



World Energy Council – who we are



"The world energy leaders' network"

- Truly global
- Inclusive and impartial
- Committed to our sustainable energy future since 1923
 - 93 national committees chaired by energy ministers, leading CEOs and practitioners
 - Represents over 3000 government, private sector and experts organisations
 - Flagship event: World Energy Congress, every three years – next in Daegu, South Korea, 2013









WEC: more than two decades of scenarios expertise

 Cooperating with businesses, governments, international organisations, member committees

Building on previous WEC scenarios studies:

- Global Energy Perspectives 2000–2020 (1989)
- Energy for Tomorrow's World (1993)
- Global Energy Perspectives to 2050 and Beyond (1995)
- Global Energy Perspectives (WEC–IIASA, 1998)
- Energy for Tomorrow's World Acting Now (2000)
- Drivers of the Energy Scene (2003)
- Deciding the Future: Energy Policy Scenarios to 2050 (2007)
- Global Transport Scenarios 2050 report (2011)



WEC Scenarios Project Process

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Now we are here

Objectives

Approach

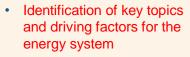
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Orientation

Scenario building

Affirmation and challenge

plications and insights



- Research and desktop studies combined with regional and topical workshops/meetings
- · Analysis of future endstates of identified key drivers and critical uncertainties
- Synthesis of end-states into scenario stories
- Identifying most important regional drivers underlying the global evetem

Obtain additional input and challenge from a variety of internal and external stakeholders

Input from Member Committees network

Modelling and quantification of scenario stories

- Analysis of findings from the scenario stories
- Regional questionnaires using Energy Trilemma Metric
- Developing strategic messages for policy makers and the public





- Description of identified driving forces of the future energy system. Overview of key uncertainties, whose resolution will shape the global energy system
- Identification of predetermined trends; those that will happen in all
- Description of future energy space in terms of scenario stories, illustrating potential outcomes along a projected timeline and a series of possible events
- Regional insights in combination with overarching global drivers

Better understanding of regional concerns and aspects, prioritisation and improved messaging of the scenario stories

Checking logic and feasibility of scenario messages against quantified data

- Final report with key messages
- Stakeholder engagement program



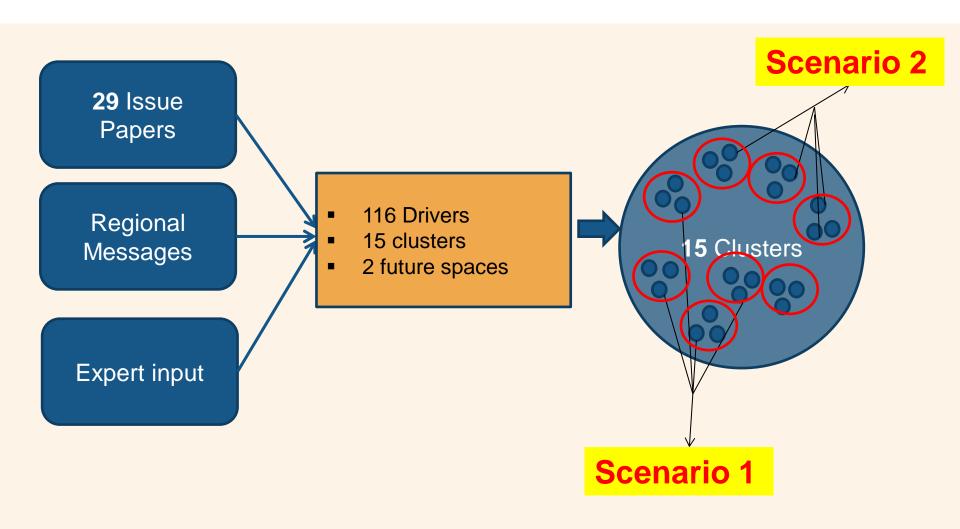
Laying the foundation: 5 Workstreams & 29 Issues

Economics Finance Trade	Energy Systems & Technologies	Resource Availability & Access	Consumer Behaviour & Acceptance	Government Policies
Super-Cycles vs. Boom and Bust? Population & Megacities Investment in infrastructure Prices of energy- commodities-CO2 Rise of China Globalization & Trade	 Energy Efficiency Technology - supply & demand side Technology - Environmental Smart Grids (incl. interconnectivity) Renewables (true associated costs) Mobility (Report) 	 Reserves - coal, oil, gas, rare earths, etc. Security of supply & demand Geopolitics - MENA instability Competition for resources Energy-Water Nexus Energy Poverty 	 Costs vs Values Leadership - state vs. private groups Acceptance 	 Climate change & Environment Competiveness, price, affordability Demand management & energy Efficiency Energy mix R&D Security of supply
	Nuclear (Report)	➤ Land use and access		

- > Study Group was organised into 5 workstreams
- > 29 Lead authors, with co-authors worked on each issue
- 447 page background document prepared
- > Crucial in understanding the drivers of the energy system



Scenario Building Process



Key Clusters



- 1. Role of State
- 2. Availability of Funds
- 3. Mitigation of CO2
- 4. Equality
- 5. Global Economics
- 6. Energy Prices
- 7. Consumer/citizen acceptance
- 8. Energy Efficiency

- 9. Technology developments
- 10. Security of supply
- 11. China and India
- 12. Energy Poverty
- 13. Energy Sources
- 14. Competition for resources
- 15. Skills shortages

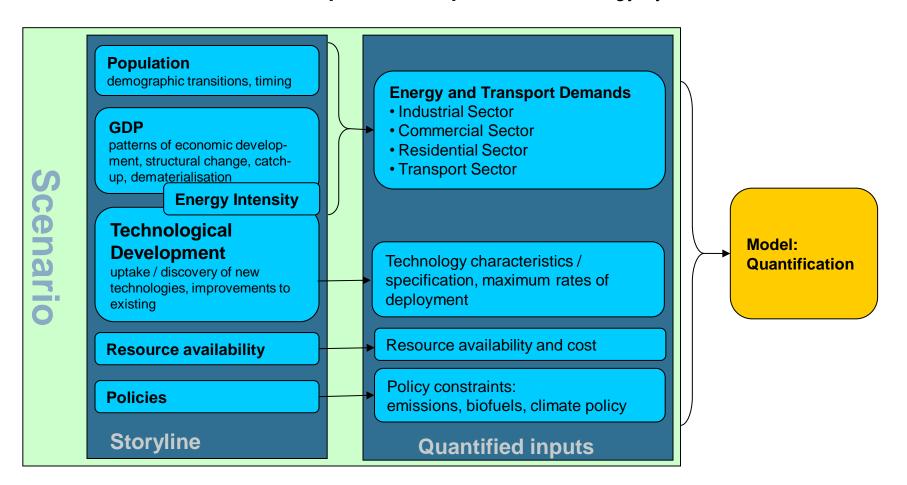


Brief outline of Global Scenario stories

Jazz	Symphony	
World where there is a consumer focus on achieving energy access, affordability, and individual energy security with the use of best available energy sources	World where there is a voter consensus on driving environmental sustainability and national energy security through corresponding practices and policies	
Main players are multi-national companies, banks, venture capitalists, and price- conscious consumers	Main players are private and public-sector companies, local governments, NGOs, and environmentally-minded voters	
Technologies are chosen in competitive markets	Governments pick technology winners	
Energy sources compete on basis of price & availability	Select energy sources are subsidised and incentivized by governments	
Higher GDP growth due to optimised (efficient) market practices.	Lower GDP due to non-optimal economic policies	
Free-trade strategies lead to increased exports	Nationalistic strategies result in reduced exports/imports	
Renewable and low carbon energy grows in line with market selection	Certain types of renewable and low carbon energy actively promoted by governments in the first part of the scenario period	
In the absence of international agreed commitments Carbon market grows more slowly from bottom up based on regional, national and local initiatives.	Carbon market is top down based on an international agreement, with commitments and allocations.	

Energy Model Framework: Key scenario drivers

- Evolutions of key scenario drivers are expressed in a **coherent storyline** of future economic and social developments
- Some drivers are **interdependent**, e.g. energy intensity
- Drivers must be **translated into quantified inputs** for the energy system models



Balancing the "Energy Trilemma"



"promoting an affordable, stable and environmentally sensitive energy system for the greatest benefit of all"

Energy security

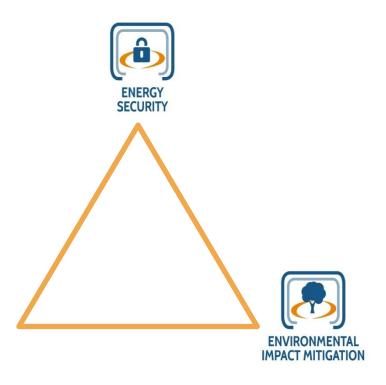
The effective management of primary energy supply from domestic and external sources, the reliability of energy infrastructure, and the ability of participating energy companies to meet current and future demand.

EQUITY

Environmental impact mitigation

Encompasses the achievement of supply and demand-side energy efficiencies and the development of energy supply from renewable and other low-carbon sources Social equity

Accessibility and affordability of energy supply across the population



Mapping the scenarios around the trilemma



Social Equity (access and affordability)

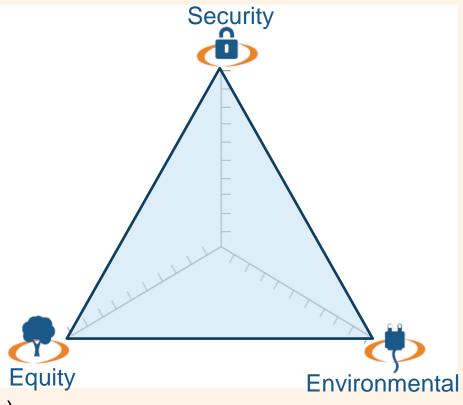
- Marginal electricity generation cost
- Marginal cost of petrol/diesel
- Costs vs. GDP
- Investment required
- Access (grid connections)

Energy Security

- Share of fuels in primary energy mix
- Diversity of supply
- Diversity of demand
- Reserve capacity (electricity product

Environmental Sustainability

- CO₂ emissions
- Competition for land (biofuels)
- Water use (unconventional oil and gas)



Model description and quantification of scenario stories



- Modelling partner: Paul Scherrer Institut, Switzerland (PSI)
- Model used: GMM (Global Multi-regional MARKAL model)
- Model features: MARKAL (MARKet Allocation)

Bottom-up, perfect foresight cost-optimization models

Least-cost solutions

Endogenous technological learning (ETL)

8 Demand Sectors (detailed transport sector)

Time horizon: 100 years, 10-year intervals

Discount rate: 5% p.a. across all technologies

 Current regional split: North America (NAM), Latin America, Middle East and Africa (LAFM), Western Europe (WEUR), Former Soviet Union and Eastern Europe (EEFSU), Asia (ASIA), and Other OECD (OOECD)



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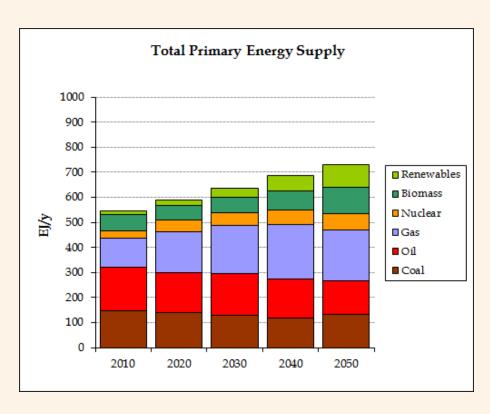
INDICATIVE MODELLING RESULTS: GLOBAL LEVEL



Jazz

Total Primary Energy Supply 1000 900 800 700 ■ Renewables Biomass 600 ■ Nuclear 500 ■ Gas 400 Oil ■ Coal 300 200 100 2010 2020 2030 2040 2050

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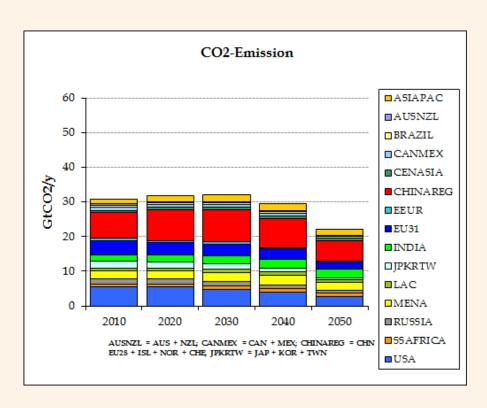




Jazz

CO2-Emission ASIAPAC 60 AUSNZL 50 □ BRAZIL ■CANMEX 40 ■CENASIA GtCO2/y CHINAREG ■EEUR ■EU31 20 ■INDIA □JPKRTW 10 **BLAC** MENA 2010 2020 2030 2040 2050 ■RUSSIA ■55AFRICA AUSNZL = AUS + NZL; CANMEX = CAN + MEX; CHINAREG = CHN EU28 + ISL + NOR + CHE, JPKRTW = JAP + KOR + TWN ■USA

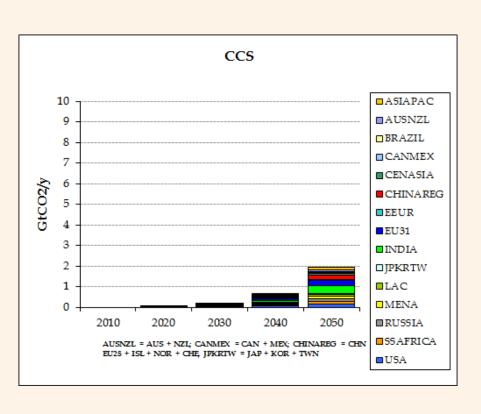
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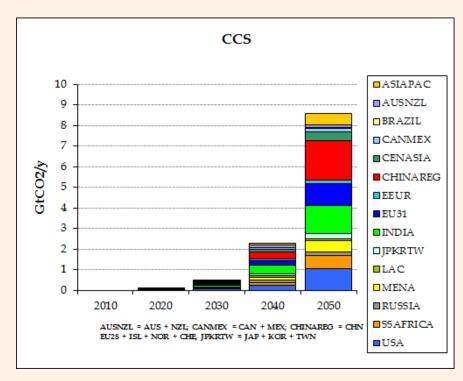




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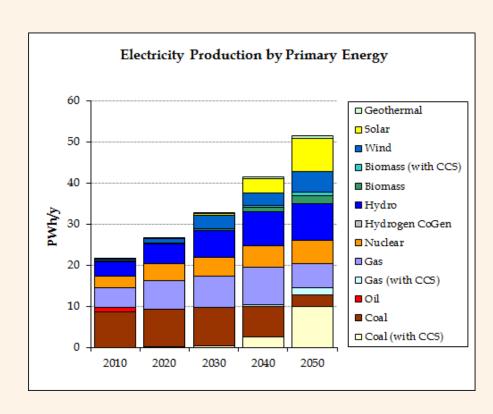




Jazz

Electricity Production by Primary Energy 60 □ Geothermal □ Solar 50 Wind ■ Biomass (with CCS) 40 Biomass ■ Hydro PWh/y ■ Hydrogen CoGen ■ Nuclear ■ Gas 20 Gas (with CCS) Oil 10 ■ Coal □ Coal (with CCS) 2010 2020 2030 2040 2050

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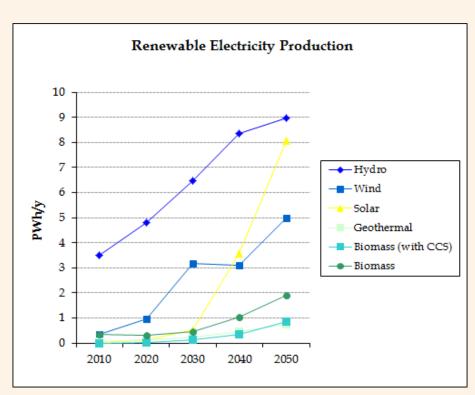




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Renewable Electricity Production 10 9 8 7 Hydro Wind 6 PWh/y Solar Geothermal -Biomass (with CCS) Biomass 3 2 2010 2020 2030 2040 2050

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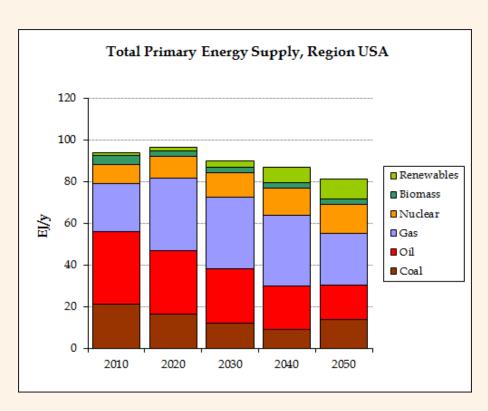
INDICATIVE MODELLING RESULTS: USA



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Total Primary Energy Supply, Region USA 120 100 ■ Renewables 80 ■ Biomass ■ Nuclear ■ Gas ■ Oil 40 ■ Coal 20 2010 2020 2030 2040 2050

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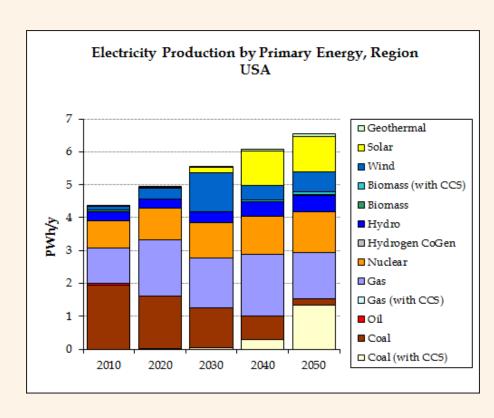




Jazz

Electricity Production by Primary Energy, Region USA □ Geothermal □ Solar 6 Wind 5 ■ Biomass (with CCS) ■ Biomass PWh/y ■ Hydro ■ Hydrogen CoGen ■ Nuclear Gas 2 ☐Gas (with CCS) 1 Oil ■ Coal Coal (with CCS) 2010 2020 2030 2040 2050

Symphony



North America scenario workshop



Some key messages emerging:

- ► Fossil fuels, especially from unconventional sources, continue to play a major role for longer than expected by general public
- Gas in Transport
- Important role for CCS and CCUs in managing greenhouse gases
- Climate change policies and constraints need review
- Developments in power storage technologies are key
- Demand side management is required
- "new realism" emerging
- Transitions take time and a lot of capital
- Energy policy is an important driver of economic policy at international level