter, and thinner. A thin wing smooths airflow for dramatically higher lift-to-drag ratio. The second, a tailless design, integrates a single aft engine into the body (fig. 2-20, in the middle). The third design (fig. 2-20, at right) was probably inspired by natural gliders like the Javan cucumber's five-inch seeds that can glide hundreds of yards.[131] The aft engines are more efficient and cut cabin noise. Such a carbon-fiber plane could save more than half the fuel used by today's most efficient aircraft. Composite construction also potentially enables "compliant" structures, allowing the seamless wing to flex and morph into optimal shapes for different flight modes, replacing today's hinged flaps for another 5–12% in fuel savings.[132]

So what's holding up this aeronautic revolution? With blended wing body (BWB) designs, manufacturers and airlines would need attractive ways to fit passengers and cargo into the novel shape. Airports, too, would need to change gate geometries (as some have for the giant A380). But the biggest obstacle is that most airlines lack the capital to replace their fleets, and turnover times tend to be long.

For standard jet transportation, the fastest route to short-term fuel savings is speeding the adoption of more efficient planes like the 787, in turn accelerating manufacturers' innovation and retooling. New policies, such as a scrappage program similar to "cash for clunkers" linked similarly to secured federal loan guarantees for buying superefficient new airplanes, could vault the capital hurdle. So could landing fees that rise with higher noise, emissions, and fuel use. Such policies are already being tried in England, Germany, Switzerland, and Sweden. The charges range from a 6% discount on landing fees for the cleanest aircraft at Basel (and rebates for low emissions at Heathrow and Gatwick—think feebates) to a 40% surcharge for the dirtiest aircraft at Zürich, in a steeply graduated fee structure meant to speed the next generation of advanced aircraft.

The full suite of efficient airplanes, if adopted at a feasible rate as they become available, could cut projected 2050 civil-aviation fuel use 47%—ultimately up to 70%, or more than tripled efficiency, with full adoption. Just as with long-haul trucks, we won't eliminate the need for liquid fuel for airplanes. But we can eliminate the need for oil-based airplane fuel by switching to biofuels now: the oils of many plants, from algae to halophytes, can be processed into jet-quality fuel that many civilian and military users are adopting, as we'll see below.

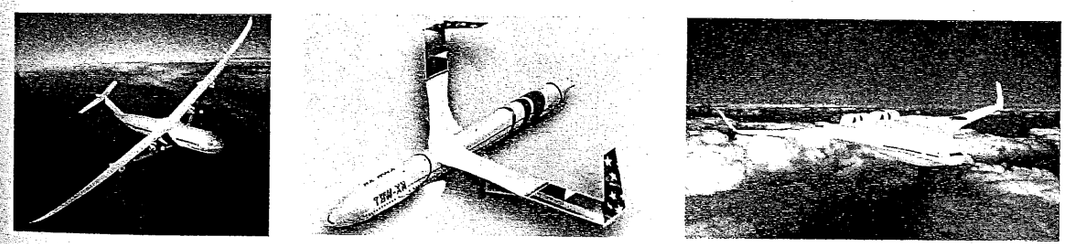


Fig. 2-20. From left: Boeing's SUGAR Volt electric-battery/gas-turbine hybrid propulsion system with a strut-braced wing, saving 70% of fuel; NASA's truss-braced wing design with a buried single rear propulsor, saving 60–80%; and MIT's H Series blended wing body (BWB) concept with podded, actively controlled boundary-layer-inlet propulsion, saving 59%.

Displacing Flights and Conserving Flight Time

Why travel to China to close a deal if you can still look your partner in the eye across the table using advanced teleconferencing? Even though high-end systems like Cisco's, HP's, and others' cost $300,000 each, software giant SAP found that they can pay back in just one year in reduced travel costs. Moore's Law is starting to bring vivid telepresence to the desktop. Using such teleconferencing nationwide could reduce business air travel by 12%, or 2.5% of total air travel.

When we do need to fly, finding ways to cut the 1.3 million barrels of jet fuel consumed every day is just good business. For airlines and airfreight companies, fuel is the single largest expense. Shaving off a few thousand gallons here or there can mean the difference between profits and red ink.

It's no surprise, then, that airlines are constantly searching for efficiency improvements. Planes are taxiing slower, for instance, using one engine instead of two or four. They're carrying lightweight catering carts, cruising slightly slower, gliding to direct landings without fuel-hungry maneuvers, and using new avionics with advances in air traffic management to chart the fastest routes and carry less excess fuel. These little steps add up to hundreds of millions of dollars saved.

The vast network of airports and airplane routes can also be made more efficient. In the current system, powerful major airlines hold near-monopolies on some airports, using them as hubs to connect many of their other flights so they can control more market share and charge higher prices. An exception is Southwest Airlines, which has achieved consistent profitability—in an industry that hasn't cumulatively broken even since the Wright brothers—largely by adopting direct point-to-point routing.[133] While Southwest is primarily in the business of domestic flights with single-aisle airplanes, previously discussed advances in efficiency would allow airplanes in all classes to fly farther more cheaply, enabling airlines to cover more direct routes that could expand the proven point-to-point model to international scale.[134]

A shift to point-to-point routing would nevertheless face barriers. Allocating airports' gates and slots through periodic auctions, rather than letting "fortress hub" monopolists keep hoarding them, would create a more level playing field and help shift the balance from hub-and-spokes business models to the more fuel- and capital-efficient point-to-point models.

Not only do short flights between regional hubs consume much more fuel per seat-mile than long flights due to less time spent in efficient cruising flight, but they also add to air, ramp, and terminal congestion. A more efficient alternative to these trips along dense corridors is high-speed rail (HSR). As trains have gotten faster and regional plane travel slower due to traffic and security-related delays, rail can beat air in door-to-door travel time at longer and longer distances. One study predicts that adopting current HSR technology would save the U.S. 29 million automobile trips and nearly 500,000 flights per year. HSR yields other benefits too: reduced airport-related road congestion, mixed-use development opportunities around main train stations, expanded labor markets from convenient and affordable medium-distance transport options, and higher business productivity through quicker travel.[135]

Combined Savings for Airplanes

Air travel's global importance makes continued growth in business and leisure air travel seem certain. But we can cut its fuel intensity even faster. Capturing available and likely use and design-related aviation improvements would cut 2050 demand 54% (fig. 2-21) despite 61% more seat-miles. That would leave 0.8 Mbbl/d of remaining demand, which could be met by advanced "drop-in" biofuels[136] at a lower cost than fossil-derived jet kerosene as soon as 2020, and ultimately by liquid hydrogen if desired.

Trains, Boats, and Other Vehicles

Americans don't use oil just to drive our autos, fly to business meetings or vacation spots, fuel our military mobility, and haul big truckloads of cargo. Gasoline and diesel also fuel the motorboats that take us fishing, the buses that cart our kids to school, the delivery trucks that bring our packages, and the trains and pipelines that carry everything from coal to hydrocarbons and chemicals. These miscellaneous uses add up: in 2010, they totaled 1.7 million barrels of oil a day.

But the same design principles and technologies that can wean our autos from fossil fuel can also slash the oil needed for these other civilian vehicles by a remarkable four-fifths by 2050. Today's 10 mpg urban delivery trucks average 30 cents per mile for fuel. Replacing these with lightweight, aerodynamic, battery-electric or plug-in-hybrid versions, recharged at the depot, drops that fuel cost to just 2.5 cents. FedEx's E700 hybrid delivery vehicles increased fuel economy by 36%, while UPS has considered using a hydraulic hybrid to save 60–70%.[137]

Buses, too, benefit from lightweight design, halved air drag, better tires, and electrification. Hybrids are especially useful for typical stop-and-start driving in urban areas. GM already makes hybrid buses that boost mpg by up to 55%, and cities from Albuquerque to New York have begun rolling out not just hybrids but also efficient biofueled buses. All these vehicles are also candidates for natural gas, which powers 15–20% of the world's new transit buses and garbage trucks. And bus rapid transit—the "surface subway" system pioneered in Curitiba, Brazil, providing subwaylike capacities at a tenth the cost of even surface light rail—is now found in more than 80 cities, chiefly in South America, but headed for Los Angeles. Bogotá's BRT system was built in three years and carrying a million riders a day by year six. Even costlier kinds of transit

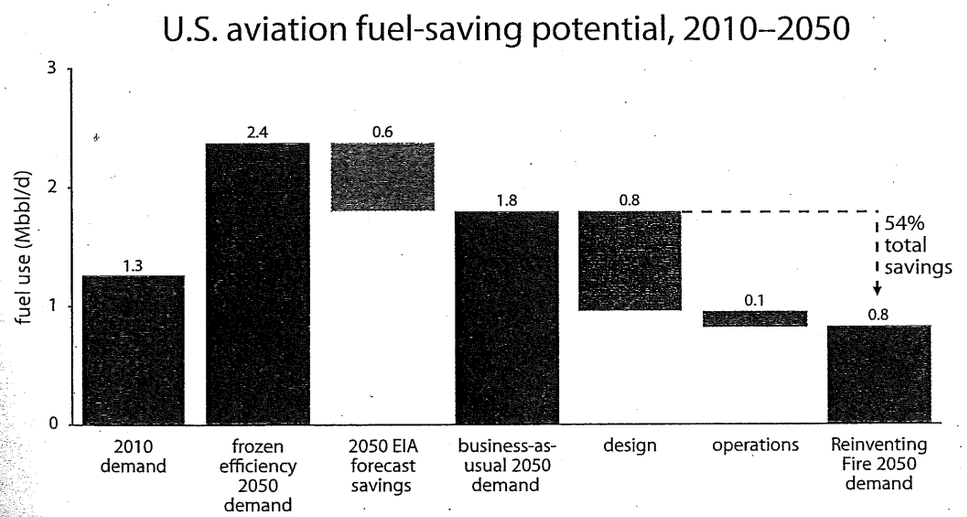


FIG. 2-21. Together, design and use improvements can cut 2050 jet-fuel demand by 54%.[138]

systems are far cheaper than automobile-based systems.

A new category of ultralight rail, like the CyberTran invented at the Idaho National Laboratory, shows promise of manyfold reductions in light-rail system costs, with easier installation and greater versatility. Its ingeniously light vehicle multiplies weight and cost savings in its truss-mounted overhead rail system. There's also plenty of room for improvement in conventional light trains. In the 1990s, Danish State Railways (DSB) developed the Copenhagen S-train with 46% lower weight per seat than the 1986 model. One of the most elegant light-rail energy-saving ideas is Victorian: humped track that decelerates arriving and accelerates leaving trains in London Underground stations.

Hauling goods by rail has already been an efficiency success story. Since 1980, U.S. rail freight has doubled while fuel use has barely increased, due to computerized throttle controls, hybrid-electric drive, efficient diesel engines, and idle control (the average Canadian locomotive was found in 1984 to be idling about 54–83% of the time). But further improvements are possible: fuel cells, widespread electrification, better aerodynamics, further reductions in idling, and regenerative braking. Norfolk Southern has tested a prototype 1,500 hp switching locomotive that's all battery-powered, can run 24 hours on a charge, and reportedly costs the same to build as a normal diesel locomotive.[139] Chinese bullet-train engineers have even invented a way for passengers to enter and leave without the train stopping, via a "connector cabin" that the train drops off at each station while picking up a new one.

Ships are an efficient way to move freight, but they still consume about 1% of U.S. transportation fuel. Now data on the fuel efficiency of nearly every large oceangoing vessel, collected by the nonprofit Carbon War Room,[140] help smart shippers pick the most efficient vessels. Low-cost upgrades can also raise the efficiency of each ship by 20–50%. Merely using low-friction paint the next time a ship needs repainting boosts its efficiency by 9%. Some fleet owners have already experimented with several kinds of modern sails to displace oil in their freighters: SkySails quotes a 35% fuel saving.

Military-Led Design Efficiencies

America's number one airline is not a civilian company but the U.S. Department of Defense (DoD)—the world's largest single buyer both of oil (three-fourths of which goes to its thousands of airplanes) and of renewable energy. DoD directly burns some 0.36 million barrels a day, 1.9% of U.S. oil use, plus whatever its contractors use. That's not a huge amount of oil—it could all come from two Gulf of Mexico platforms—but *delivering* it to thirsty vehicles in war zones is enormously costly in blood, treasure, and weakened combat capability. More than a thousand American servicemembers died in convoy attacks during the past decade, hauling mainly fuel. Just the monetary cost of delivering a gallon in Afghanistan averages $25–$45. In remote outposts, where winter resupply can be a 45-day struggle, delivery can cost up to tenfold more. The delivered cost of fuel thus totals about 20–36% of the total budgetary cost of the Afghanistan deployment.

Logistics—hauling things around, mostly fuel—uses about half the Pentagon's people and a third of its budget, so saving oil in combat could save tens of billions of dollars a year, free up whole divisions of logisticians and fuel guards for combat, and eliminate grave vulnerabilities. In 2010 alone, heating and cooling inefficient U.S. military structures in Iraq and Afghanistan cost $20 *billion*. Just spraying $95 million worth of foam insulation on tents in Iraq, inefficiently air-conditioned by electricity from 10% efficient oil-fired generators, is saving about $1 billion a year and taking 11,000 fuel trucks off the road. In Afghanistan, where foam hasn't yet been added, its payback is 51 days in a big base and 3 days in a remote one—and construction cost goes *down* because the foam costs less than the power, heating, and cooling equipment it avoids.[141] Such fuel savings also protect, multiply, and enable military forces.

Until 2010, the Pentagon hadn't counted the huge costs and risks of fuel delivery when buying the things that used the fuel. Now it values saved fuel at its full *delivered* cost, ranging from many to hundreds of times higher.[142] For contractors developing innovative military vehicles, this is lucrative news. The race is on to find and scale competitive advantages in energy-efficient design. For those squarely in the civilian sector, that race can spur domestic progress.

Those in or serving the airline industry, for instance, will want to follow the development of ultralight airframes, advanced engines and aerodynamics, and military blended-wing-body heavy aircraft, which can carry twice the weight twice as far using about 80–89% less fuel per ton-mile, or unmanned aircraft that can loiter for 50 hours using 97% less fuel (fig. 2-22a). Other proposals include a tiltrotor aircraft with tripled speed but five to six times greater range and fuel efficiency than legacy platforms (fig. 2-22b) and an airship that can float above 20,000 feet using far less fuel than normal heavy-lift dirigibles and can quietly deliver 20 tons, potentially hundreds of tons, of cargo with no ground infrastructure (fig. 2-22c). Cruise lines will want to emulate proposed ship retrofits that could save up to one-sixth of the Navy's nonaviation fuel—or consider new electric actuators that, if substituted for six hydraulic systems in one aircraft carrier, could save 1.4 million pounds, 61,000 square feet, 500 personnel,

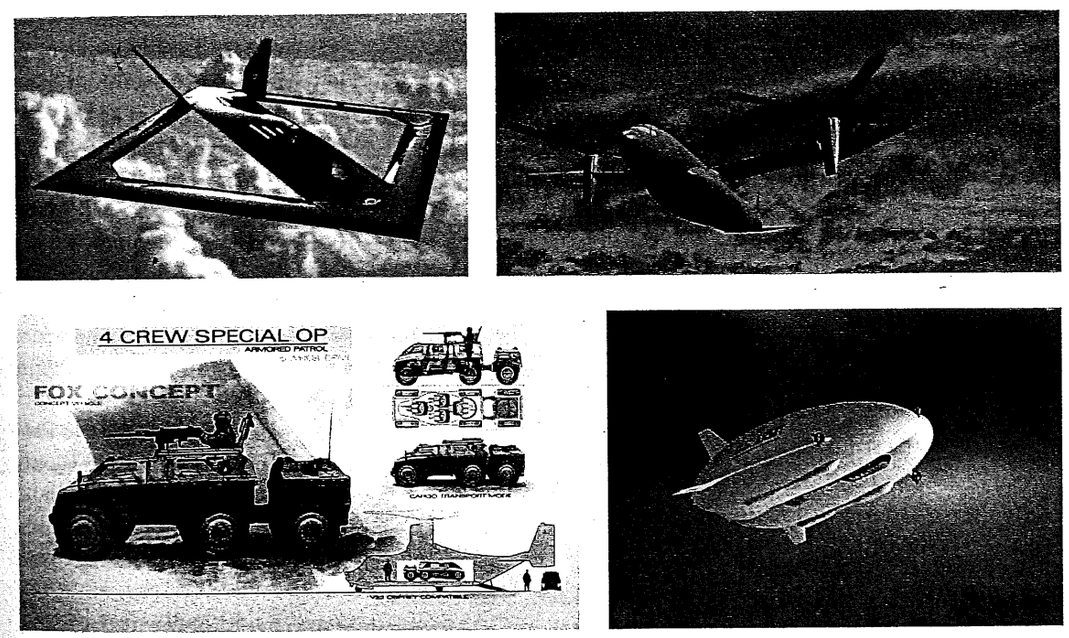


FIG. 2-22. Four proposed military platforms with exceptional energy efficiency and combat effectiveness (see text), clockwise from upper left.

and $20–$25 million a year. And a new family of ultralight armored vehicles (fig. 2-22d) promises five-star protection from roadside bombs and agility like a great pickup truck's, all with lower cost, weight, and fuel use than a HMMWV ("Humvee").

Military R&D has long created new industries that reshape our entire economy, from the Internet and Global Positioning System to microchips and jet engines. DoD's keen new interest in the fitness and fuel-frugality of its land, sea, and air platforms seems bound to spill over into civilian vehicles, accelerating the national journey beyond oil and perhaps creating DoD's biggest-ever national-security win.

That, in turn, can transform our Armed Forces' risks and responsibilities. Light, agile platforms can go farther, faster, and longer, adding revolutionary combat capabilities—and speeding the oil savings that make them less likely to be needed.[143] End America's dependence on oil, especially imported oil, and it's no longer so important to protect unstable oil-producing nations and supply routes. Our sons and daughters have twice gone to fight in the Persian Gulf in half-mile-per-gallon tanks and 17-feet-per-gallon-equivalent aircraft carriers, in part because back home, we were still driving 15-mile-per-gallon SUVs. A worthy tribute to their sacrifice would be building military prowess on the fuel efficiency that makes such sacrifices less necessary, eases global tensions, undermines tyrants, and ultimately turns Persian Gulf intervention into "Mission Unnecessary."

POWERING VEHICLES WITH CLEANER ENERGY

Even if we realize all the potential for efficient design and use across the whole range of vehicles, we still need to fuel or power those vehicles by better and cheaper means than oil. Fortunately, four options—electricity (which will also become far cleaner), hydrogen, natural gas, and advanced biofuels—offer ample choices and robust competition.

Getting a Charge

When your gasoline gauge drops near empty today, you rarely have to worry about where your next tank of fuel is coming from. The U.S. has more than 110,000 gas stations, along with nearly 150 refineries and the intricate intricately linked pipelines and truck delivery routes that keep them supplied.

But what happens when you're in your electric auto, driving, say, from Los Angeles to San Francisco along Highway 1? As you marvel at the Big Sur scenery, you notice that you're so low on power that you might not make it to your destination, especially over some of the steep hills that lie ahead. And there's no place to get a charge.

Welcome to a new worry for the age of the electric auto: "range anxiety."[144] It happened to the very first buyer of the Nissan Leaf, Olivier Chalouhi. After all the hoopla of picking up his auto in Petaluma in December 2010 and driving for photo ops near the Golden Gate Bridge, Chalouhi saw he had just 37 miles left before it ran out of juice. His trip home was 37 miles. Chalouhi had to stop at City Hall for a charge before he could safely be on his way. It's no wonder, then, that when 85% of U.S. respondents to a recent Nielsen survey said they'd buy an electric auto, they strongly preferred plug-in hybrids, backed up by an onboard engine, to pure battery cars.[145]

The lesson: Getting off oil by moving to Revolutionary+ autos is not just a matter of developing the autos. To the extent they get their electricity only from onboard batteries, it also requires infrastructure to recharge them, preferably from renewables.

Fortunately, the physical infrastructure for recharging is rapidly maturing, based on an industry-standard smart plug. Companies like AeroVironment, Inc., have also developed not just charging stations for homes and businesses but also charging technology that promises to cut charging time from many hours to a nearly full charge in a fraction of an hour. AeroVironment has teamed up with NRG Energy, a Princeton-based utility, to create a whole electric "ecosystem" in Houston. NRG plans to invest $10 million in a network of more than 50 fast-charging stations along major freeways, in business districts, at shopping malls, and in workplace parking areas. Rather than being at the whim of gasoline prices, NRG customers lock in subscription rates for charging plans. California is also rapidly building a fast-charging network and battery-swapping stations throughout the state. Other major players in this field include Coulomb Technologies, GE, Schneider Electric, and Better Place.[146]

One cost-effective way to build electric-auto infrastructure is to include the installation of charging equipment in the normal course of working on roads or building new parking garages, an idea promoted by RMI's Project Get Ready (PGR) that has spread to 16 cities. One PGR partner city, Vancouver, British Columbia, has led the world in requiring new mixed-unit dwellings to install electric conduits for future charging stations. Some major merchants even plan to add charging stations in their parking lots—often powered by solar cells so as not to raise the grid's daytime peak load—and to offer charging to attract customers.

Charging infrastructure could also bring an unexpected benefit to electric-auto owners—and to the whole electricity system. Plugged-in automobiles could sell their stored electricity back to the grid when it's most valuable, such as when utilities are struggling to meet downtown demand on hot summer afternoons. Thus Americans' second-biggest household asset could earn money during some of the 96% of the time that it's parked. And as we'll see in chapter 5, utilities' ability to draw on parked autos' "distributed storage" and to inform or control their charging times to match the grid's needs could be very valuable to the electricity system. Today's standard charging plugs have two-way communication to ensure that charging doesn't unduly burden the grid at peak periods, pricing matches scarcity, and drivers selling power back to the grid get paid for their electricity and their slight battery-life degradation.

Building a new infrastructure won't be cheap. By some estimates, each new electric vehicle will require about 1.1 charging stations—though 80% will be at homes and paid for (costing about $1,500) by the auto buyer. The other 20% will be a mix of workplace and public charging, ranging from $2,000 for a basic unit to tens of thousands of dollars for a direct-current fast-charging station. Some areas will need utility distribution upgrades, especially if on-peak charging isn't surcharged. A new financial infrastructure will enable users to pay by credit card, as easily as visiting an ATM.

But compared to building railroads or new highways, adding an electricity infrastructure is relatively easy. Electricity is already ubiquitous. As chapter 5 shows, we have enough of it. In most cases, hooking up an electric auto is no more difficult than buying and installing a new appliance.

Gassing Up with Hydrogen

A competing source of the electricity for electrified autos is fuel cells. Remember the high-school chemistry experiment where an electric current splits water into hydrogen and oxygen? Fuel cells do that backward, chemically reacting hydrogen with oxygen (from air) to make electricity, pure water, heat, and nothing else. There's no combustion. Fuel cells are compact, efficient, extremely reliable, costly if handmade, but competitive if mass-produced. Their hydrogen is stored at 5,000 psi pressure in ultrastrong, ultrasafe 1990s-vintage carbon-fiber tanks, refueled just like the compressed natural gas (CNG)

discussed below for heavy trucks (which could use compressed hydrogen instead).

Several official studies have found, and some policymakers believe, that hydrogen-powered autos are impractical. But all those studies assumed unfit vehicles, and hence unaffordably big fuel cells and impossibly bulky hydrogen tanks. Vehicle fitness solves those problems[147] without a breakthrough in storage technology, making hydrogen a technically feasible, economically competitive option that's at least as safe as gasoline, and depending on its source, a reasonably or completely clean and climate-safe fuel for autos.[148]

Automotive hydrogen would initially be made at the filling station from natural gas, using efficient miniature "reformers" already developed and emitting two to three times less CO_2 per mile than gasoline cars emit today. Climate-safe biofuels could be reformed too if renewable electricity or direct use of sunlight to split water doesn't ultimately become even cheaper. Neither cost nor timing is problematic: Deutsche Shell said a decade ago it could sell hydrogen at all its German filling stations in about two years[149]—as fast as Portugal just built its national electric-car recharging network.

The supposedly intractable "chicken-and-egg" problem of hydrogen infrastructure—no auto sales without it, but no infrastructure without customers—was solved in 1999.[150] GM and independent experts even found that nationwide implementation would cost less than sustaining equivalent oil-fueling capacity.[151] A 2010 McKinsey study confirmed that hydrogen production and fueling infrastructure cost only about 5% as much as the vehicles they support.[152] When asked whether fuel-cell cars will come to market in 10, 20, or 50 years, the general manager of Lexus in the U.S. replied simply, "It will be far sooner than you think."[153]

Frigid liquid hydrogen is also feasible for airplanes. Though bulky, it has 2.8 times jet fuel's energy per pound. The U.S. Air Force and major airplane makers have established the feasibility and safety of such "cryoplanes," and Boeing has developed the "Phantom Eye," a spy plane whose hydrogen fuel keeps it aloft 60% longer. Boeing also successfully flight-tested a hydrogen-fuel-cell-powered two-seat airplane in 2008. The liquid hydrogen would even allow highly efficient, lightweight superconducting electric motors turning modern propellers—a recipe for long-run efficiency perhaps beyond the tripling already available from advanced airplanes,[154] and potentially extendable with onboard ultralight solar cells.

Putting Natural Gas on the Road

Unlike autos, even very efficient long-haul trucks can't yet be cost-effectively electrified. Normally they'd use biodiesel, with a longer-term option of hydrogen fuel cells. But in the near and medium term, switching from diesel to natural gas would save money and cut trucks' greenhouse gas emissions 20–30%. Such trucks could even become nearly fossil-fuel-free by using "renewable natural gas" from landfills, wastewater treatment plants, and livestock manures.

The technology is well established: more than 12 million vehicles around the world now use CNG, which in 2010 was on average 42% cheaper than U.S. diesel fuel per unit of energy contained. CNG has four times the volume of diesel fuel, so it's impractically bulky for today's long-distance heavy trucks, but it's well suited to trucks two to three times more efficient, shrinking the tanks correspondingly for the same range. Lightweight integrated tanks may soon help even less-efficient trucks to carry more CNG.

Another solution is liquefied natural gas (LNG), costlier but 2.4 times less bulky than CNG and increasingly cost-competitive with diesel fuel. Converting a long-haul truck to LNG is estimated to cost about $70,000. With natural gas costing $0.75 less than an equivalent diesel gallon (as it does today in California), an average long-haul truck can recoup the conversion cost in about five years. At a $1.50 difference, costs can be recovered in just two years.[155]

The barriers? One concern is over safety.[156] LNG must be kept in vacuum-insulated tanks at –261°F. If released, it can shatter materials like steel and create a ground-hugging layer of supercold but highly flammable gas. New compact composite tanks developed by BMW and others can reduce cost and improve safety, but the gas could still be deliberately released to cause a ground-level firestorm worse than from propane or gasoline, whose tank trucks are already of homeland-security concern.

Another barrier is scarce infrastructure. Tens of thousands more natural-gas filling stations will be needed if natural-gas vehicles are to displace much diesel fuel, and LNG has even higher infrastructure costs than CNG. Natural-gas fueling systems may therefore work best for centrally fueled fleets like buses and delivery trucks, rather than trying to cater to everywhere trucks may go. Both for safety and because natural gas (methane) is over 20 times as potent a greenhouse gas as CO_2, scaled-up natural-gas fueling would need careful engineering and procedures to avoid leakage.

All these fueling challenges we've identified for heavy trucks can be met, keeping the freight moving with far less liquid fuel, no oil, and ultimately no fossil fuel. The resulting oil savings—18% of all U.S. oil use today—would be the most important nonautomotive way to get the nation off oil by 2050. And the more truck fuel we save and diversify, the less the burden on the backstop technology—biofuels.

Pumping Biofuels

Leilani Münter is one of the world's top ten female race-car drivers. She made it to Daytona by 2006 and became a fixture in NASCAR racing—America's most-watched sport with 100 million viewers. But she's also been listed by *Newsweek* as "surprisingly green" and was named *Discovery*'s Planet Green #1 Eco Athlete. Why? For every race, she buys and protects an acre of rain forest to offset her carbon footprint. And now her mission is to convert NASCAR entirely to biofuels.

No matter how quickly we follow the paths to enormous fuel savings, as described in this chapter, the nation will still need liquid fuel—lots of it, falling over decades. As discussed above, planes and heavy trucks can't yet be cost-effectively electrified. Hydrogen-based designs face transitional barriers. But wherever electricity and hydrogen can't ultimately displace oil, biofuels can. With recent technological advances, there's nothing oil can do that ethanol, green diesel, and other biofuels can't—including powering race cars like Leilani's.

So how much biofuel do we need? What type should it be? And where will it come from?

If we speed down the road to Revolutionary+ automobiles and other dramatically improved vehicles and smarter uses, we can cut the total amount of liquid mobility fuel needed in 2050 to about 3.1 million barrels per day (fig. 2-23). Only 20% of this remaining demand is for automobiles. Forty percent would go to heavy trucks, 25% to planes. Buses, the military, medium-duty trucks, trains, ships, and pipelines would consume the remaining 15%. Can biofuels cost-competitively meet this demand without harming the world's food supply or environment?

From the Ground Up: Biofuels

In the giant vats of biofuel plants across the U.S., yeast transforms sugar from corn into ethanol in the age-old process of fermentation. This first-generation biofuel has become big business. U.S. ethanol producers made 13 billion gallons in 2010, the equivalent of 0.6 million barrels of oil a day.[157]

That's one-fifth of the total 2050 need for mobility fuel, so this first-generation technology wouldn't be enough for all mobility needs nor suitable for some (notably airplanes), and it might interfere with food production, despite co-produced feed.

Because they can be made from crop residues or dedicated energy crops grown on lands *not* taken out of food production, second-generation biofuels avoid the conflict between food and fuel that can arise when corn or soybeans are turned into fuels.[158] Decoupling fuel from food also reduces unwelcome linkages of food prices to oil prices.

Second-generation ethanol can be made from crop residue such as corn leaves, stalks, husks, and cobs (together called "stover") or from inedible crops like prairie grass. Such "cellulosic ethanol" would nevertheless face barriers. Pure ethanol doesn't work in cold climates, so its U.S. sale would need to be seasonal and regional. But that's no reason for any new U.S. auto to lack the capability to burn ethanol. An "open fuels standard" (a bipartisan proposal in Congress since 2009) would require new vehicles to have "flex" capability—the ability to burn varying blends of ethanol and gasoline.[159] Of course, ethanol standards alone do nothing to insure against volatility in the food market resulting from food-based ethanol production. Restructuring U.S. corn and soy ethanol subsidies would allow inherently cheaper cellulosic feedstocks to compete fairly, accelerating the shift away from food-based fuels. Ultimately desubsidizing agriculture would help even more.

Researchers and companies are progressing not only with cellulosic ethanol but also with "drop-in" fuels chemically and functionally indistinguishable from today's medium petroleum fuels used in trucks and airplanes. These advances promise big gains in the fight against climate change, emitting 60–120% fewer lifetime greenhouse gases than fossil fuels—far better than ethanol or biodiesel. (The 120% reflects the potential to take CO_2 out of the air, put it back in tilth where it belongs, and reward farmers who do so.)[160]

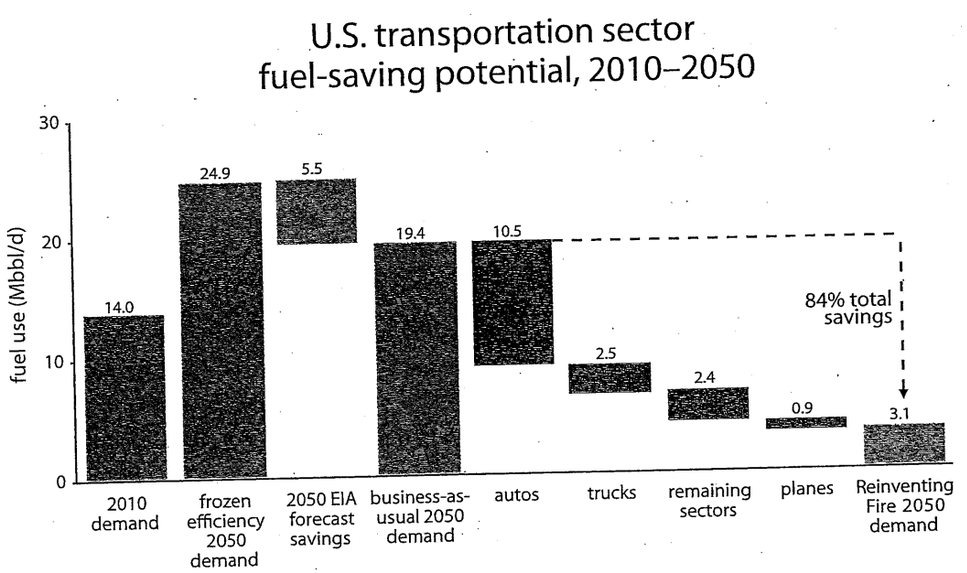


FIG. 2-23. By 2050, autos, trucks, planes, buses, and trains will still require about 3 Mbbl/d of fuel to operate.[161]

In total, second-generation biofuels distributed through existing infrastructure and run on existing engines could fuel all our land, sea, and air vehicles by 2050 if not outcompeted by natural gas, electricity, or hydrogen. The actual mix among these four competitors is impossible to predict and will be best determined in a fair marketplace. But do we have enough land and water to grow the crops needed to make three million barrels of biofuel per day? Can we do it without taking land away from the food production needed to meet growing world population and demand? And can we grow the feedstocks sustainably?

Recent studies say yes to all three questions. A 2005 USDA-DOE analysis concluded that U.S. farmland could sustainably provide each year more than one billion dry tons of collectable biomass *wastes*—enough to make three Mbbl/d of fuel—without taking food off the world's tables. About half of those billion tons would be agricultural crop residues such as corn stover. The rest would be mostly municipal waste and perennial non-food energy crops like switchgrass.[162]

And we needn't rely just on farms. The U.S. has 500 million acres of forests, covering one-fifth of the nation. Logging scraps, thinnings, and other types of wood can produce 400 million dry tons of feedstocks a year for another 1.3 Mbbl/d of biofuels. Figure 2-24 illustrates the volume of each of these feedstocks and their relative costs with projected 2050 technological improvements in three broad categories of conversion processes.

Producing advanced biofuels can also be more efficient than fermenting corn into ethanol. Some methods are 45–75% efficient in converting feedstock energy to fuel energy, compared to grain

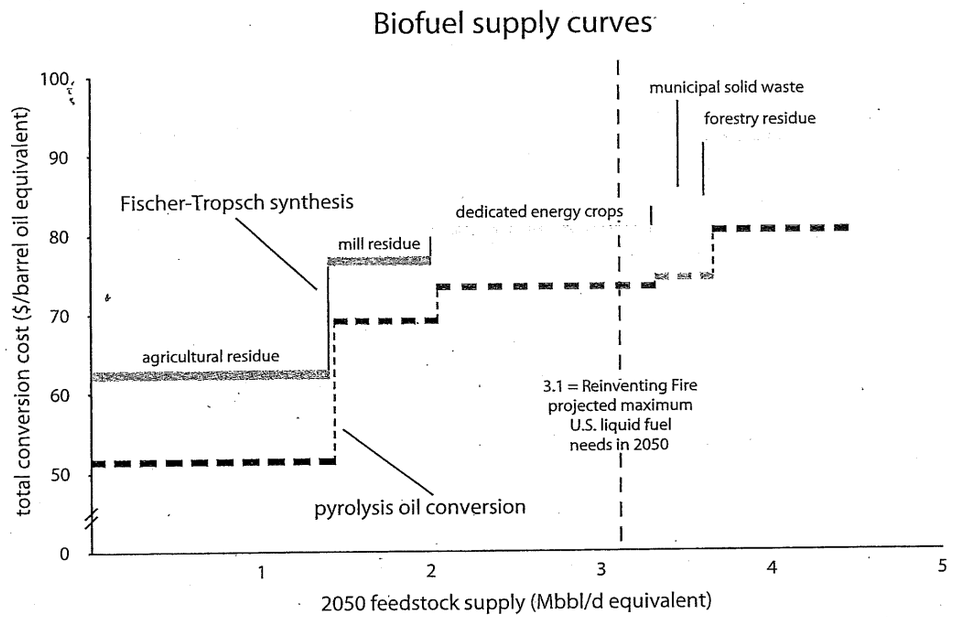


FIG. 2-24. Second-generation biofuels (which don't include fuels derived from algae) have the potential to provide a total of over 4 Mbbl/d by 2050 at unsubsidized costs (net of coproduct credits) lower than projected future oil prices. Cellulosic ethanol, not shown, runs between the two curves shown for thermochemical processes and has a slightly better yield, resulting in total supply of 4.7 Mbbl/d. See www.reinventingfire.com for details.[163]

ethanol's 38%. What's more, some of the processes create valuable by-products. Thermochemical gasification's electricity by-product lowers the effective cost per barrel of oil equivalent by about $10. Some biological conversion pathways that turn sugar into fuel can also produce a wide variety of specialty chemicals worth upwards of $5,000/ton, far more valuable than ethanol. Eventually it may be possible to apply integrative design to create biorefineries that combine biofuel conversion technologies, agricultural enterprises, fine-chemicals production, and algal production into highly profitable, zero-net-carbon facilities.

The Next Generation: Algal Fuels

Companies like DuPont Danisco Cellulosic Ethanol are building commercial plants to make ethanol from switchgrass.[164] Other major firms like Shell, BP, and Dow are in the cellulosic-ethanol race, as are private-equity-funded players like Amyris and LS9. But even as progress is being made on such second-generation fuels, venture capitalists from Bill Gates to Pierre Omidyar, entrepreneurs, oil majors[165] (Exxon, Chevron, BP, Valero), and governments have begun to invest in a more exotic feedstock—algae. Why? Algal fuels offer the promise of a major leap in biofuel productivity. Optimists claim that algae could turn 217 tons of CO_2 into nearly 10,000 gallons of oil, 18.5 tons of protein, and 18.5 tons of biomass per acre (versus about 400–500 gallons of oil for corn or sugar cane, and 1,100 for switchgrass). If such staggering yields are possible, an acre of algae could generate $50,000 per year—an order of magnitude larger than other terrestrial biomass crop production—and it needn't even use land.[166]

As with next generation Revolutionary+ fuel-cell autos, hydrogen-powered trucks, and advanced plane designs, the production and processing of algae face significant technology challenges at every step. Algae in open "raceway" ponds outyield conventional[167] fuel crops, but this approach needs flat land, water, sun, and, perhaps most critically, CO_2, and that may limit algae production to fewer suitable sites than land-grown feedstocks. Other approaches include growing the algae indoor in photobioreactors using solar-like artificial light, and cultivating "heterotrophic" algae that can grow in darkness. These indoor growing techniques have so far tended to be much more capital-intensive than growing algae in open ponds.

BIOFUEL INNOVATION

Dozens of firms are addressing the challenges presented by both algal and second-generation biofuels. Here are a few examples:

- Solazyme produces algae with genetically modified microbes that feed on sugar in large fermenting kettles. Mature algae are pressed to extract the oil. In 2010, the U.S. Navy ordered 150,000 gallons of algae-based jet fuel from Solazyme.
- Sapphire Energy recently broke ground on a 300-acre facility in New Mexico for growing genetically modified algae in ponds. Algal by-products like protein and nutrients will be kept in-house to feed more algae. By 2012, the test facility is expected to produce one million gallons of algal fuel a year.
- German firm Choren has built a large plant capable of converting 68,000 tons of biomass per year into 4.8 million gallons of diesel and 45 MW of electricity through a biomass-to-liquid approach that gasifies the feedstocks into synthetic gas and then converts the gas to second-generation fuel via Fischer-Tropsch synthesis.
- Colorado-based Rentech is building a beta pilot plant, funded by 2009 federal stimulus grants, that will produce nine million gallons per year of synthetic green diesel and 35 MW of clean power.

Despite the technological challenges of cost-effectively growing algae for biofuel at scale, a number of commercial ventures hope to scale to commercial production capacity within the next five years (see Biofuel Innovation sidebar). Continued progress with genetic modification should increase yields. DOE estimates that another 1.4 Mbbl/d of biofuel could be produced from algae by 2050.

In anticipation of second-generation and algal biofuels becoming available, airlines and military users have already begun testing engine compatibility, fuel consistency, performance, and logistics. Some airlines are skipping isolated testing altogether: Lufthansa burns a 50% biofuel blend in one of the two engines on its scheduled four-times-a-day flight between Frankfurt and Hamburg. With major test flights already completed worldwide on diverse engines and airframes, ASTM, a major standards organization, approved 50% biofuel blends for commercial airliners in December 2010. The U.S. Navy and Air Force have both flown advanced supersonic fighters on half aviation fuel, half biofuel derived from a mustard-like weed. The Air Force aims by 2016 to shift half its domestic aviation fuel off oil, and the Navy, to sail an oil-free Strike Group. By 2020, the whole Navy aims to be 50% oil-free.

New Business Models

Biofuels' rapid growth poses both challenge and opportunity to the petroleum industry—and presents some tough choices. Should oil companies and refiners stick to fossil fuels or move into biofuels themselves? If so, should they aim to produce ethanol, or should they move to more hydrocarbon-like fuels (like butanol) that are compatible with their existing massive infrastructure? Different companies are making different bets. Major refiner Valero Energy, for instance, snapped up corn ethanol plants at fire-sale prices after big ethanol producer VeraSun went bankrupt in 2008. And in 2010, BP acquired a leading second-generation biofuels company, Verenium.

From an agricultural perspective, moving into advanced biofuels will reduce U.S. biofuels' demand for edible crops but increase the demand for crop residues, perennial grasses, and trees. The potential emergence of algae could decrease the land needed to meet the remaining U.S. transportation fuel demand yet simultaneously increase the animal feed supply. Thus, whereas the challenge of first-generation biofuels was fuel or food, the promise of advanced biofuels is fuel and feed.

CONCLUSION: BETTER MOBILITY AT LOWER COST WITHOUT OIL

This chapter has explained how we can keep America's vast transportation system humming, growing, and improving—all without oil. By 2050, we'd drive superefficient vehicles fueled by a flexible mix of electricity, hydrogen, and sustainable biofuels (and, if desired, some natural gas for trucks), and we'd use those vehicles far more productively. To power our increasingly efficient heavy trucks and airplanes, we'd need, at most, biofuels equivalent to 3.1 million barrels of oil per day. That's less than five times the volume of today's U.S biofuels industry, which provided only 3% of 2010 mobility fuel.

This new transportation system would not only be cleaner and more efficient, reducing threats from both oil dependence and climate change; it also would cost trillions of dollars less to run than the business-as-usual alternative. All told, transitioning to more efficient autos, trucks, and planes in addition to changing how we use all of these vehicles invests $2 trillion to save $5.8 trillion (fig. 2-25).

Ending oil use for transportation by 2050 is possible (fig. 2-26) but will be a daunting task. It won't be instant or easy. Inertial drag will need to be overcome by the accelerating forces of

automakers, real-estate developers, IT entrepreneurs, and others eager to make new fortunes from better ideas. We'll also need rapid innovation. It's not easy to create fit, safe, peppy, exciting autos that get the equivalent of 125–240 mpg with uncompromised or improved comfort, handling, and safety, all at attractive prices. Nor is it easy to overhaul other vehicles, tranportation systems, and human behaviors. But it's easier than coping with the consequences of not doing it. These ambitious goals are both possible and cost-effective, and first movers across the U.S. transportation system have already begun the journey.

There are three critical ways for business to lead this transformation:

Drive the transition to superefficient vehicles. A wealth of untapped efficiency remains. Airplane makers have made impressive strides but need to design radically different airplanes. Automakers need to exploit the virtuous spiral of ultralight-weighting, integrative design, and electrification to produce Revolutionary+ autos that are safe and affordable; the main obstacles are more cultural than technological or economic. Heavy trucks and other cargo carriers need to carry more weight using less fuel. First movers and fast followers will reap the rewards in fiercely competitive global markets. While risks must be intelligently managed, incrementalism is now the high-risk and transformation the lower-risk strategy.

Value of U.S. transportation sector savings, 2010–2050

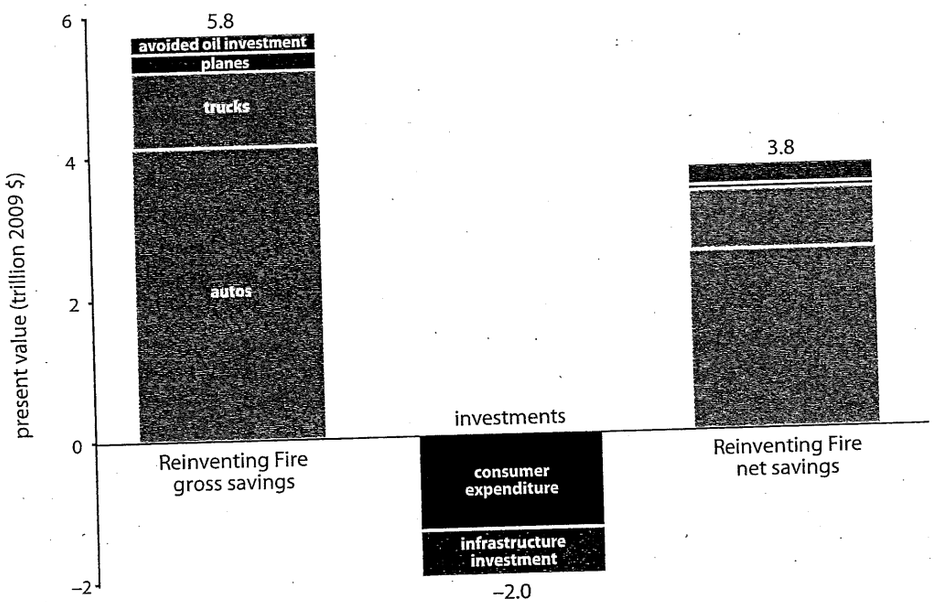


FIG. 2-25. The 2010 net present value (NPV) savings of $3.8 trillion includes the cost of building the distribution infrastructure needed to support a fleet of autos running on a mix of electricity and hydrogen by 2050 (the exact mix isn't important). Over the 40-year period, autos save $4 trillion in NPV ($400 billion from improved use), trucks about $0.8 trillion, and planes about $100 billion. About $270 billion of investment in domestic oil supply is also avoided.[168]

Projected decline in U.S. transportation sector fuel use, 2010–2050

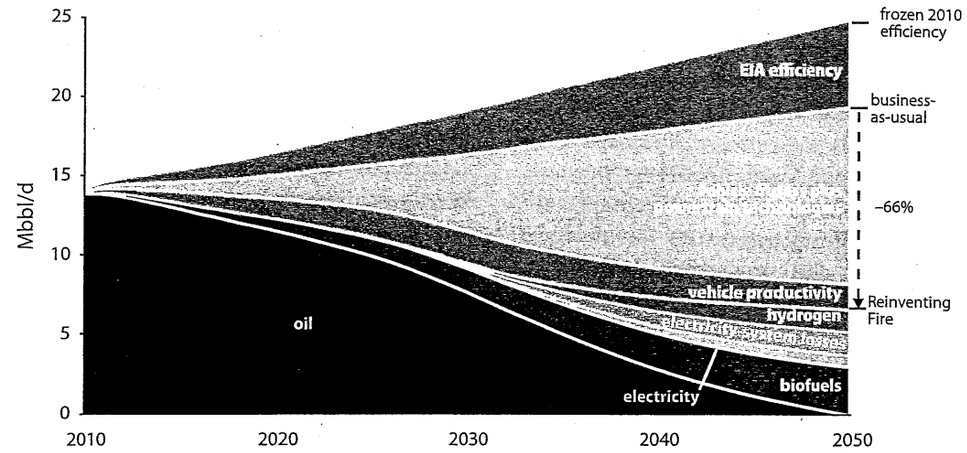


FIG. 2-26. A 2050 U.S. transportation system would need no oil if it productively used superefficient vehicles to provide the same services at lower cost and risk. The fuel mix of electricity, hydrogen, natural gas, and advanced biofuels—of which one illustrative possibility is shown here—cannot be determined in advance but is very flexible, supporting robust competition to 2050 and well beyond. If the hydrogen shown is all reformed from natural gas, it will come half from gas and half from steam.[169]

Decisive, inspiring leadership will be needed—and is starting to emerge, now that Detroit's recent near-death experience has concentrated minds wonderfully. Engendering a culture of innovation and establishing a long-term vision toward the large-scale production of revolutionary products starts at the top. Laggards will take the greater risk of having to catch up with competitors already well down the three synergistic learning curves. Leaders, though, can reap profits by locking up market share, supply chains, and a reputation for cutting-edge technology. Being any but the fastest kind of follower in such a fast-paced, multidimensional competition risks being left behind as a typewriter maker.

Invest across technologies and fuel types. We'll probably need, in some degree, all the vehicle technologies and alternative fuels presented in this chapter to move transportation off oil. Not all may ultimately be needed, but their diversity, especially in powertrains and fuels, provides valuable insurance against failures. That means investing now in everything from advanced-composites structural manufacturing processes and lightweight wheel motors to batteries, automotive fuel cells, and advanced biofuels. Casting the net wider lowers risk, widens opportunity, and bolsters competition.

For instance, investing in low-cost carbon-fiber precursors and production could position the U.S. as a major provider of this crucial raw material (vying with Japan, China, and Europe), as well as reducing cost to vehicle makers. Supporting the development of natural fibers and precursor alternatives like olefins could decouple carbon-fiber production from oil and its price.

Manufacturers need investment in retooling and in emerging manufacturing innovations to slash cycle time in producing breakthrough advanced-composite structures—an area underserved by venture capital. Start-ups, with additional capital support, could enter the market by designing and licensing new automotive technology.

Investing in service-oriented start-ups that provide mobility rather than vehicles and fuels, and in carsharing and ridesharing business models and IT enablers, could help companies expand their fleets. This would foster competition among manufacturers to provide fuel-efficient offerings for those large blocks of guaranteed market.

Biofuel technologies provide ripe investment opportunities, particularly advanced "drop-in" biofuels for heavy trucks and airplanes. With diverse feedstocks and conversion techniques already under development, many of these innovative approaches could be producing substantial amounts of biofuels as soon as 2020, even as rapid gains in vehicle efficiency increase those biofuels' share.

Support policies to speed the transition to radical vehicle efficiency and productivity. The right policies would provide a critical push. Size- and revenue-neutral feebates would offset advanced vehicles' initially higher prices, stimulating sales so manufacturers can rapidly scale up production and deepen cost cuts, accelerated by smart fleet purchases.

Harmonized trucking regulations could allow fewer trucks to carry more freight more quickly, with compounding benefits from reduced traffic, noise, congestion, highway wear, and fleet costs.

Land-use policies that now subsidize and mandate sprawl should be reversed to reward smart growth; otherwise the socialized costs of sprawl will continue to burden business by raising taxes, commuting times, and the salaries needed to offset commuting costs. Financiers and the whole business community have a strong stake in locationally efficient mortgages, which help reduce defaults, increase savings, and boost local economies. Taxing driving, not fuel, could restore depleted infrastructure funds, signal the societal costs of driving, let nondrivers invest in their own mobility rather than others', and level the playing field with other forms of or substitutes for mobility while reducing unwanted travel time for all.

So where could these actions lead?

At the start of World War II, Detroit switched *in six months* from making four million cars a year to making no cars—but instead churning out around the clock the tanks and planes, the Jeeps and munitions, that won the war. By 1945, one-fifth of the entire dollar value of U.S. war materiel came from the former auto industry—which then emerged from war with the scale and scope to create and dominate global vehicle markets.

That transformation was driven by coherent mobilization of an entire society to win a cataclysmic global conflict. In today's peaceful struggle for success in world markets, emerging transformation will be enabled and sped by innovative policies—but driven fundamentally by competitive forces and carried out by private enterprise. This is the sort of challenge for which a century of industrial development prepared us, wars steeled us, and the IT revolution inspired us. We need only rise to the occasion—or buy from those who do.

To help capture opportunities from the transition to energy efficiency and renewable energy, here are a few recommendations for the main stakeholders to focus on, other than the real-estate and community design suggestions above.

TABLE 2-1. Recommendations for key actors in the transportation sector

	NO-REGRETS	OPPORTUNISTIC	INNOVATIVE
VEHICLE MAKERS AND SUPPLIERS	Reduce rolling resistance, aerodynamic drag, and mass by conventional incremental improvements. Strengthen intellectual capital (design, analysis, and manufacturing) in advanced materials and electric powertrain. Fully count downsized powertrain when valuing improved vehicle fitness.	Master ultralighting and sharpen mass-decompounding analytics. Try a Hypercar-class concept vehicle to test new ways to organize small, fast design teams. Roll out non-fossil-fuel niche vehicles. Market the safety and performance of lightweight vehicles. Begin integrating composite parts into existing architectures. Develop service business models that sell mobility rather than vehicles.	Transform design process and culture to become bold and highly integrative. Develop and produce Revolutionary-fitness high-volume non-fossil-fuel vehicles. Launch high-volume manufacturing of advanced-composite structures; retrain repair shops to deal with them. Sell obsolete metal-stamping assets to competitors. Launch high-volume manufacturing of electric powertrains. Launch service businesses that offer mobility rather than vehicles.
FUEL PROVIDERS	Assess how core skills can best be leveraged in the post-fossil-fuel era. Invest and learn across non-fossil-fuel technologies. Develop strategy for peak oil on the demand side.	Invest in diverse non-fossil-fuel production and retailing. Invest in vehicle smart- and fast-charging infrastructure, allying with electricity providers. Launch non-fossil-fuel partnerships with test fleets.	Market non-fossil fuels on a large scale. Invest in vehicle efficiency technologies; if they succeed, make less money on oil, more on "negabarrels."
FLEET AND PRIVATE VEHICLE OWNERS AND OPERATORS	Consider public transit when making location decisions. Educate yourself on non-fossil-fuel vehicles; if you're a fleet, try some.	Test non-fossil-fuel vehicles. Test service business models that provide mobility rather than vehicles. Support integration, IT enhancement, and expansion of public transit. Implement employee parking cashout.	Switch to non-fossil-fuel vehicles on a large scale. Switch on a large scale to service business models that provide mobility rather than vehicles. Implement public-transit-only corporate mobility strategy, or close to it.

Continues

	INCREMENTS	OPPORTUNITIES	INNOVATIVE
GOVERNMENT AND NGOS	Increase fuel economy standards (CAFE). Provide affordable government financing to jump-start innovation, new industries, and retraining. Help low-income families buy very efficient new cars (while scrapping clunkers). Encourage innovation by procuring efficient and non-fossil-fuel vehicles, especially in fleets whose size can help speed automakers' innovation. Help make walking and biking safe, convenient, and popular.	Enact and scale well-designed feebates. Harmonize truck weight and size rules, ultimately nationwide. Speed the retirement of old, inefficient vehicles (cash for clunkers). Expand prize competitions for superefficient vehicles. Consider airplane landing feebates or graduated efficiency-based fees. Provide carbon-policy clarity to reduce investment uncertainty and risk. Facilitate P2P auto and parking rentals.	Implement long-term policies aimed at curbing or reversing sprawl in favor of smart-growth models. Offer multi-million-dollar prize for retrofitting a device that will improve existing auto fleet fuel economy by more than 20% for less than $500. Scrap vehicles older than 15 years (exempting bona fide collectors). Fully price, and perhaps tax, private and municipal urban parking spaces; use the tax income to modernize transit. Try surface rapid transit, CyberTran, and other novel transit modes.

FIG. 2-27. As our discussion shifts now from transportation to the built environment, this classic poster *Ruimte gebruik* ("Use of space") by the Dutch Cyclists' Union (www.fietsersbond.nl/english-info) reminds us that mobility choices aren't only about oil; they shape how we live. In bike-friendly Holland's morning rush hour, bikes outnumber cars and arrive faster. After introducing the ambitious Hypercar concept, RMI's 1995 *Atlantic* feature "Reinventing the Wheels" added: "Whether we also have the wisdom to build a society worth driving in—one built around people, not cars—remains a greater challenge. As T.S. Eliot warned, 'A thousand policemen directing the traffic/Cannot tell you why you come or where you go.'"