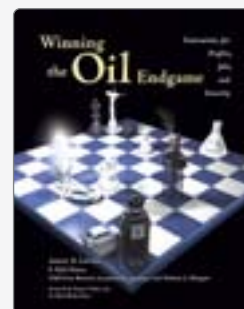


## Overview Contents

Detailed Contents . . . . .	<i>iv</i>
Abstract . . . . .	<i>vii</i>
Executive Summary . . . . .	<i>ix</i>
Forewords . . . . .	<i>xv</i>
George P. Shultz	<i>xv</i>
Sir Mark Moody-Stuart	<i>xviii</i>
Frontispiece . . . . .	<i>xxiii–xxiv</i>



[www.oilendgame.com](http://www.oilendgame.com)

Oil Dependence . . . . .	I
<b>This Report</b> . . . . .	<b>33</b>
<b>Saving Oil</b> . . . . .	<b>43</b>
<b>Substituting for Oil</b> . . . . .	<b>103</b>
<b>Combined Conventional Potential</b> . . . . .	<b>123</b>
<b>Implementation</b> . . . . .	<b>127</b>
<b>Implications and Conclusions</b> . . . . .	<b>243</b>

Image credits . . . . .	276
Table of figures and tables . . . . .	277
Acknowledgments . . . . .	278
About the publisher and authors . . . . .	282
References . . . . .	286
Other RMI publications	307

## Detailed Contents

*Winning the Oil Endgame: Innovation for Profits, Jobs, and Security*

# Oil Dependence ..... I

### Boxes

**1:** An example of domestic energy vulnerability (p. 12)

**2:** Oil is fungible (p. 14)

**3:** The uncounted economic cost of oil-price volatility (p. 16)

**4:** Hedging the risk of oil depletion (p. 24)

Oil is the lifeblood of modern industrial economies—but not forever 1

Even an important industry can be displaced by competitors 4

America can replace oil quickly—and already has 7

Oil supplies are becoming more concentrated and less secure 8

*Domestic oil is limited* 12

Counting the direct cost of oil dependence 15

Oil dependence's hidden costs may well exceed its direct costs 17

*Petrodollars tend to destabilize* 18

*Sociopolitical instability drives military costs* 19

*Nonmilitary societal costs* 21

*Adding up the hidden costs* 22

Could less oil dependence be not only worthy but also profitable? 26

*Beliefs that hold us back* 26

Whatever exists is possible 29

# This Report ..... 33

**5:** Conventions (p. 39)

Structure and methodology 33

Conservatisms and conventions 37

# Saving Oil ..... 43

Option 1. Efficient use of oil 43

*Transportation* 44

Light vehicles 44

*The conventional view* 49

*Advanced automotive technologies: lightweight, low-drag, highly integrated* 52

Drag and rolling resistance 52

Lightweighting: the emerging revolution 53

Ultralight but ultrastrong 57

Applying ultralight materials 61

Lighter-but-safer vehicles dramatically extend cheap oil savings 64

Heavy trucks 73

Medium trucks 77

Intelligent highway systems (IHS) 78

Other civilian highway and off-road vehicles 79

Trains 79

Ships 79

Airplanes 79

Military vehicles 84

The fuel logistics burden 84

Military efficiency potential 85

*Feedstocks and other nonfuel uses of oil* 93

*Industrial fuel* 97

*Buildings* 97

*Electricity generation* 98

*Combined efficiency potential* 99

**6:** How do light vehicles use fuel, and how can they save fuel? (p. 46)

**7:** Superefficient but uncompromised (p. 62)

**8:** Analyzing an ultralight hybrid's efficiency (p. 68)

**9:** Analyzing and extending ultralight vehicle costs (p. 69)

**10:** Comparing light-vehicle prices (p. 72)

**11:** Saving oil in existing military platforms (p. 86)

## Substituting for Oil ..... 103

### Option 2. Substituting biofuels and biomaterials 103

*The input side: biomass feedstocks and rural economies* 107

*Biomaterials* 110

### Option 3. Substituting saved natural gas 111

*Overview* 111

*Saving natural gas* 112

Electric utilities 113

Buildings 115

Industrial fuel 115

*Substituting saved gas for oil* 117

**Boxes** (continued)

**12:** Replacing one-third of remaining non-transportation oil use with saved natural gas (p. 118)

## Combined Conventional Potential ..... 123

## Implementation ..... 127

### Strategic vision 127

*The prize* 127

*Vaulting the barriers* 128

### The endangered automotive sector—why it’s important to act now 130

*Four competitive threats* 132

*China and India* 135

*Suppressing the signals* 136

### Crafting an effective energy strategy: transformative business innovation 137

*The creative destruction dilemma* 138

*Business challenges: market, business, and customer realities* 139

Most U.S. light-vehicle buyers scarcely value fuel economy 139

Most firms underinvest in energy efficiency too 141

The risk of being risk-averse 143

*Business opportunities: competitive strategy for profitable transformation in the transportation sector* 145

Lowering light vehicles’ manufacturing risk 146

*Manufacturing investment and variable cost* 146

*Market adoption* 149

Restoring profitability in the trucking sector 150

Revitalizing the airline and airplane industries 154

*Getting generation-after-next planes off the ground* 157

*Creating a new high-technology industrial cluster* 159

*Restoring farming, ranching, and forest economies* 162

### If we don’t act soon, the invisible hand will become the invisible fist 166

**13:** Guilt-free driving: hybrid cars enter the market (p. 131)

**14:** Opening moves: Boeing’s bet on fuel efficiency as the future for commercial aircraft (p. 133)

**15:** Radically simpler automaking with advanced composites (p. 147)

**16:** Flying high: fuel savings arbitrage (p. 156)

(Implementation continued next page)

## Detailed Contents (continued)

*Winning the Oil Endgame: Innovation for Profits, Jobs, and Security*

(Implementation continued from previous page)

### Crafting coherent supportive policies 169

#### *Government's role in implementation* 169

Fuel taxes 173

Standards, mandates, and quotas 175

#### *Federal policy recommendations for light vehicles* 178

Feebates 186

Low-income scrap-and-replace program 191

Smart government fleet procurement 197

“Golden Carrots” and technology procurement 199

“Platinum Carrot” advanced-technology contest 201

Supporting automotive retooling and retraining 203

R&D and early military procurement 204

Automotive efficiency and safety regulation: first, do no harm 206

#### *Other federal policy recommendations* 208

Supporting investment in domestic energy supply infrastructure 208

Heavy-vehicle policy 211

Aircraft policy 212

Other transportation policy 212

*Shifting taxation from fuel to roads and driving* 212

*Integrating transportation systems* 214

*Is this trip necessary (and desired)?* 214

Non-transportation federal policy 215

#### *States: incubators and accelerators* 216

Transportation 216

Electricity and natural-gas pricing 219

Renewable energy 220

#### *Military policy: fuel efficiency for mission effectiveness* 221

#### *Civil preparedness: evolving toward resilience* 222

#### *Civil society: the sum of all choices* 223

#### *Beyond gridlock: changing politics* 225

### Option 4. Substituting hydrogen 227

#### *Beyond mobilization to a basic shift in primary energy supply* 227

#### *Hydrogen: practical after all* 230

#### *Eight basic questions* 233

Why is hydrogen important, and is it safe? 233

How would a light vehicle safely and affordably store enough hydrogen to drive 300+ miles? 233

Under what conditions is hydrogen a cheaper light-vehicle fuel than oil? 234

What's the cheapest way to produce and deliver hydrogen to meet the economic conditions required for adoption? 236

Are there enough primary energy sources for this transition? 238

What technologies are required to enable the hydrogen transition? 241

How can the U.S. profitably make the transition from oil to hydrogen? 241

When could this transition occur? 242

#### Boxes (continued)

**17:** *Gridlock as Usual* according to Thucydides, ca. 431–404 BCE (p. 170)

**18:** Modeling the effects of policy on light vehicle sales and stocks (p. 182)

**19:** How feebates work (p. 186)

**20:** More antidotes to regressivity (p. 196)

**21:** Golden Carrots: theme and variations (p. 200)

**22:** Realigning auto-safety policy with modern engineering (p. 207)

**23:** Pay-at-the-Pump car insurance (p. 218)

## Implications and Conclusions ..... 243

### Implications 243

*Employment* 243

*Allies and trading partners* 244

*Developing countries* 245

Leapfrog development 245

Climate change and development 246

The global economy, oil savings, and development 247

*Oil-exporting countries* 248

*The creative destruction challenge for oil companies* 250

*Other energy industries* 257

*U.S. military force structure, posture, and doctrine* 261

Toward a new strategic doctrine 262

*U.S. federal budget* 265

*Environment, public health, and quality of life* 268

### Conclusions 271

#### Boxes (continued)

**24:** Shell's visionary energy futures (p. 252)

**25:** What about nuclear power? (p. 258)

#### Abstract:

**This independent, peer-reviewed synthesis for American business and military leaders charts a roadmap for getting the United States completely, attractively, and profitably off oil. Our strategy integrates four technological ways to displace oil: using oil twice as efficiently, then substituting biofuels, saved natural gas, and, optionally, hydrogen. Fully applying today's best efficiency technologies in a doubled-GDP 2025 economy would save half the projected U.S. oil use at half its forecast cost per barrel. Non-oil substitutes for the remaining consumption would also cost less than oil. These comparisons conservatively assign zero value to avoiding oil's many "externalized" costs, including the costs incurred by military insecurity, rivalry with developing countries, pollution, and depletion. The vehicle improvements and other savings required needn't be as fast as those achieved after the 1979 oil shock.**

**The route we suggest for the transition beyond oil will expand customer choice and wealth, and will be led by business for profit. We propose novel public policies to accelerate this transition that are market-oriented without taxes and innovation-driven without mandates. A \$180-billion investment over the next decade will yield \$130-billion *annual* savings by 2025; revitalize the automotive, truck, aviation, and hydrocarbon industries; create a million jobs in both industrial and rural areas; rebalance trade; make the United States more secure, prosperous, equitable, and environmentally healthy; encourage other countries to get off oil too; and make the world more developed, fair, and peaceful.**