Meeting the energy challenge

• The world needs twice as much energy for half the CO2

• Industry needs to compete – and win – in a CO2 constrained market whilst maintaining shareholder returns
The energy system today sets the context for the future

- Oil: 33%
- Gas: 21%
- Coal: 27%
- Biomass: 10%
- Nuclear: 6%
- Renewables: 3%

World population 7 billion; 50% in urban environment

Source: Shell International BV; UN Population Division; IEA 2011
Multitude of choices and actions

Energy resource diversification
- A further shift to natural gas
- Nuclear power
- Renewables
- Hydro power
- Bio products

Energy saving, efficiency and environmental protection
- Mass transportation
- Road transport
- Buildings
- Low-energy appliances
- Carbon capture and storage
Lead time and lifetime matter!

The rate of technological change is related to lead times to develop new equipment, obtain permits to deploy, and lifetimes of capital stock and equipment.
Overview of Global Transport

- Consumption: 2,200 mtoe (19% of global energy)
- **96% of transport fuels from oil** (gasoline/diesel/jet fuel/residual)
- 62% of global oil production
- 76% road transport (LDVs/trucks/buses/other), ~ 1 billion cars-trucks

Source: WEF, 2010
In Developing Nations, vehicle fleet growth is on top of already congested urban centres. High-density and congestion will trigger stress & innovation.

**Table 1.1: Projection of car ownership per 1,000 people**

<table>
<thead>
<tr>
<th></th>
<th>India</th>
<th>China</th>
<th>Brazil</th>
<th>US</th>
</tr>
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<tbody>
<tr>
<td>2000</td>
<td>5</td>
<td>7</td>
<td>137</td>
<td>480</td>
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<tr>
<td>2030</td>
<td>81</td>
<td>188</td>
<td>429</td>
<td>538</td>
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<tr>
<td>2050</td>
<td>382</td>
<td>363</td>
<td>645</td>
<td>555</td>
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</tbody>
</table>


*Chart 1.3: Projections of total cars owned (millions)*

Source: Goldman Sachs

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Promoting the sustainable supply and use of energy for the greatest benefits of all
Vehicle design, fuel, traffic management

Vehicle design
- Light weight - Composite materials
- Aerodynamics - biomimetics
- Road resistance
- Drive Train
- Batteries, super capacitors

Fuels
- Fuel Standards
- Dieselisation
- Bio
- Hydrogen
- Electricity
- Gaseous Fuels
- Synthetic Fuels

Traffic management
- Intelligent Traffic Systems
- Public Transport
- Road improvements
- Congestion charging
- Driving behaviour

Improve fuel economy + CO2 reduction
Vehicle design, fuel, traffic management

Vehicle design
- Light weight - Composite materials
- Aerodynamics - biomimetics
- Road resistance
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Fuels
- Fuel Standards
- Dieselisation
- Bio
- Hydrogen
- **Electricity**
- Gaseous Fuels
- Synthetic Fuels

Traffic management
- Intelligent Traffic Systems
- Public Transport
- Road improvements
- Congestion charging
- Driving behaviour

Improve fuel economy + CO2 reduction
Technologies are available today

**Hybrid Electric Vehicle**
- Over 1,000,000 sold
- Hybrid drive system proven

**Hydrogen Fuel Cell Vehicle**
- Honda commercial version showcased 2007

**Battery Electric Vehicle**
- Several available
- Cost challenges

**Plug-in Hybrid Electric Vehicle**
- Traction concept identical to HEV
- Only change in battery type and battery management

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Promoting the sustainable supply and use of energy for the greatest benefits of all
Rare earth elements in hybrids

HYBRID electric motor and generator

REO Consumption AAGR%

2005-10: 12.6%
- Neodymium
- Praseodymium
- Dysprosium
- Terbium

HYBRID NiMH battery

REO Consumption AAGR%

2005-10: 30.6%
- Lanthanum
- Neodymium
- Cerium

REO = Rare Earth Oxide
AAGR = Annual Average Growth Rate

Quelle: Lynas Corporation
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Promoting the sustainable supply and use of energy for the greatest benefits of all
Rare earth elements resources – global deposits

Quelle: Bundesanstalt für Geowissenschaften und mineralische Rohstoffe, Hannover; Institute for Geo Resources, Tsukuba, Japan; NZZ, Daniel Puntas Bernet, Zürich

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Promoting the sustainable supply and use of energy for the greatest benefits of all
WEC transport scenarios: Goal

describe global transport scenarios that reflect potential developments in transport fuels, technologies, and systems to 2050
WEC transport scenarios: Approach

- WEC assembled a study team of 54 experts from 29 countries.
- Team used case studies and quantified examples of available/emerging technologies & fuels.
- Gathered regional inputs on local issues and major driving forces via regional workshops.
- Combined in two transport scenarios.
- Translated into numeric assumptions and fed them into the model developed with PSI for quantification.
Variety of methods

- Scenario 1
- Scenario 2
- Scenario 3

Inductive

- Alternative scenario
- Official future

Incremental

Deductive

- Scenario 1
- Scenario 2
- Scenario 3
- Scenario 4

Normative

Vision

Promoting the sustainable supply and use of energy for the greatest benefit of all
Study team identified and evaluated 11 critical factors:

<table>
<thead>
<tr>
<th>critical factors</th>
<th>Drivers</th>
<th>Constraints</th>
<th>Responses</th>
<th>Critical Uncertainties:</th>
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<td>1. Government Regulation</td>
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<td>2. Regional &amp; Global Cooperation / Integration</td>
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<td>4. Geopolitics</td>
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<td>5. Global Reserves and Supplies</td>
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<td>6. Environmental and Health Concerns</td>
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<td>7. Policies and Regulations</td>
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<td>8. Lifestyle Changes</td>
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<td>10. Fuel Efficiencies</td>
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<td>11. Innovative Technologies</td>
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</table>
## Global Transport Scenarios 2050

**FREEWAY**

The “Freeway” scenario envisages a world where pure market forces prevail to create a climate for open global competition.

- **1-Trade, FDI**: Free & expanding
- **2-Resources & CO2**: High competition, efficient intl. solutions
- **3-Governments**: Less corruption, bureaucracy, taxes and subsidies
- **4-Energy markets**: Open upstream, supply surge, lower prices in SR but higher in LR
- **5-Air traffic & freight**: High growth

**TOLLWAY**

The “Tollway” scenario describes a regulated world where governments intervene in markets to promote technology solutions and infrastructure development.

- **1-Trade, FDI**: Restricted
- **2-Resources & CO2**: Less competition, no effective intl. mechanisms
- **3-Governments**: All remain an issue
- **4-Energy markets**: Lack opening, high prices in SR but moderate in LR
- **5-Air traffic & freight**: Lesser growth

More than 50 factors are described & compared for the two scenarios in full report (available at www.worldenergy.org)

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«effective international carbon markets»

«technology micro-management by governments»
Global Transport Scenarios 2050

**FREEWAY**
The “Freeway” scenario envisages a world where pure market forces prevail to create a climate for open global competition.

**TOLLWAY**
The “Tollway” scenario describes a regulated world where governments intervene in markets to promote technology solutions and infrastructure development.

- **Total fuel demand in all transport modes:** +82% to +30%
- **Transport sector fuel mix (gasoline, diesel, fuel oil and jet fuel):** 88% to 80%
- **Demand for major fuels (gasoline, diesel, jet fuel and fuel oil):** +68% to +10%
- **Demand for diesel and fuel oil:** +200% to +16%
- **Demand for jet fuel:** +300% to +200%
- **Demand for gasoline:** -16% to -63%
- **Total number of cars in the developing countries:** +557% to +430%
- **Total number of cars in the developed countries:** +41% to +36%
- **Global fuel consumption for cars:** +51% to -13%

Total number of cars more than doubles: 2.2-2.6 times)

Download the full report on www.worldenergy.org/publications
Global Transport Scenarios 2050

**FREEWAY**
The “Freeway” scenario envisages a world where pure market forces prevail to create a climate for open global competition.

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**TECHNOLOGY MIX**

- **FREEWAY**
  - Conventional liquid fuel ICEV: 43% gasoline / 35% diesel
  - Gasoline and diesel hybrids: 7% gasoline / 4% diesel
  - Gas ICEV and gas hybrids: 7%
  - Remaining technology mix: electric, fuel cells and plug-in vehicles: 4%
  - Total: 78% (96)

- **TOLLWAY**
  - Conventional liquid fuel ICEV: 19% gasoline / 7% diesel
  - Gasoline and diesel hybrids: 18% gasoline / 8% diesel
  - Gas Vehicles: 34%
  - Others: 6%
  - Total: 26%
Global Transport Scenarios 2050

**FREEWAY**
The “Freeway” scenario envisages a world where pure market forces prevail to create a climate for open global competition.

**TOLLWAY**
The “Tollway” scenario describes a regulated world where governments intervene in markets to promote technology solutions and infrastructure development.

### CO₂ EMISSIONS

- **36%** increase in CO₂ emissions from cars
- **79%** increase in CO₂ emissions from all transport
- **46%** drop in CO₂ emissions from cars
- **16%** increase in CO₂ emissions from all transport

**Increase in CO₂ car emissions come from emerging non-OECD markets, especially Asia (India by seven-fold and China by more than eight-fold). Reductions expected in OECD countries (US will drop by about 38%).**

**Most reductions in CO₂ car emissions are expected from OECD markets (i.e., US and Western Europe drop by about 80%). Increase expected in non-OECD countries, especially Asia (India by about four-fold and China by three-fold).**

Download the full report on [www.worldenergy.org/publications](http://www.worldenergy.org/publications)
Critical uncertainties

Need for action

WEC Issues Surveys 2011
the LAC energy agenda

Weak signals
Critical uncertainties

Need for action

Weak signals

Macroeconomic Risks & Vulnerabilities
Energy Geopolitics
Energy Business Environment
Energy Vision

WEC Issues Surveys 2011
the EUROPEAN en. agenda

uncertainty

energy-water nexus

hydrogen economy

energy-efficiency

sustainable cities

business cycle

trade barriers

currency uncertainty

terrorism

US policy

energy poverty

talent

capital markets

large scale accidents

Russia

capital markets

UNCO

large scale
hydro

biofuels

unconventionals

hydrogen

energy-water

nexus

unconventionals

talent

currency uncertainty

terrorism

US policy

energy poverty

large scale
hydro
WEC Issues Surveys 2011
the N-AM energy agenda
Push for US cars to run on natural gas

General Electric and Chesapeake Energy have formed an alliance to promote the use of natural gas as a fuel for cars and trucks, in a bid to capitalise on the US shale gas boom.

The two companies will work together on developing gas infrastructure for transport, including new units for compressing natural gas for use at filling stations.
Key Messages

1. Future of transport critically depends on Government Policies
2. Shifting to developing Countries
3. Global transport dependent on fossil fuels
4. Government regulation needed to:
   - Develop infrastructure and technologies
   - Reduce externalities (emissions, congestion, noise and fatalities)
5. Strong regional differences
Implications

- Policy makers (emission targets, infrastructure, etc.)
- Oil producers and refiners – refining requirements?
- Manufacturing (cars, airplanes, rails, etc.) – vulnerable, multiple pathways
- Consumers behaviour – new choices