Energy Technology Perspectives: Modelling approach and scenarios

Uwe Remme

The World in 2050 Interactive Science Meeting (TWI2050), 10-12 March 2015, IIASA
IEA’s programme of work in energy technology

- Where do we need to go?
- Where are we today?
- How do we get there?
How we generate our scenarios

Global energy system today
How we generate our scenarios

Global energy system in 2050 in the 2DS
ETP model finds cost-effective investment and operation of energy technologies to meet energy demands from now to 2050
Cost-effective strategies for meeting global energy system demands...

...from now to 2050, in 28-40 regions.
Carbon Intensity of supply is stuck
A transformation is needed

Graph showing annual reductions and future projections of CO2 emissions.

- **2020**
  - Power generation efficiency and fuel switching: 6%
  - Nuclear: 11%
  - End-use fuel switching: 6%
  - End-use fuel and electricity efficiency: 5%
  - Renewables: 18%
  - CCS: 1%

- **2050**
  - Power generation efficiency and fuel switching: 30%
  - Nuclear: 36%
  - End-use fuel switching: 16%
  - End-use fuel and electricity efficiency: 7%
  - Renewables: 11%
  - CCS: 1%

Legend:
- Power generation efficiency and fuel switching: 1%
- Nuclear: 8%
- End-use fuel switching: 10%
- End-use fuel and electricity efficiency: 39%
- Renewables: 30%
- CCS: 12%
Electricity Generation: a share reversal

Generation today:
- Fossil fuels: 68%
- Renewables: 20%

Generation 2DS 2050:
- Renewables: 65%
- Fossil fuels: 20%
Often overlooked: Heating and cooling

Global energy and CO₂ impacts of heating and cooling in 2012

Primary energy use 560 EJ

- Heating and cooling 34%
- Other end-uses 66%

Final energy consumption 371 EJ

- Heating and cooling 44%
- Other end-uses 56%

CO₂ emissions 34.5 Gt

- Heating and cooling 29%
- Other end-uses 71%

Final energy use for heating and cooling

100% 80% 60% 40% 20% 0% 250 200 150 100 50 0

- 2012 - 2020 - 2030 - 2040 - 2050

6DS 2DS

- Oil
- Coal
- Gas
- Electricity
- Heat sold
- Biomass
- Geothermal
- Solar
- Renewable share
‘Avoid, shift and improve’ strategy for transport
Investment in our future pays off...

...and it is cost effective to make the transition
Not on track in many technology areas

- Renewable power
- Nuclear power
- Gas-fired power
- Coal-fired power
- Carbon capture and storage
- Industry
- Transport
- Biofuels
- Electric and Hybrid electric vehicles
- Buildings
- Smart grids
- Co-generation and district heating and cooling
Energy Technology Roadmaps: How to get to the 2DS?

Example: Nuclear energy technology roadmap

20 Energy Technology Roadmaps available

Nuclear energy roadmap actions and milestones

- Reactor technology
  - 2015: Recognise the value of long term operation to maintain low carbon generation capacity and security of energy supply; provided safety requirements are met. Clearer policies needed to encourage investment in both long-term operation and new build.
  - 2020: Optimise Gen III designs to improve constructability and reduce costs. The learning rate from FOAK construction needs to be accelerated to ensure that NPP plants are built on time and to budget.
  - 2030: Accelerate the development of SMR prototypes and launch construction projects (at least 5 projects per design) that can demonstrate the benefits of modular design and factory-assisted construction.
  - 2050: Incorporate feedback from operation of Gen IV prototypes to develop FOAK Gen IV commercial plants.

- Nuclear fuel cycle
  - 2020: Recognise the long-term benefits of developing Gen IV systems in terms of resource utilisation and waste management, and support R&D and the development of at least one or two fast breeder Reactor prototypes to ensure technology is ready for deployment by 2030-2040.
  - 2030: Put in place public-private partnerships to develop demonstration projects for nuclear cogeneration.
  - 2040: Invest in environmentally sustainable uranium mining to address expected long-term demand.
  - 2050: Ensure that policies are in place for long-term storage and disposal, including deep geological disposal of high level waste.

- Licensing and regulation, nuclear safety
  - 2020: Ensure that regulators are strong, independent and staffed with enough skilled, competent and adequately remunerated personnel to carry out their missions.
  - 2030: Continue to promote international co-operation through fora of regulators, industry and operators, and intergovernmental organisations and initiatives.
  - 2040: Develop licensing frameworks for advanced reactors, including SMRs and Gen IV reactors.
  - 2050: Implement post-Fukushima safety upgrades in existing reactors in a timely manner.

- Financing nuclear development
  - 2020: Enhance and monitor safety culture across the nuclear sector and at all levels of staff.
  - 2030: Ensure a level playing field for all low-carbon power technologies, and provide clear policies (national but also within financial institutions, e.g. multilateral development banks) and stable long-term strategies for nuclear development.
  - 2040: Favour investment in low-carbon electricity sources through carbon trading schemes, carbon taxes or mandates for low-carbon electricity.
  - 2050: In nuclear countries, undertake national skills evaluations to quantify the need for a skilled nuclear workforce to maintain the operation of existing fleets, for future decommissioning activities as well as for nuclear new build.

- Training and capacity development
  - 2020: In newcomer countries, develop local training programmes aimed at developing a nuclear-aware and nuclear-competent workforce.
  - 2030: In newcomer countries, develop local training programmes aimed at developing a nuclear-aware and nuclear-competent workforce.
  - 2040: Accelerate harmonisation of codes and standards to improve the integration of a global supply chain.
  - 2050: Develop targeted education and information programmes to improve the general public’s understanding of the benefits and risks of nuclear energy.

- Codes and standards
- Communication and public acceptance

Nuclear Energy Agency · International Energy Agency  www.iea.org/roadmaps
Thank you!

Explore the data behind ETP

www.iea.org/etp2014
IEA Energy modelling and scenarios

- **Forecasts (next 5 years):** Medium-term market reports

- **Market-based scenarios (Next 25 years):** World Energy Outlook

- **Long-term planning scenarios (Next 35 years):** Energy Technology Perspectives

- **GIVAR project:** Analysis of flexibility resources/market design for vRE
Integration of variable renewables

Analysis of flexibility options with linear dispatch model

Role of smart EV charging in 2DS variant in US (for one week)

Analysis of storage needs

2050 ETP Long-term model

2050 ETP Dispatch model
Strategies to decarbonise electricity vary across regions.

Generation mix 2050

- Solar PV
- CSP
- Wind
- Hydro
- Biomass and waste
- Other renewables
- Coal
- Natural gas
- Nuclear