UNECE

ENERGY

Workshop on Attaining Carbon Neutrality in the ECE region – Role of Nuclear Energy to Attain Carbon Neutrality in the UNECE region

Day 1

23 November 2020

Housekeeping rules

Mute your microphone if you are not speaking

Use “Chat” function to ask questions and share comments

What we will cover?

Welcome & Opening remarks

Vladimir Budinský, Acting Chair, Group of Experts on Cleaner Electricity Systems

Nuclear Energy Technology & Policy Brief

King Lee, Director Harmony Programme, World Nuclear Association & Vice-Chair Group of Experts on Resource Management & Group of Experts on Cleaner Electricity Systems

Nuclear technology & applications

Henri Paillere, Head of Planning and Economic Studies Section, International Atomic Energy Agency (IAEA)

Economic & cost curves

Michel Berthélemy, Nuclear Energy Analyst, OECD Nuclear Energy Agency

Environmental & health impact of nuclear energy

Thomas Gibon, Research & Technology Associate, Luxembourg Institute of Science and Technology

What we will cover?

National perspective on the future role of nuclear energy

Nuclear energy for Net Zero – UK energy system appraisal

James Murphy, Chief Strategy Officer, National Nuclear Laboratory (NNL)

Poland nuclear energy development plan

Józef Sobolewski, Poland Director at National Center of Nuclear Research and Adviser to the Minister of Climate and Environment in Poland

Closing Remarks

King Lee, Director Harmony Programme, World Nuclear Association & Vice-Chair Group of Experts on Resource Management & Group of Experts on Cleaner Electricity Systems

Opening Remarks

Vladimir Budinský

Acting Chair, Group of Experts on Cleaner Electricity Systems

King Lee

Director Harmony Programme, World Nuclear Association & Vice-Chair Group of Experts on Resource Management & Group of Experts on Cleaner Electricity Systems

Technology Brief on Nuclear Energy

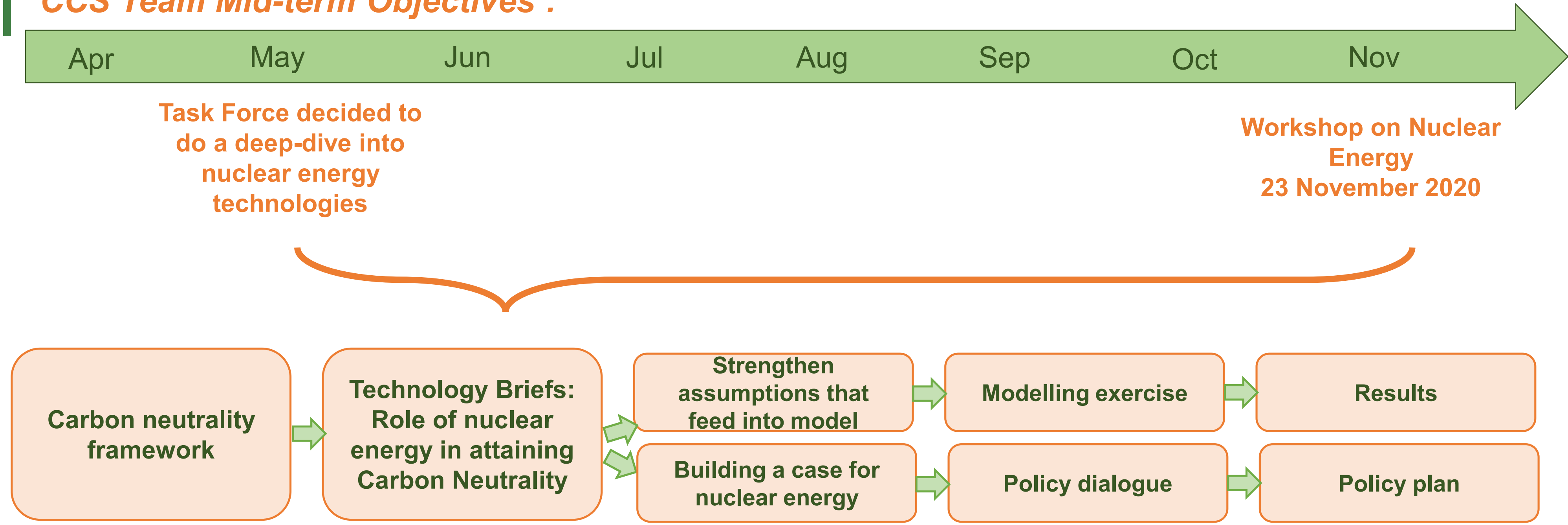
ENERGY

☐ **Role of nuclear energy in attaining carbon neutrality**

  ☐ Technology focus

  ☐ Policy focus

CCS Team Mid-term Objectives :



Apr May Jun Jul Aug Sep Oct Nov

Task Force decided to do a deep-dive into nuclear energy technologies (May)

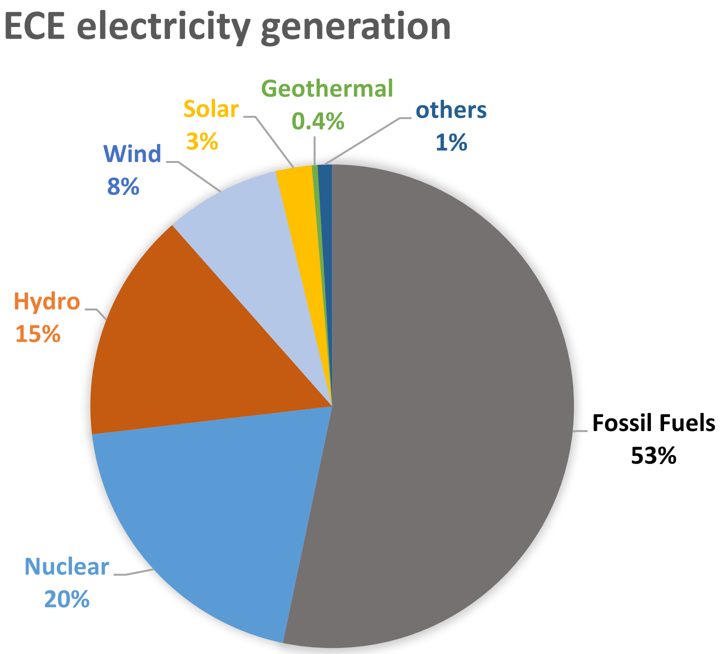
Workshop on Nuclear Energy 23 November 2020 (Nov)

Carbon neutrality framework → **Technology Briefs: Role of nuclear energy in attaining Carbon Neutrality**

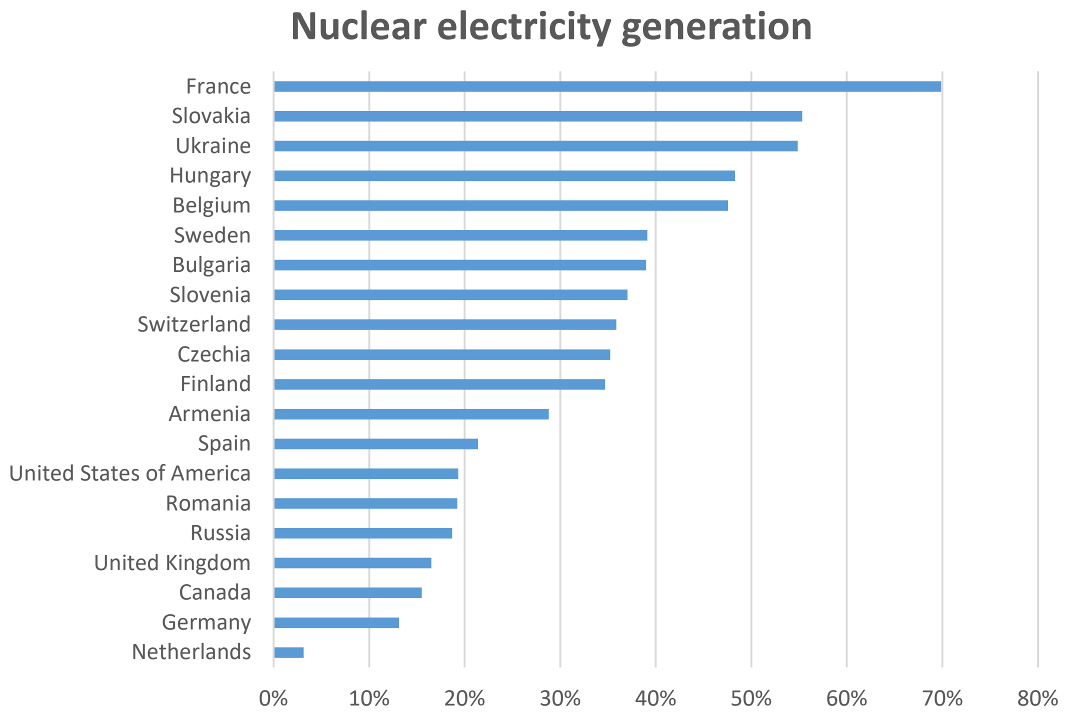
→ **Strengthen assumptions that feed into model** → **Modelling exercise** → **Results**

→ **Building a case for nuclear energy** → **Policy dialogue** → **Policy plan**

ECE Countries electricity generation (2019)



ECE electricity generation

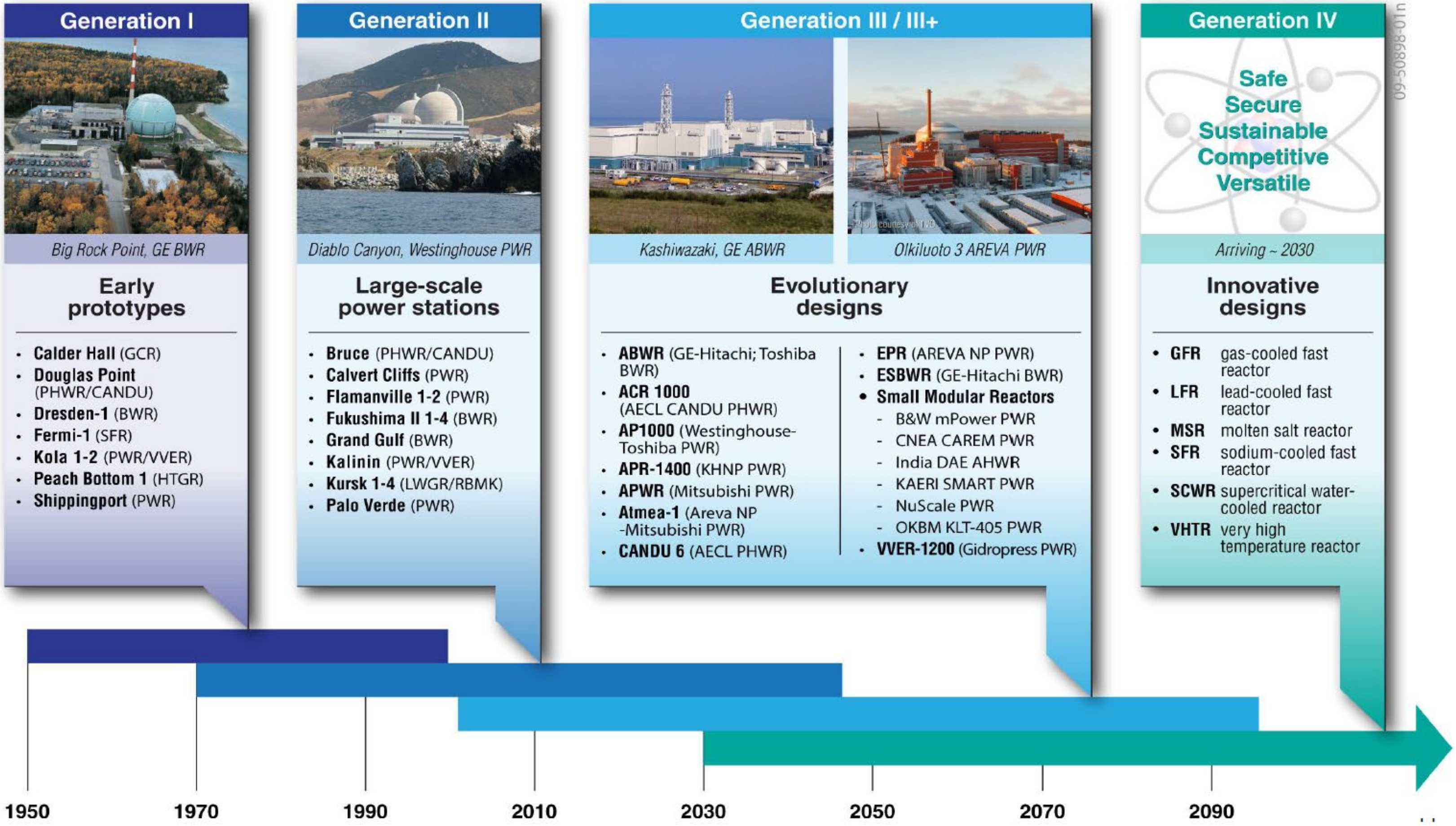


Nuclear electricity generation

Nuclear energy provides the largest contribution of low carbon electricity in ECE.

20 ECE Member States currently operate nuclear power plants. These nuclear countries produce 85% of ECE total electricity generation. 22 countries have new reactor under construction or planning new nuclear development.

Nuclear energy is a mature technology that provide reliable low carbon source of electricity today.



Generation I

Big Rock Point, GE BWR

Early prototypes

- **Calder Hall** (GCR)
- **Douglas Point** (PHWR/CANDU)
- **Dresden-1** (BWR)
- **Fermi-1** (SFR)
- **Kola 1-2** (PWR/VVER)
- **Peach Bottom 1** (HTGR)
- **Shippingport** (PWR)

Generation II

Diablo Canyon, Westinghouse PWR

Large-scale power stations

- **Bruce** (PHWR/CANDU)
- **Calvert Cliffs** (PWR)
- **Flamanville 1-2** (PWR)
- **Fukushima II 1-4** (BWR)
- **Grand Gulf** (BWR)
- **Kalinin** (PWR/VVER)
- **Kursk 1-4** (LWGR/RBMK)
- **Palo Verde** (PWR)

Generation III / III+

Kashiwazaki, GE ABWR

Olkiluoto 3 AREVA PWR

Evolutionary designs

- **ABWR** (GE-Hitachi; Toshiba BWR)
- **ACR 1000** (AECL CANDU PHWR)
- **AP1000** (Westinghouse-Toshiba PWR)
- **APR-1400** (KHNP PWR)
- **APWR** (Mitsubishi PWR)
- **Atmea-1** (Areva NP -Mitsubishi PWR)
- **CANDU 6** (AECL PHWR)
- **EPR** (AREVA NP PWR)
- **ESBWR** (GE-Hitachi BWR)
- **Small Modular Reactors**
  - B&W mPower PWR
  - CNEA CAREM PWR
  - India DAE AHWR
  - KAERI SMART PWR
  - NuScale PWR
  - OKBM KLT-405 PWR
- **VVER-1200** (Gidropress PWR)

Generation IV

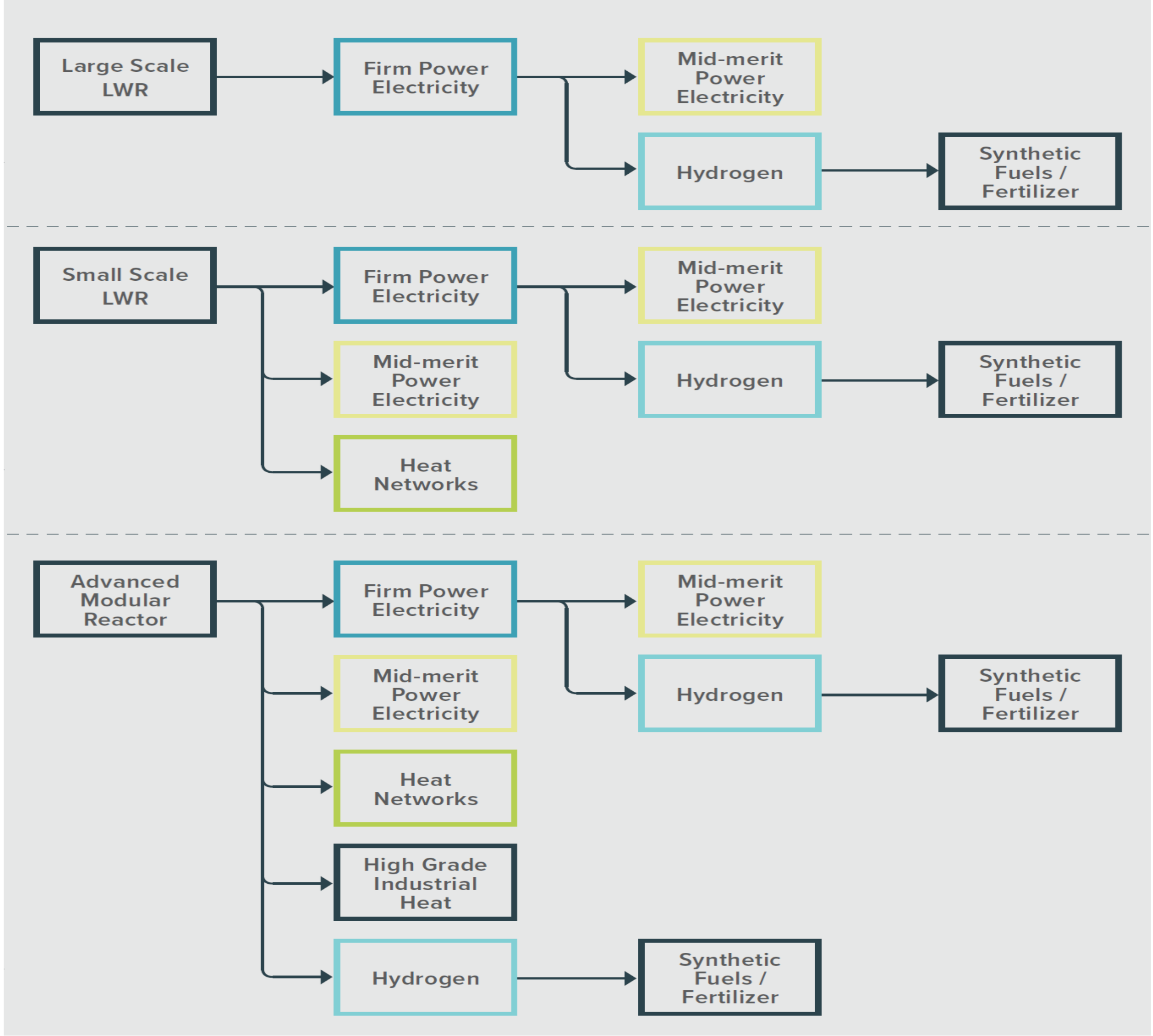
Safe
Secure
Sustainable
Competitive
Versatile

Arriving ~ 2030

Innovative designs

- **GFR** gas-cooled fast reactor
- **LFR** lead-cooled fast reactor
- **MSR** molten salt reactor
- **SFR** sodium-cooled fast reactor
- **SCWR** supercritical water-cooled reactor
- **VHTR** very high temperature reactor

Current and future nuclear technologies can support all three energy vectors of electricity, heat and hydrogen (including synthetic fuels).



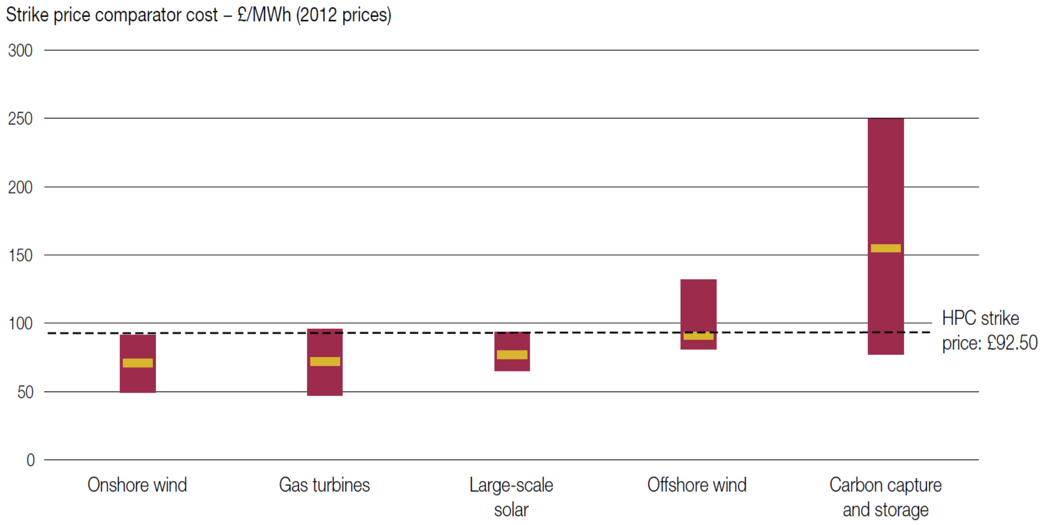
Cost effectiveness of nuclear energy - UK nuclear project

<u>National Audit Office's report June 2017 – review the Hinkley Point C (HPC) deal</u>

HPC CFD, similar to contracts for other low-carbon technologies

- No Government subsidy as such (commitment at the time)
- All up front risk under the private sector.
- In return : Guaranteed price for the electricity.
- By 2016, UK had set 40 CFDs with low-carbon electricity generators: 6.7 GWe – 15 year, £80 to £150/MWh (2012).
- HPC deal is competitive in price at the time.

The Department's estimates show that the strike price for HPC (£92.50/MWh) is within or just outside the range of costs of alternative large-scale generation technologies



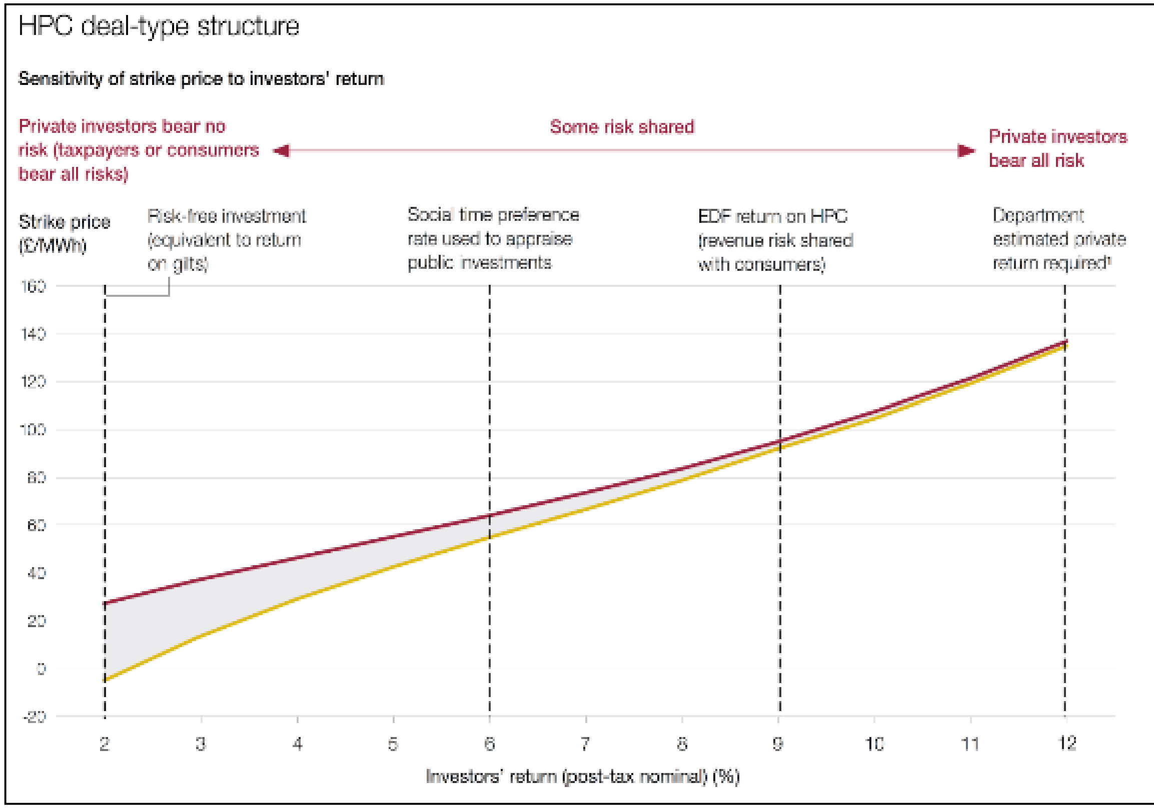
£/MWh	Onshore wind	Gas turbines	Large-scale solar	Offshore wind	Carbon capture and storage
🟥 Low case	49	47	65	81	77
🟨 Central case	71	72	77	91	155
🟥 High case	90	96	92	132	249
Difference (central case)	23% cheaper than HPC strike price	22% cheaper than HPC	17% cheaper than HPC	2% cheaper than HPC	68% more expensive than HPC

Nuclear projects – alternative structuring and financing

UK government is currently exploring Regulated Asset Base (RAB) model for the financing of nuclear project.

Capital cost of Sizewell C is estimated to be 20% lower than HPC, cost reduction from fleet effect, saving from ‘One off’ First of a kind cost, and lessons learned from previous build.

EDF has stated that the all-in cost for Sizewell will be between £40-£60/MWh versus the £92.5/MWh (2012 prices) for Hinkley Point C.



HPC deal-type structure

Sensitivity of strike price to investors' return

Nuclear technology & applications

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Henri Paillere

Head of Planning and Economic Studies Section, International Atomic Energy Agency (IAEA)

International Atomic Energy Agency
Atoms for Peace and Development

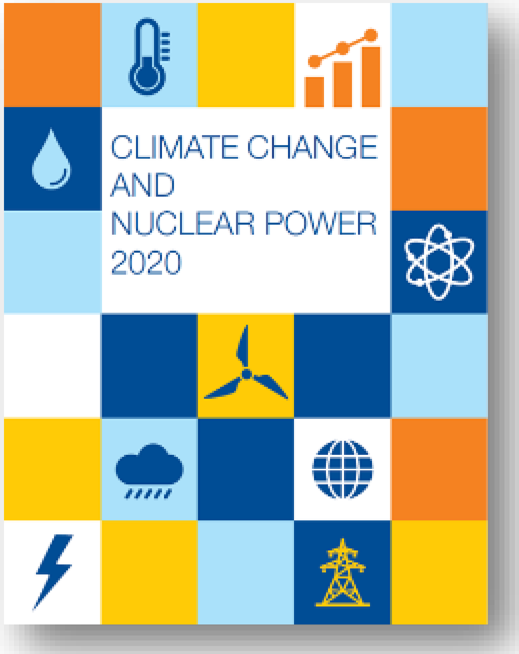
Nuclear power technologies and non-power applications

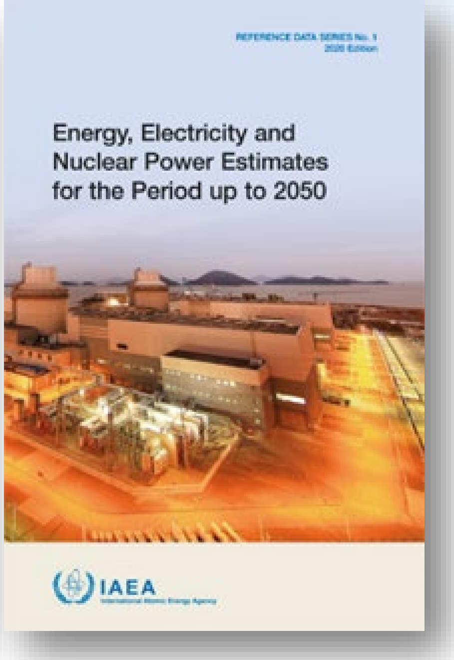
Dr. Henri PAILLERE
Section Head
Planning and Economics Studies Section
International Atomic Energy Agency

Role of Nuclear Energy to Attain Carbon Neutrality in the UNECE region
23 November 2020

Planning and Economic Studies Section

- Energy Planning support to Member States
- Nuclear power projections to 2050
- Technical and economic analysis of nuclear power and integrated nuclear/renewables systems
- Assessing contribution of nuclear energy to Climate Change mitigation
- Water-Energy Nexus, Resilience and adaptation to CC


CLIMATE CHANGE
AND
NUCLEAR POWER
2020


Energy, Electricity and
Nuclear Power Estimates
for the Period up to 2050

IAEA

https://www.iaea.org/topics/nuclear-power-and-climate-change/climate-change-and-nuclear-power-2020

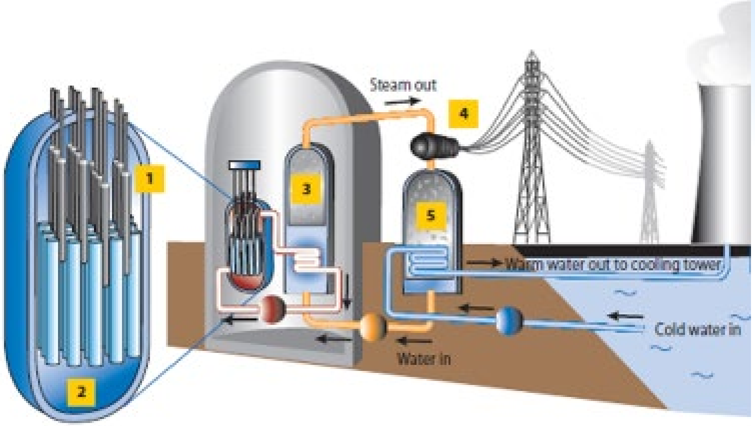
https://www.iaea.org/publications/14786/energy-electricity-and-nuclear-power-estimates-for-the-period-up-to-2050

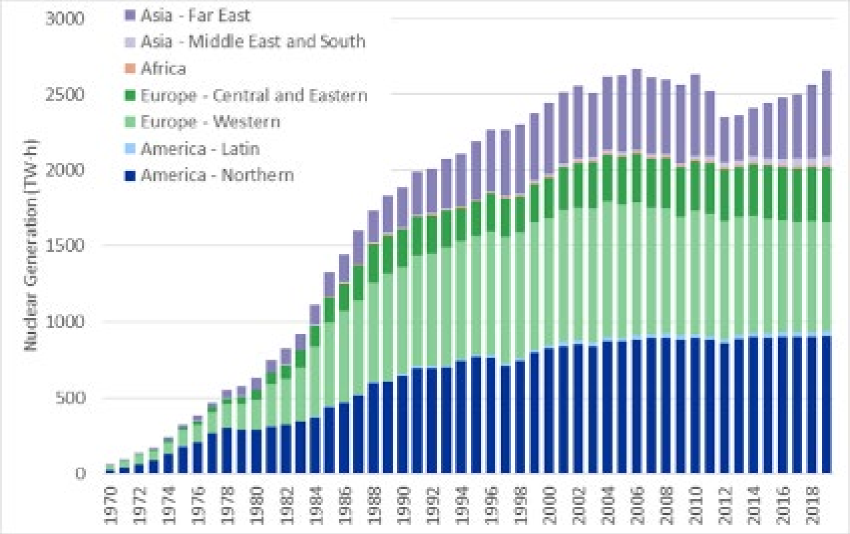
Nuclear power today

- **442** reactors <u>in operation</u> in 32 countries, including two units in newcomer countries (Belarus, UAE)
- 392 GW installed capacity
- 365 are **Light Water Reactors (83%)**

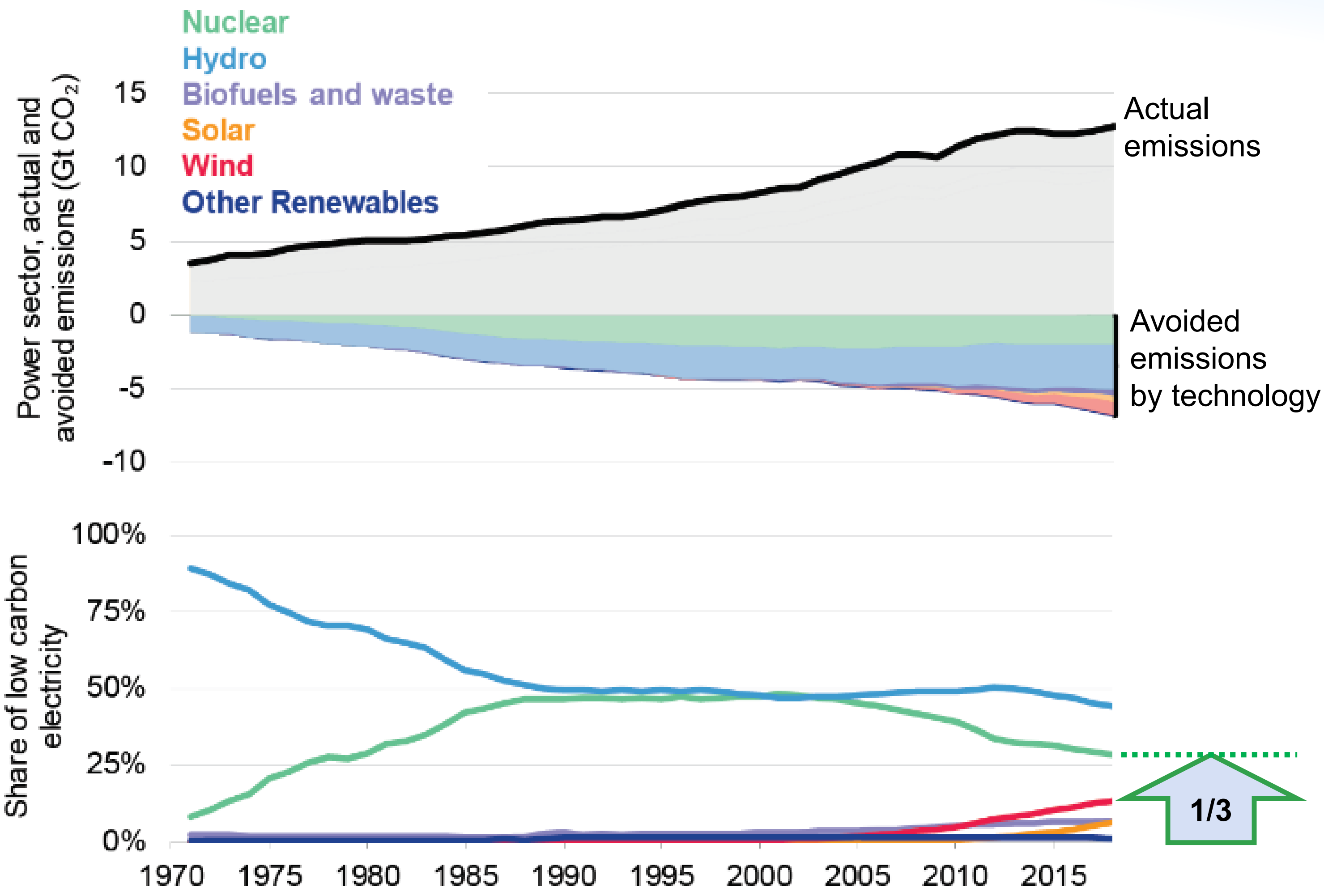
- In 2019, **10.4%** share of electricity

- **53** units <u>under construction</u> in 14 countries including 8 units in 4 newcomer countries (Bangladesh, Belarus, Turkey, UAE)
- 56 GW installed capacity
- 45 are **Light Water Reactors (85%)**





A track record CO_2 emissions avoidance



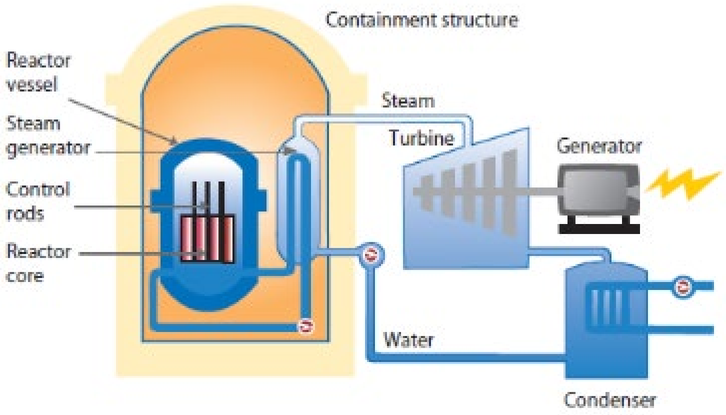
~A third of world’s low carbon electricity

Annual avoided emissions: ~ **2 Gt CO_2**

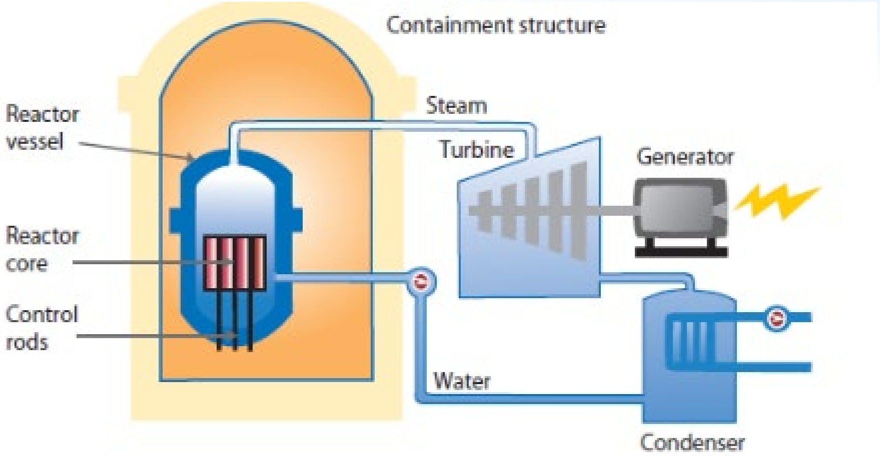
(this will decrease in the future, as the carbon footprint of the electricity mix decreases)

Cumulative avoided emissions over last 50 years: ~ **60-70 Gt CO_2** (depends on methodology)

Reactor technologies in operation today



Pressurised Water Reactor (PWR)



Boiling Water Reactor (BWR)

PWR, BWR = Light Water Reactor, with ordinary water used as coolant and moderator (to slow down fast neutrons produced in the fission reactor), Enriched uranium (3 to 5% ^{235}U) as fuel

Other reactors include:

- Pressurized Heavy Water Reactor: e.g. Canada (CANDU)
- Gas cooled reactors: cooled by CO2 (AGR in the UK)
- Fast Neutron reactors (cooled by liquid metals): e.g. BN600 and BN800 in Russia

By size

- **Large reactors**: typically 1GW or more (majority of reactors under construction today, in particular PWR)
- **Small Modular Reactors**: typically < 300MW
  - SMR based on LWR technologies
    - Including for Floating Nuclear Power Plants
  - SMR based on other technologies – “advanced” SMRs
- **Micro-reactors**: ~ $10MW_{th}$
- **Generation IV reactors / Advanced reactors**
  - Fast Neutron Reactors (closed fuel cycles), cooled by Sodium, lead or helium
  - (Very) High Temperature Reactors
  - Molten Salt Reactors
  - Supercritical Water-cooled Reactors

Large reactors: Economies of Scale

Shippingport PWR (1958, **60MW**)

x 30

Photo: courtesy of China General Nuclear Power Corporation

EPR Taishan 1 PWR (2018, **1750MW**)

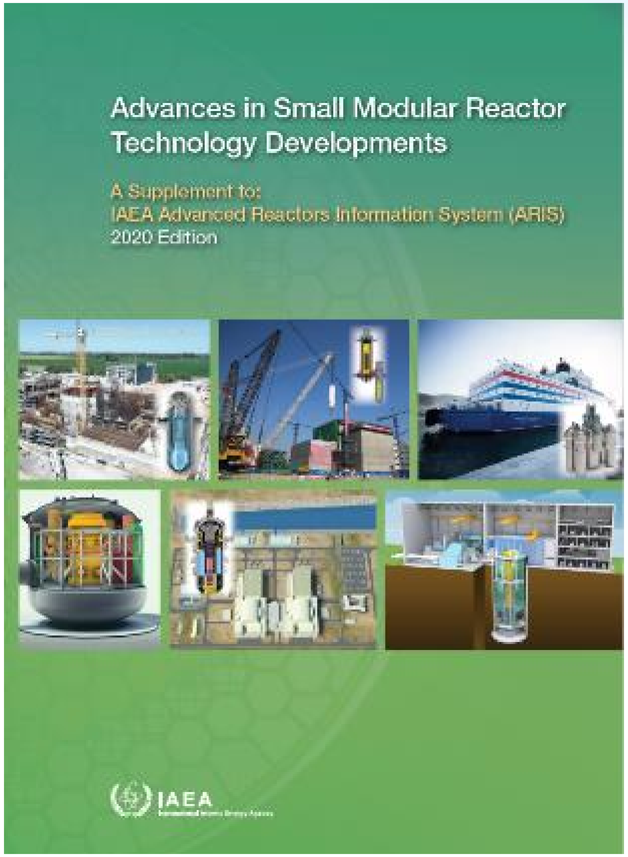
Small Modular Reactors

2020 Edition

- **Economics based on “serial production”**, modular design with factory fabrication, etc

Latest IAEA Booklet on Advanced in SMR Technology Developments:

- Design description and main features of **72** SMR designs being updated (56 in 2018)
- SMRs are categorized in types based on coolant type/neutron spectrum:
  - Land Based Water-cooled Reactors
  - Marine Based Water-cooled Reactors
  - High Temp gas cooled reactors
  - Fast Reactors
  - Molten Salt Reactors
  - Micro reactors



Advances in Small Modular Reactor Technology Developments

A Supplement to:
IAEA Advanced Reactors Information System (ARIS)
2020 Edition

IAEA

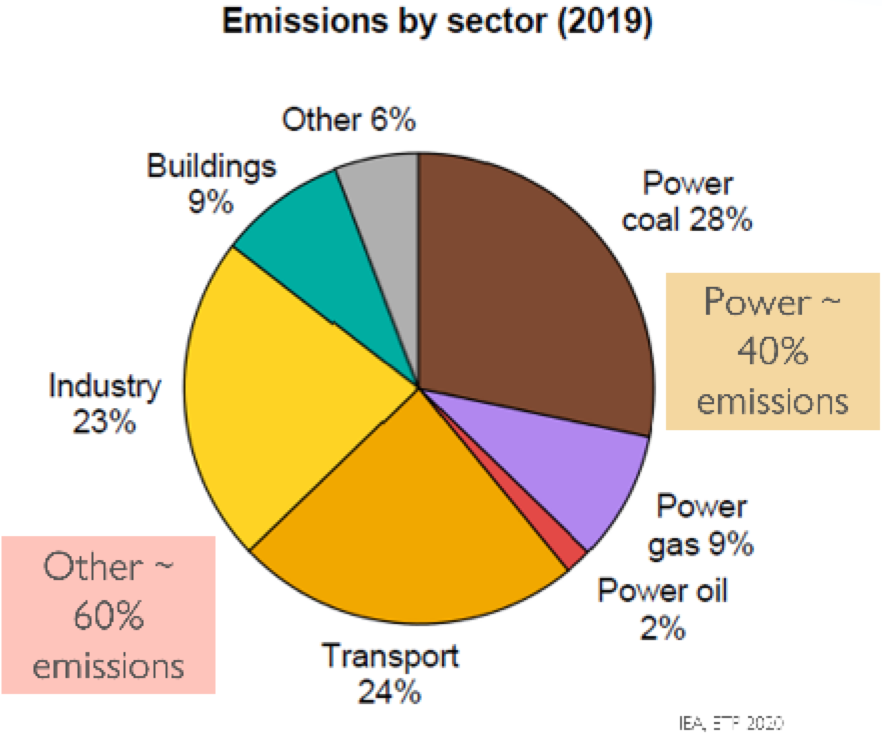
https://aris.iaea.org/Publications/SMR_Book_2020.pdf

Towards net-zero emissions

Decarbonising the power sector will not be sufficient.

Need to decarbonize other sectors, representing 60% of emissions today:

- **Electrification** whenever possible (so increased demand for clean electricity)
- Need for **low C heat sources** (eg. fossil + CCS, nuclear heat, solar thermal)
- Use of **low C fuels**, including hydrogen, produced from clean electricity (Sector Coupling)



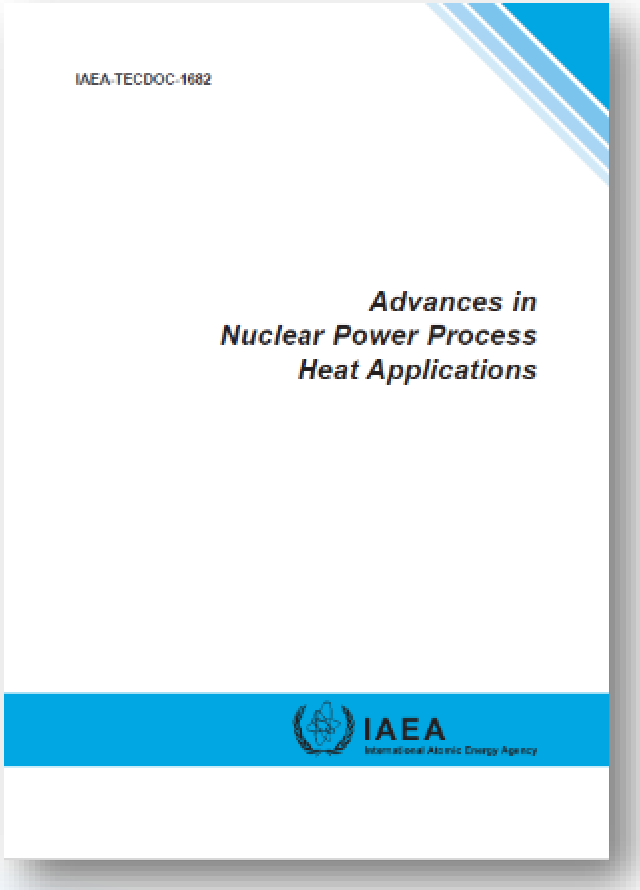
IEA, ETP 2020

Beyond power generation: District Heating

- Decades of experience, in Russia, Hungary, Switzerland, etc
- In June 2020, the new Floating Nuclear Power Plant Akademic Lomonosov, powered by two SMR units, provided 1st heat to Pevesk district (1st grid connection in Dec 2019)

Source: http://fnpp.info/

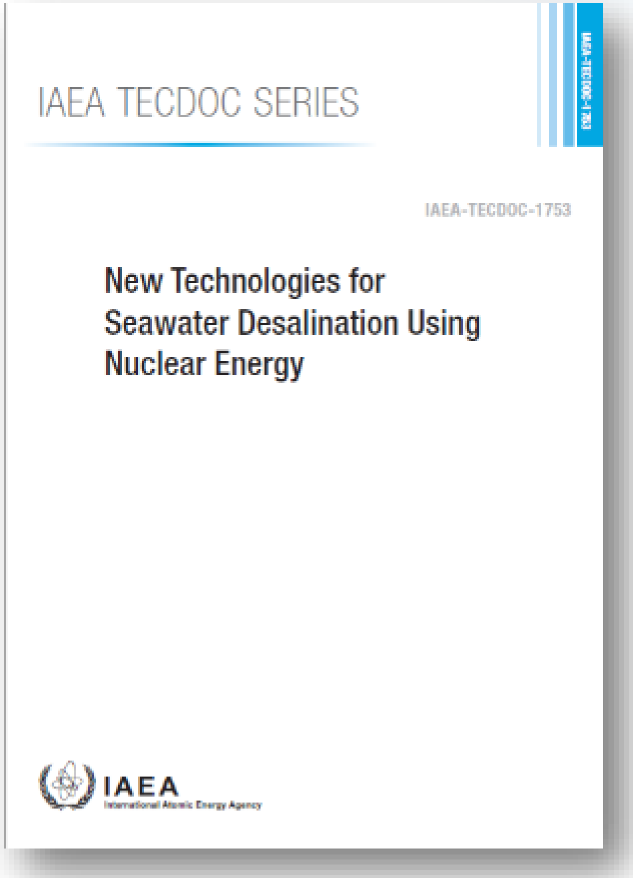
Beyond power generation: Process Heat, Desalination



IAEA-TECDOC-1682

Advances in
Nuclear Power Process
Heat Applications

IAEA
International Atomic Energy Agency



IAEA TECDOC SERIES

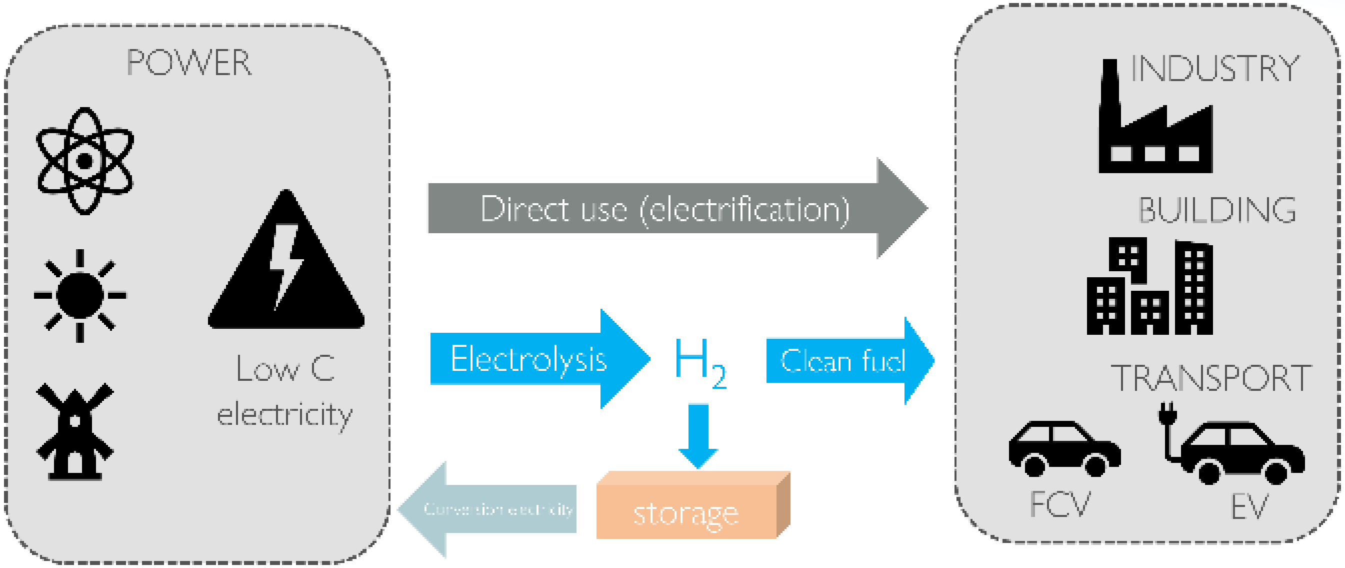
IAEA-TECDOC-1753

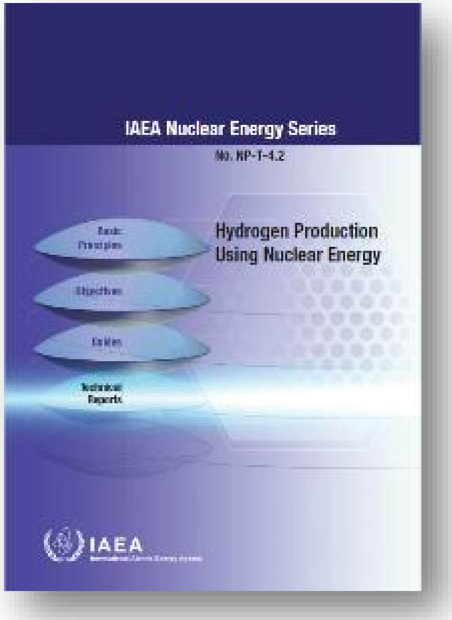
IAEA-TECDOC-1753

New Technologies for
Seawater Desalination Using
Nuclear Energy

IAEA
International Atomic Energy Agency

Beyond power generation: Hydrogen




IAEA Nuclear Energy Series
No. NP-T-4.2
Hydrogen Production
Using Nuclear Energy

How to produce “clean” / Low Carbon Hydrogen:

- Low temperature electrolysis with low carbon electricity (renewables, **nuclear**)
- High temperature steam electrolysis (**current or advanced reactors**)
- Thermo-chemical splitting (**advanced reactors**)

Take-aways

- Mature technology, over 50 years experience, with an observed consolidation of technologies towards (large) water cooled reactors – essentially for power
- 10.4% share electricity, 1/3 low carbon electricity today
- Future trends/technologies:
  - Large water-cooled reactors (Gen III)
  - Small water-cooled reactors (SMRs)
  - Advanced reactors (large and small)
  - Power but also non-power applications: heat, hydrogen
- Nuclear energy = low carbon source of power and heat!

Economic & cost curves

Michel Berthélemy

Nuclear Energy Analyst, OECD Nuclear Energy Agency

Perspectives on the economics of nuclear power

Dr. Michel Berthélemy

Role of Nuclear Energy to Attain Carbon Neutrality in the UNECE region
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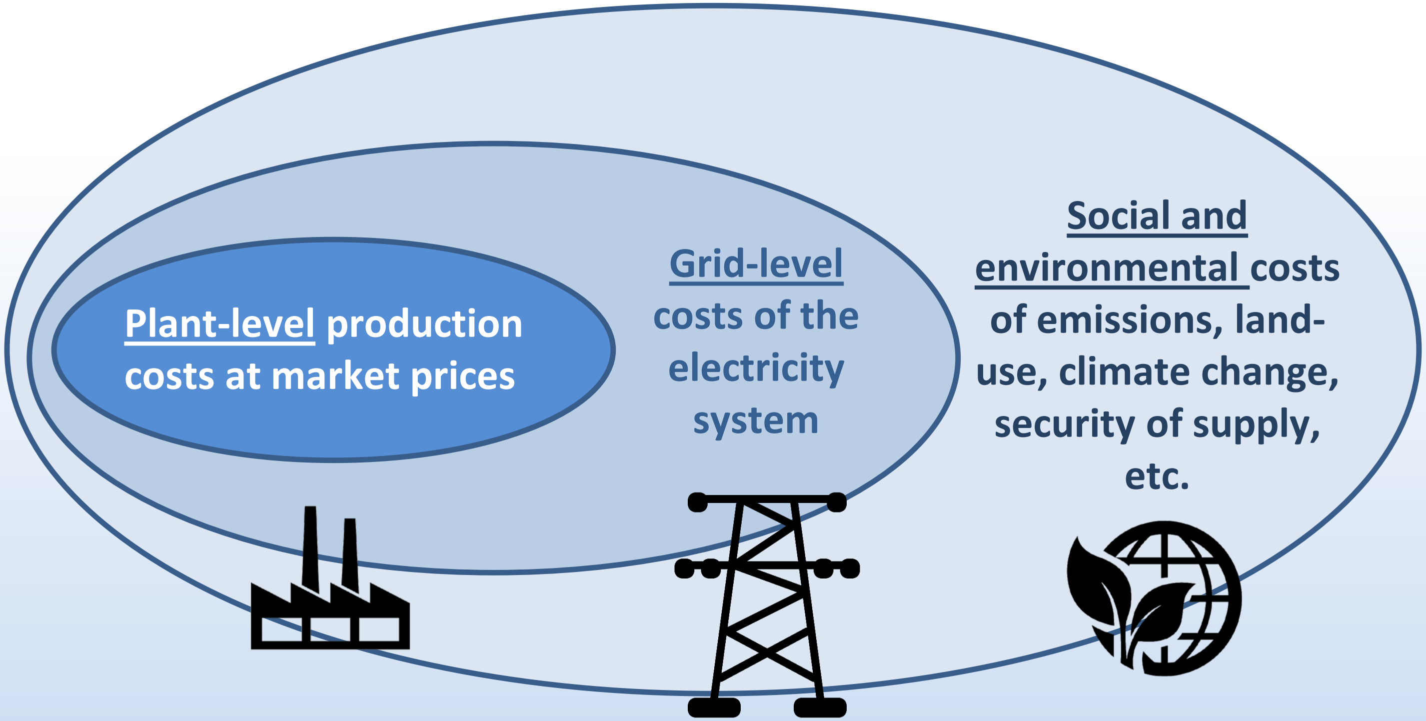
The costs of electricity: from plant-level to system costs



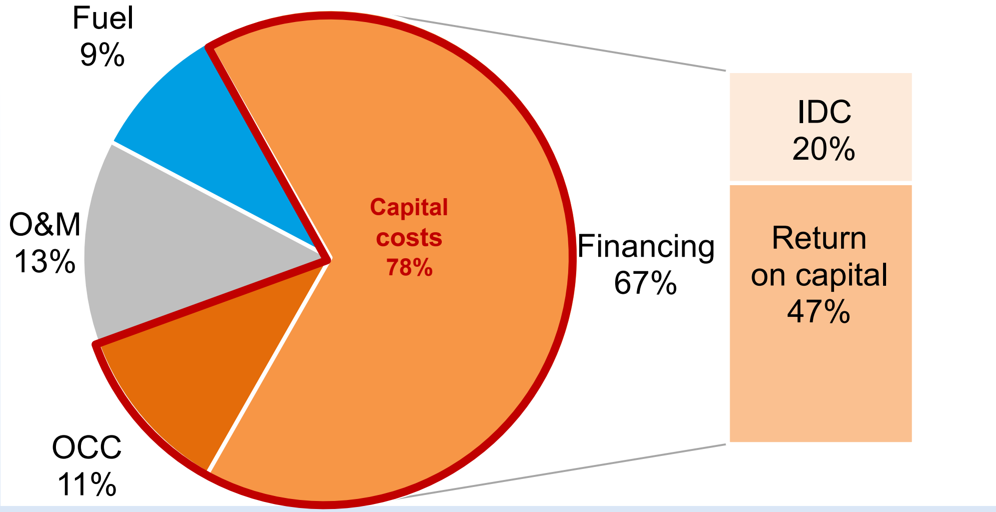
Plant-level production costs at market prices

Grid-level costs of the electricity system

Social and environmental costs of emissions, land-use, climate change, security of supply, etc.

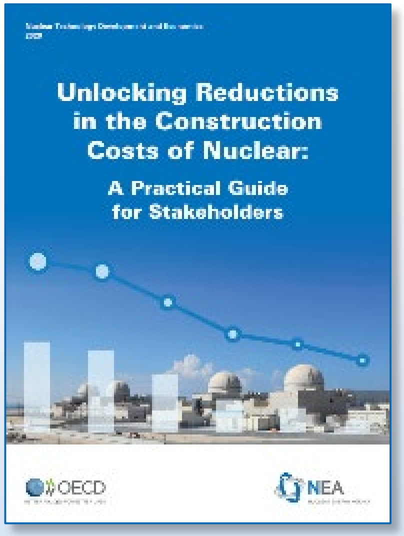
The actual cost of electricity should reflect not only plant-level GENERATION costs but also grid-level SYSTEM costs and SOCIAL & ENVIRONMENTAL costs.

Nuclear production typical costs breakdown



Note: With discount rate at 7%, Return of capital refers to interest during operation, OCC: Overnight construction cost, IDC: Interest during construction

Source: NEA



Unlocking Reductions in the Construction Costs of Nuclear:

A Practical Guide for Stakeholders

OECD NEA

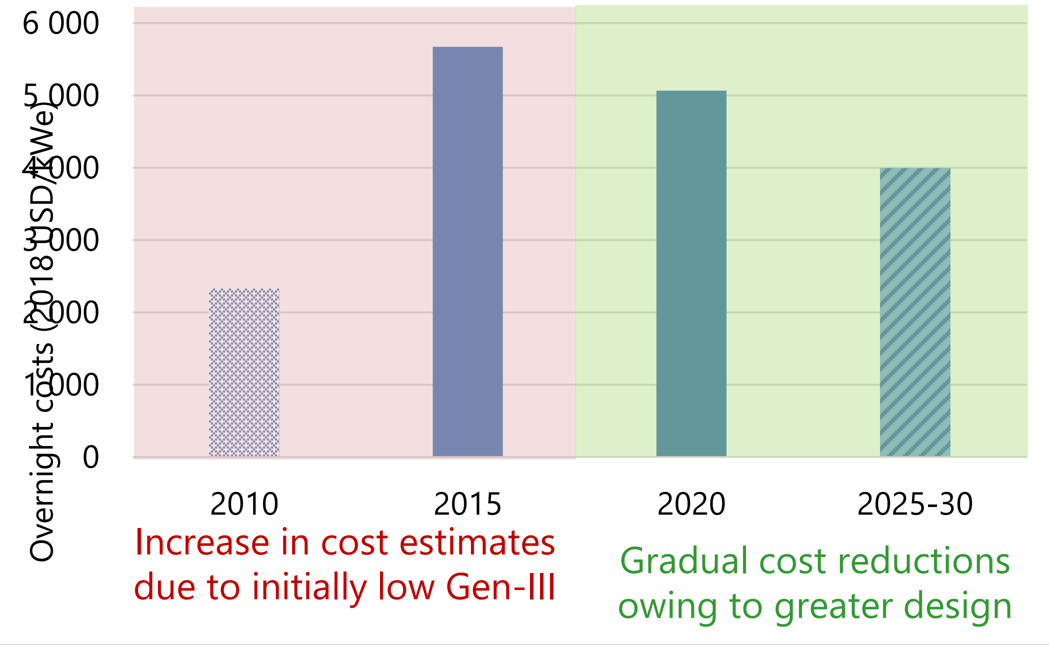
Typical investment costs represent 78% of nuclear production costs on a levelised cost basis (LCOE)

The nuclear industry is at a critical juncture with the completion of FOAK Gen-III reactors

- Gen-III initial costs estimates driven by **low level of design maturity** and the **specific political context** of announced budgets

- Recent trend in projected costs reflects **increased design maturity** and **lessons learned** for post-FOAK projects

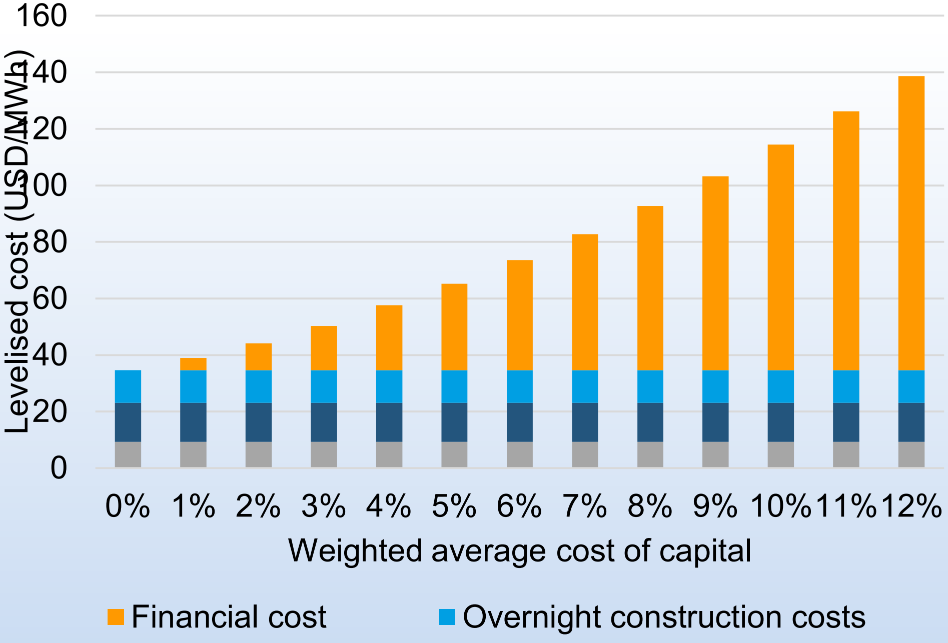
- Gap between two sets of projections has impacted overall **perceived investment risks** and has potential to impact **public acceptance**



Notes: 2010, 2015 and 2020 OECD average overnight construction cost data based on 2005, 2010 and 2015 NEA/IEA Projected Cost of Generating Electricity reports, adjusted for USD inflation using OECD statistics. NEA average estimate for 2025 based on preliminary data from the forthcoming NEA/IEA Projected Costs of Generating Electricity 2020 report.

Affordable financing key for the economic performance of nuclear: A range of government support can be envisaged

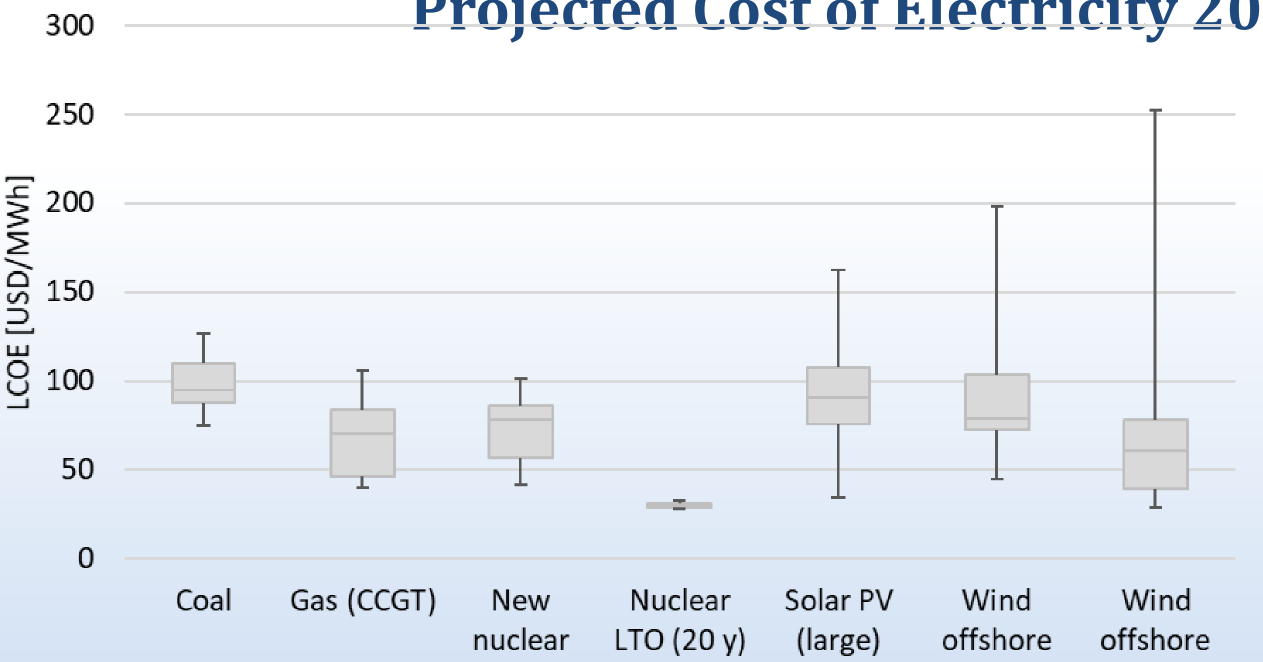
LCOE of a new nuclear power plant project according to the cost of capital

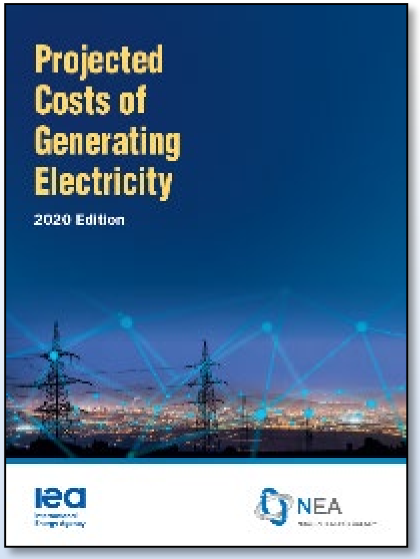


Note: Overnight cost of 4500 USD/kWe, a load factor 85%, 60-year lifetime and 7-year construction time

Direct Financial support	Indirect financial support	
	Power purchasing agreements	Regulated assets
Equity, debt, ECAs, loan guarantee	**Contract-for-difference (UK), Mankala model (Finland)**	**Rate-of-return (US), Regulated Asset Base (UK)**
Equity stake can be transitional as additional sources of financing should become available once the plant is operational	PPAs focus on market risks but often do not address explicitly construction risks, which impact risk premium	Specific conditions can be specified for the allocation of certain risks (e.g. cost sharing and cap with hybrid RAB model)

Key result from the forthcoming IEA/NEA Projected Cost of Electricity 2020




Projected Costs of Generating Electricity

2020 Edition

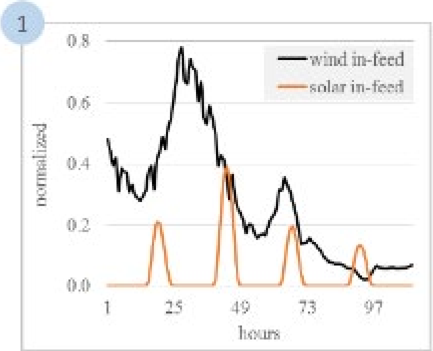
Source: IEA/NEA (forthcoming) with cost of capital of 7% and CO2 price @ 30 USD/tCO2

With the right policy framework new nuclear to remain in a competitiveness range in OECD countries

Assessing the System Costs of Electricity

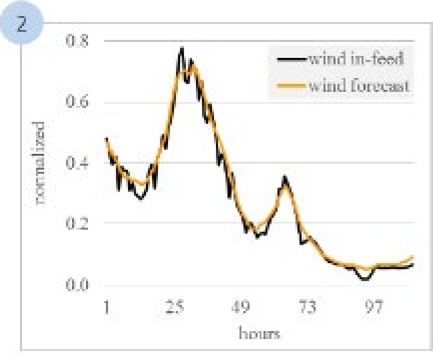
- Total system costs are the sum of plant-level generation costs and grid-level system costs
- System costs are mainly due to characteristics intrinsic to variable generation

Source: L. Hirth



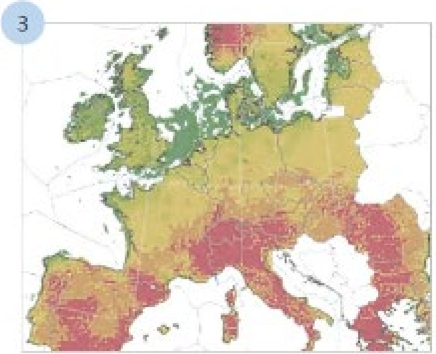
VREs are not always available

Profile costs
(Changing mix)



VREs are difficult to predict

Balancing costs
(Short-term variations)



Good VRE sites are distant from load centers

Transmission and distribution costs

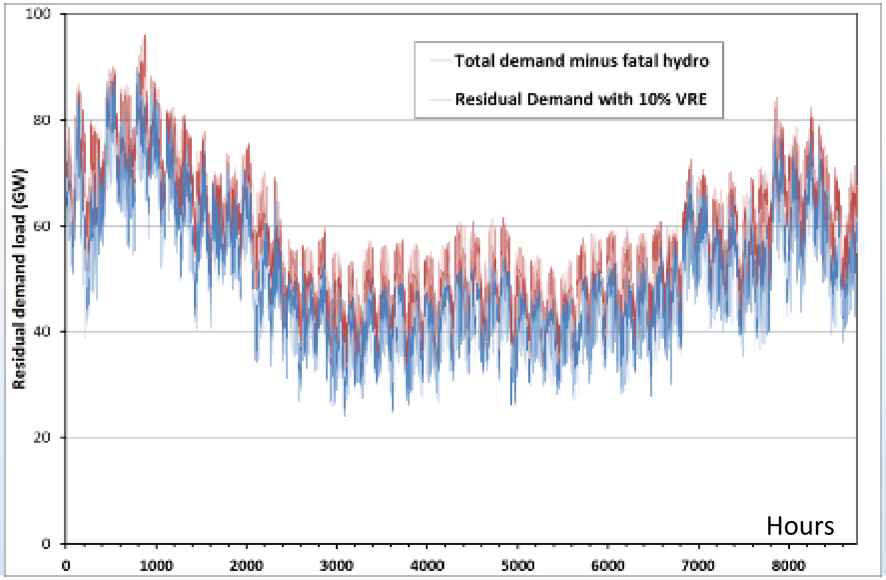
System costs depend on:

- Local & regional factors and the existing mix
- VRE penetration and load profiles
- Flexibility resources (hydro, storage, interconnections)

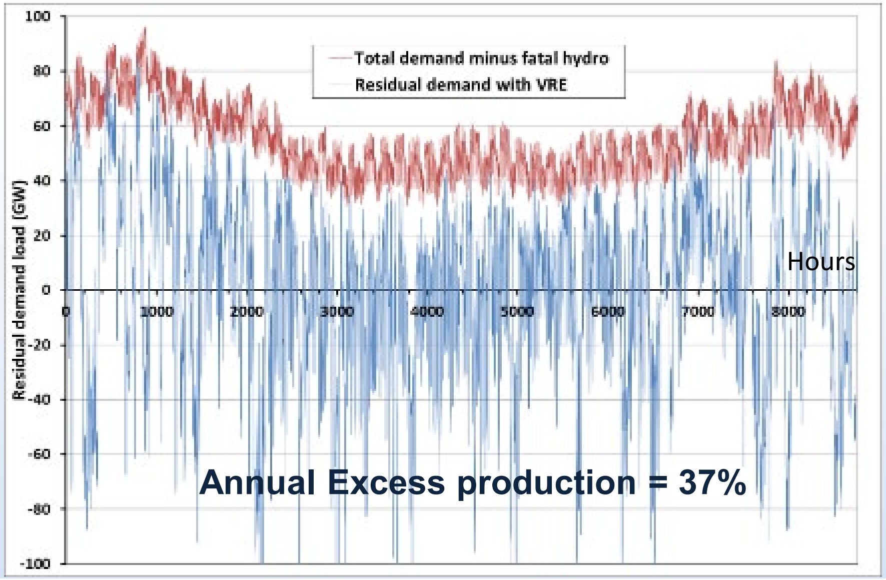
Additional impacts on load factors of dispatchable generators and prices.

High VRE Shares Result in Large Inefficiencies

10% Variable Renewables



75% Variable Renewables

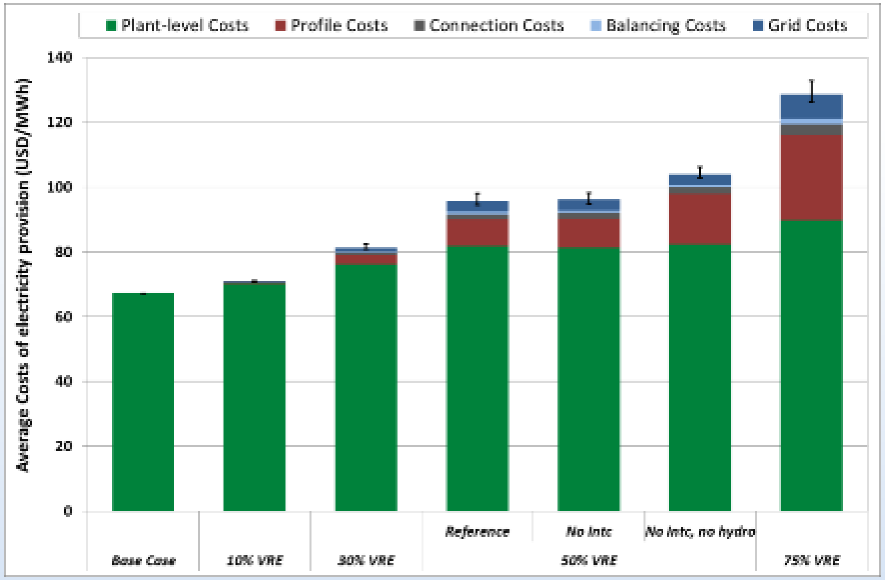


Annual Excess production = 37%

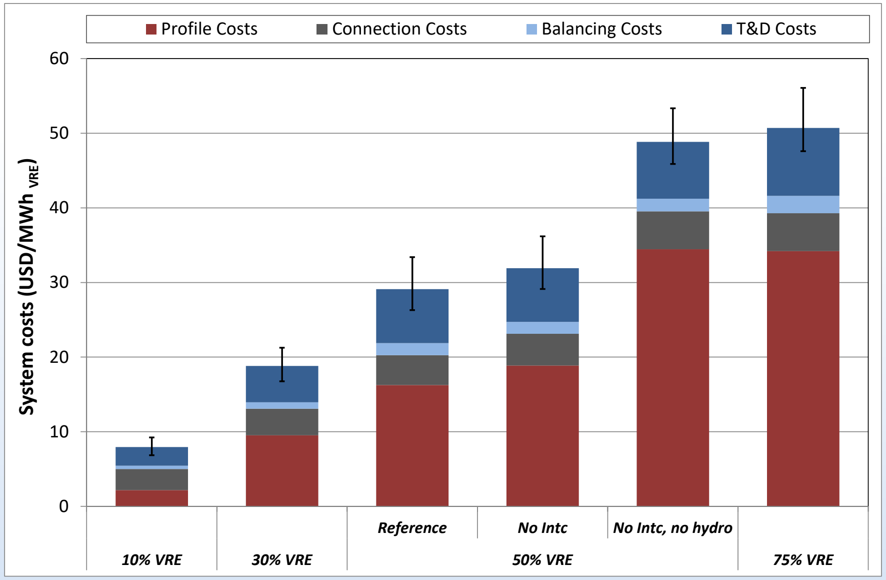
- High VRE penetration result in challenges for system management.
- Residual demand (**BLUE** line) – the available market for dispatchable generation becomes volatile and unpredictable.

As VRE Share Increases System Costs Grow Quickly

Total Costs



Breakdown of System Costs



- System costs are large and increase with VRE generation share - Profile costs are the dominant component.

Recent NEA Work:
Broad Conclusions

The Full Costs of Electricity Provision

The Costs of Decarbonisation:

System Costs with High Shares of Nuclear and Renewables

- To meet global energy and environmental requirements, all low-carbon technologies must be optimally applied—with all costs accurately allocated.
- The electricity markets must be modernized. Existing market structures make investment in any unsubsidised low-carbon technology very difficult.
- Large deployment of VRE will occur around the world – but the contribution of VRE in each country will depend on the cost of available resources.
- To the degree dispatchable capacity is needed, nuclear can serve a large role—if it is economically compatible with evolving markets.

Thank you for your attention

More information @ www.oecd-nea.org

All NEA reports are available for download free of charge.

Follow us:

Environmental and health impact of nuclear energy

Thomas Gibon

Research & Technology Associate, Luxembourg Institute of Science and Technology

Life cycle assessment

as a decision-support tool in energy policy

Thomas Gibon

Research & Technology Associate

Luxembourg Institute of Science and Technology (LIST)

November 23rd, 2020

UNECE 16th Session Group of Experts on Cleaner Electricity Systems

Includes results based on work carried out at NTNU Norwegian University of Science and Technology under the auspices of UN environment programme International Resource Panel

LUXEMBOURG INSTITUTE OF SCIENCE AND TECHNOLOGY LIST

Life cycle assessment

Definition

A method and tool for attributing environmental impacts to products and services

Considering impacts over the life cycle

Production, use, end-of-life

Considering impacts upstream in supply chains

Resource extraction, transport, etc.

Holistic

And typically:

Considering hundreds of **emitted substances** and **extracted resources**

Considering a range of impact types

Human health, ecosystem health, natural resource use

Multicriteria

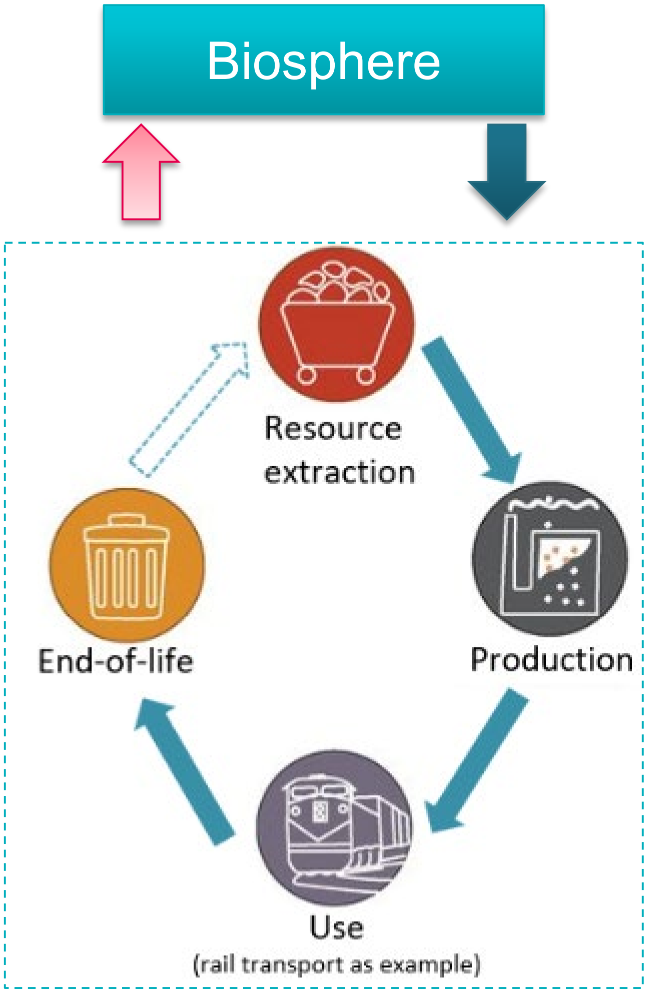
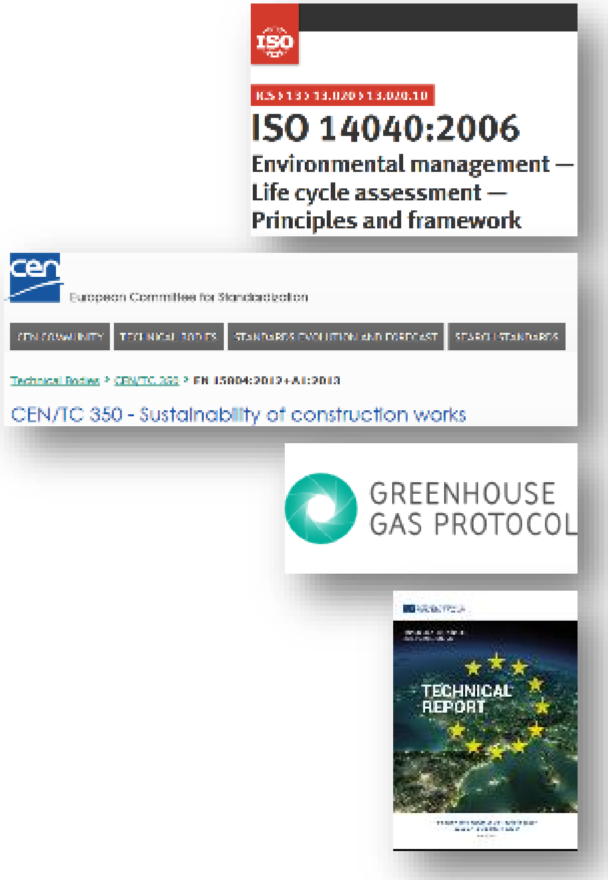


Figure: Adapted from Hellweg & Mila i Canals (2014)

Life cycle assessment

LCA as a standardized method with many applications



ICS > 13 > 13.020 > 13.020.10

ISO 14040:2006

Environmental management —
Life cycle assessment —
Principles and framework

European Committee for Standardization

CEN COMMUNITY | TECHNICAL BODIES | STANDARDS EVOLUTION AND FORECAST | SEARCH STANDARDS

Technical Bodies > CEN/TC 350 > EN 15804:2012+A1:2013

CEN/TC 350 - Sustainability of construction works

GREENHOUSE GAS PROTOCOL

TECHNICAL REPORT

ISO 14040 series

overarching principles of life cycle assessment, framework ensuring robustness and comparability

EN 15804

rules for the environmental assessment of products used in construction, principles of Environmental Product Declarations

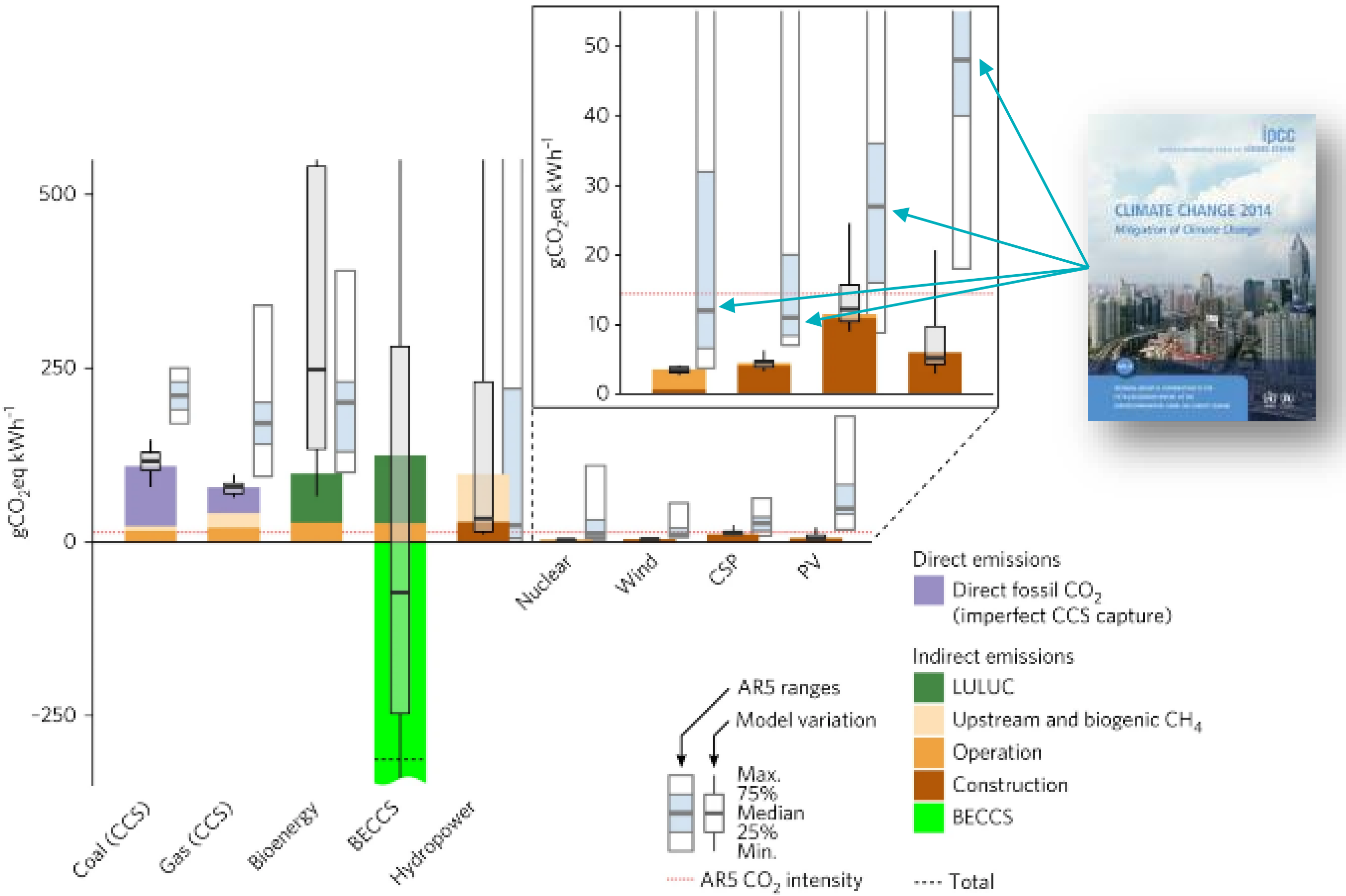
GHG Protocol

guidelines for the carbon footprinting of organizations, rules for the accounting of direct and indirect greenhouse gas emissions

EU TEG Taxonomy

setting the environmental eligibility criteria for green investments in the European Union

Carbon footprint of electricity in 2050



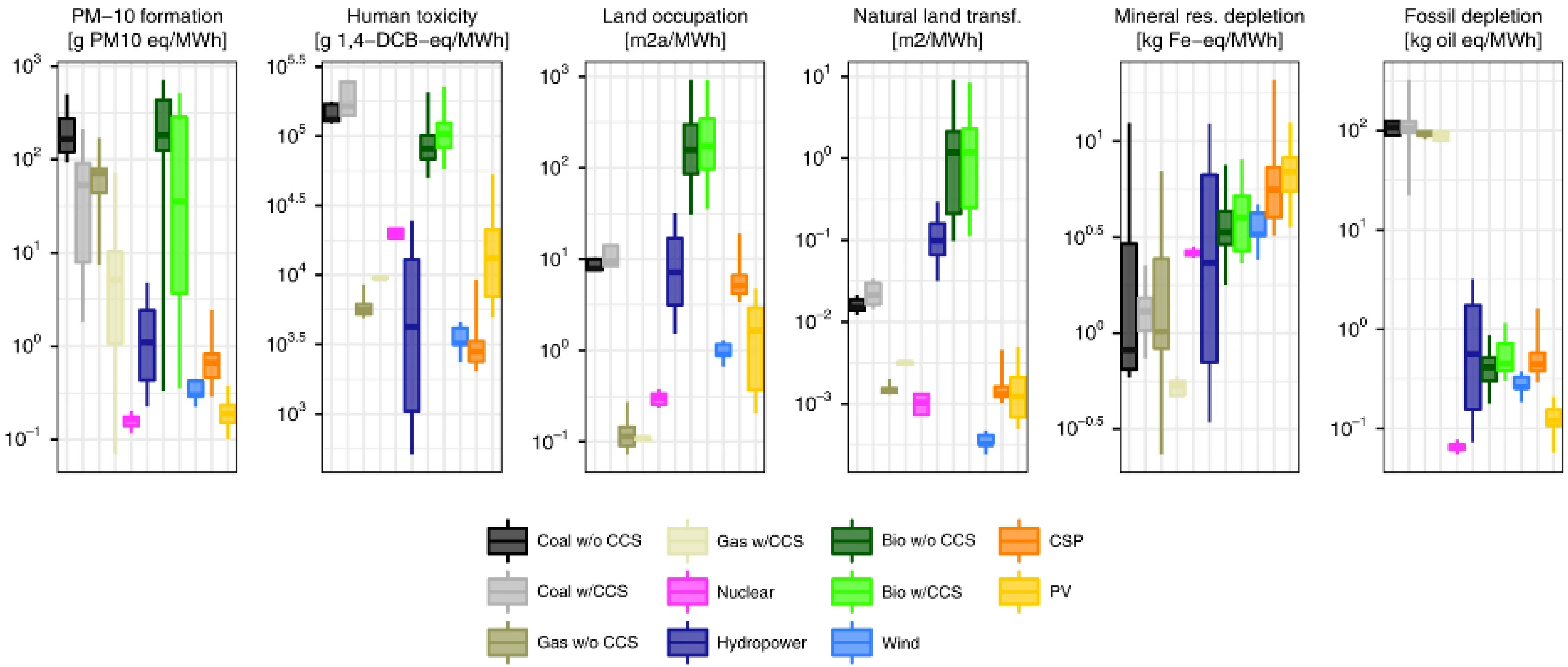
Life cycle greenhouse GHG per kWh in 2050, compared with IPCC AR5 values (2010)

As the economy decarbonizes, so does electricity production, in a virtuous cycle

Pehl, M., Arvesen, A., Humpenöder, F., Popp, A., Hertwich, E. G., & Luderer, G. (2017). Understanding future emissions from low-carbon power systems by integration of life-cycle assessment and integrated energy modelling. *Nature Energy*, *2*(12), 939-945.

Life cycle impact assessment

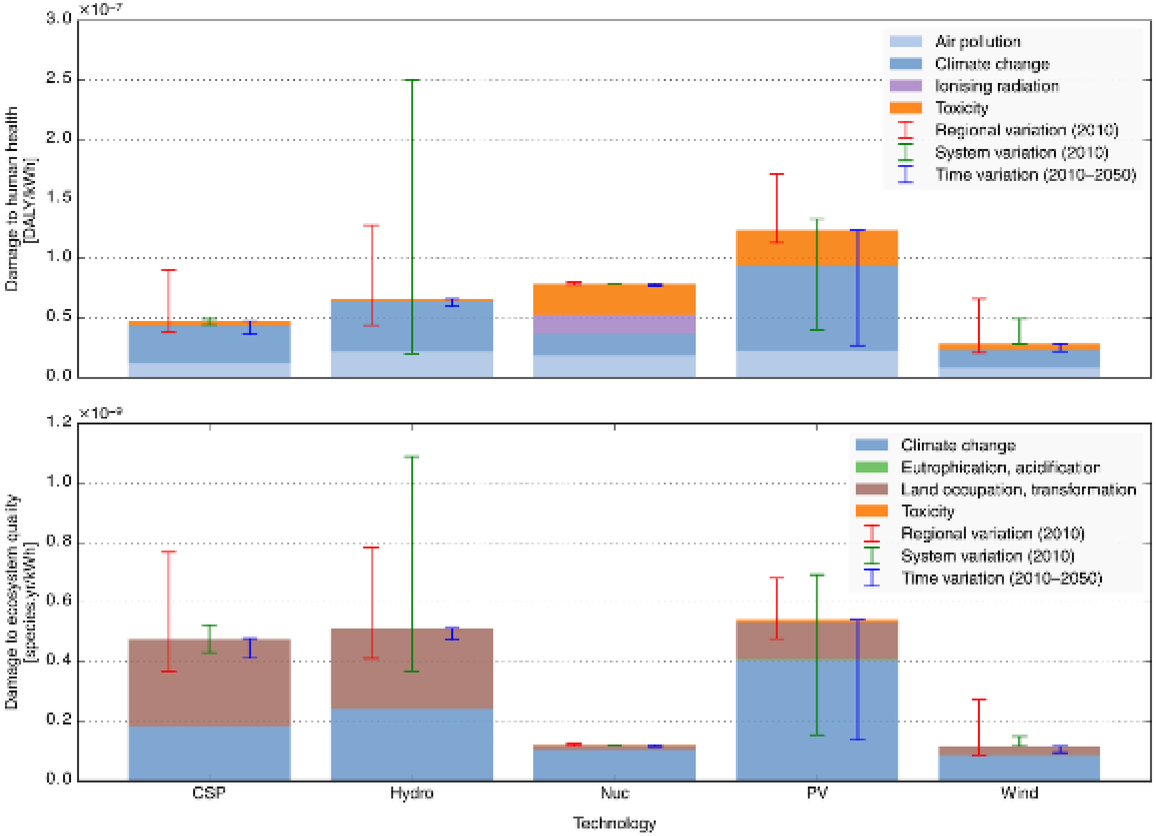
Beyond greenhouse gas emissions



Luderer, G., Pehl, M., Arvesen, A., Gibon, T., Bodirsky, B. L., de Boer, H. S., ... & Mima, S. (2019). Environmental co-benefits and adverse side-effects of alternative power sector decarbonization strategies. *Nature Communications*, *10*(1), 1-13.

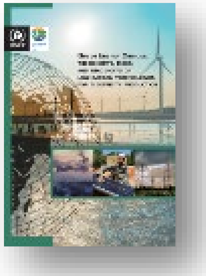
Life cycle impact assessment

Aggregating impact categories



Gibon T, Hertwich EG, Arvesen A, et al (2017) Health benefits, ecological threats of low-carbon electricity. Environ Res Lett 12: . doi: 10.1088/1748-9326/aa6047

Results based on UNEP IRP “Green Energy Choices” report



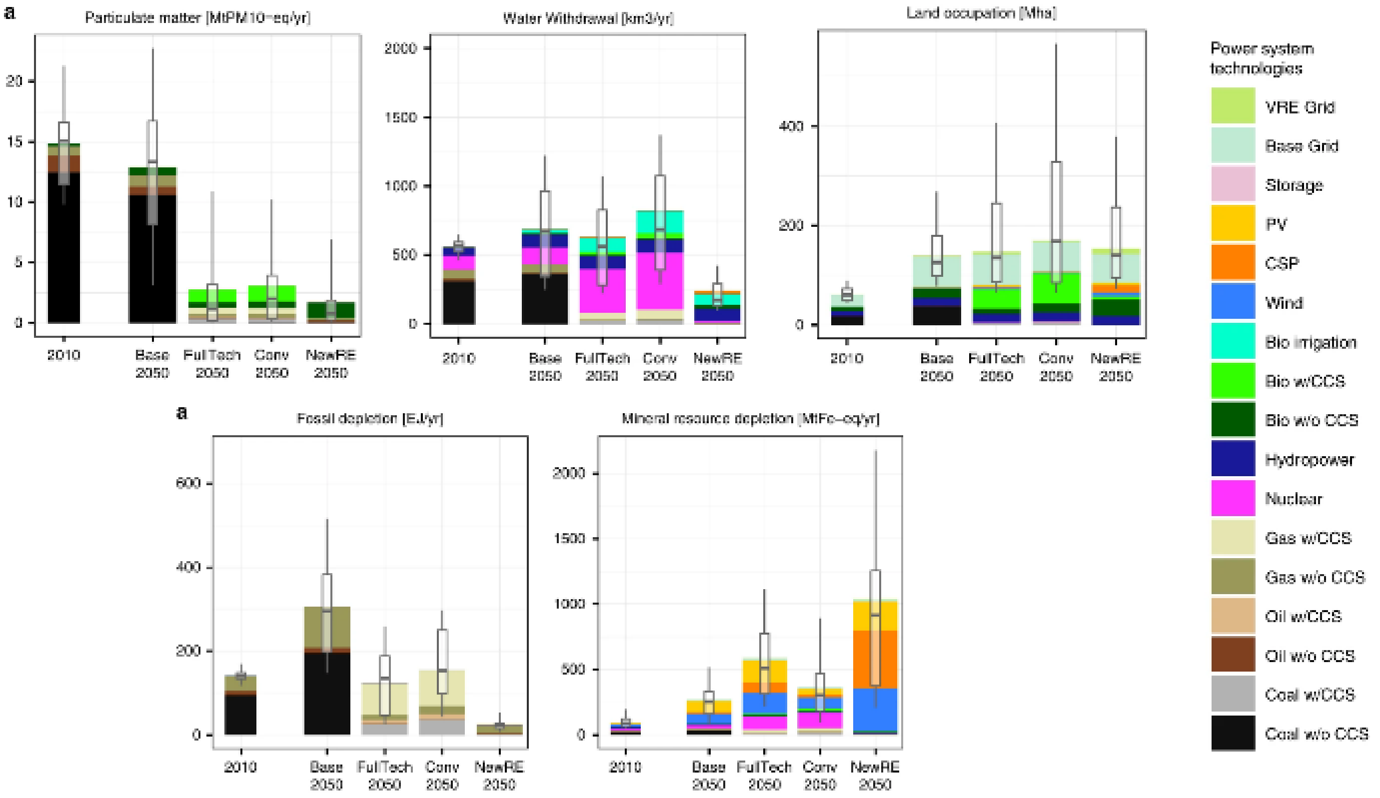
Indicators can be aggregated into damage to human health (top) or to ecosystems (bottom)

Air pollution, toxicity, concerns for human health

Land occupation concern for ecosystems

Global Scenarios to uncover co-benefits, trade-offs

Base	FullTech	Conv	NewRE
No emissions constraint	Cumulative 2011-2050 power sector emissions limited to 240 $GtCO_2$.		
Full portfolio	Full portfolio	Wind and solar power limited to 10%	Nuclear phase-out, no CCS in the power sector



Co-benefits in phasing out coal power (air emissions)

Potential trade-offs in land use (biomass and grid extension), as well as material requirements (wind, CSP, PV)

Luderer, G., Pehl, M., Arvesen, A., Gibon, T., Bodirsky, B. L., de Boer, H. S., ... & Mima, S. (2019). Environmental co-benefits and adverse side-effects of alternative power sector decarbonization strategies. *Nature Communications*, *10*(1), 1-13.

Take away messages

Life cycle assessment allows to consider all impacts **across the life cycle** and a **wide range of impact categories**

All electricity technologies have environmental impacts, transitioning away from fossil fuels **will lead to trade offs**

Low-carbon technologies **offer co-benefits** (lower air pollution, no fossil depletion) but **may entail higher land and material** requirements

Grid extension will be **needed in any case**, slightly more because of intermittent sources

Nuclear power remains **low over all categories** (including land use and materials) with moderate water use

Thank you!

For more info
thomas.gibon@list.lu

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AND TECHNOLOGY
LIST

Nuclear energy for Net Zero – UK perspectives

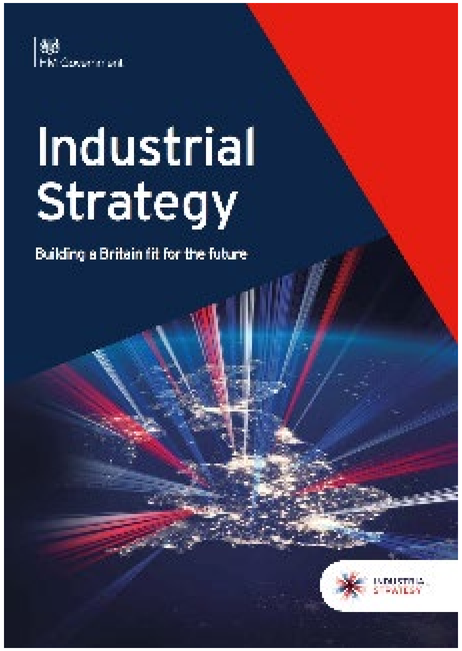
UNECE Nuclear Energy Workshop

23rd November 2020

James Murphy, Chief Strategy Officer

NATIONAL NUCLEAR LABORATORY

The UK has a requirement – enshrined in law – to achieve net zero emissions by 2050 and a responsibility to 'rebalance' it's economy

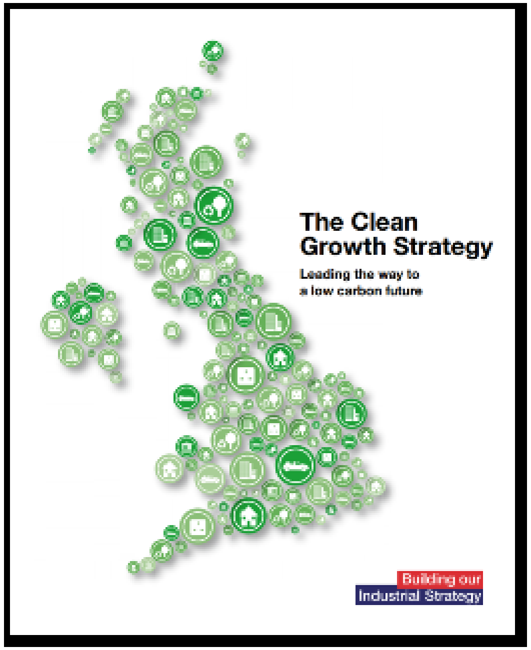


Industrial Strategy

Building a Britain fit for the future

Net Zero
The UK's contribution to stopping global warming

Committee on Climate Change
May 2019



The Clean Growth Strategy

Leading the way to a low carbon future

Building our Industrial Strategy

Three zero carbon vectors require unprecedented scale-up to displace fossil fuels in the UK

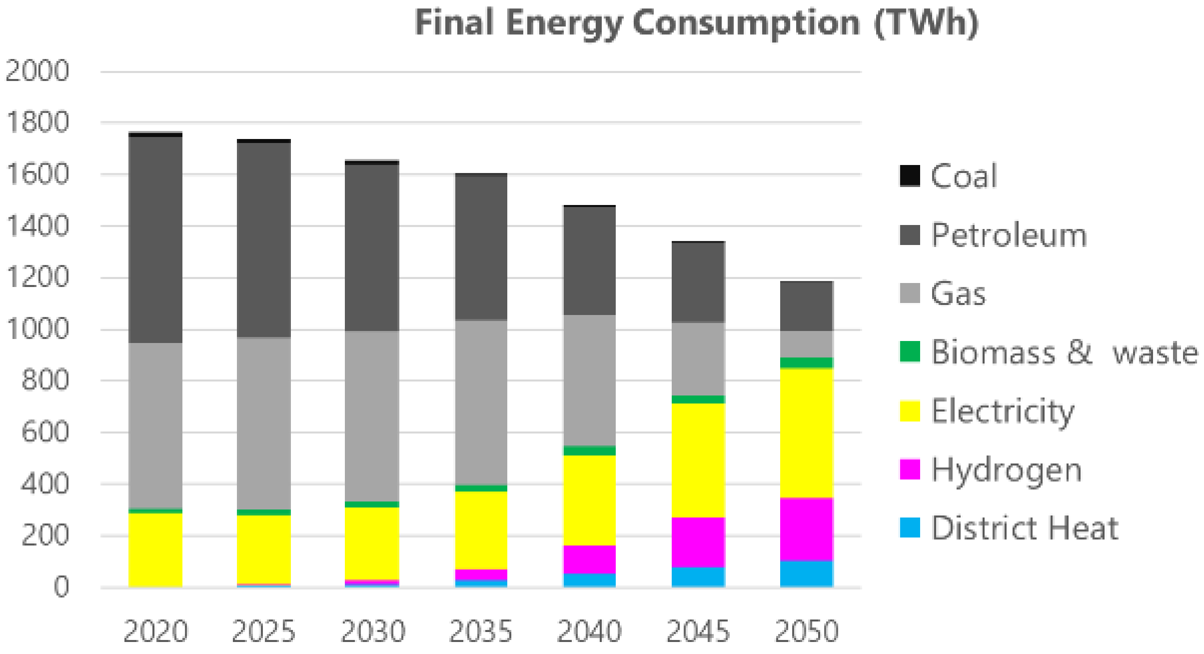
Could mean:

Unabated Fossil Fuel consumption down from **~1500TWh to <300TWh**

Electricity
600-800TWh

Hydrogen
200-300TWh

District Heat
Up to 150TWh

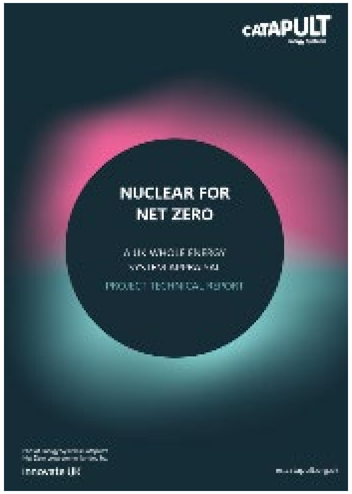


Final Energy Consumption (TWh)

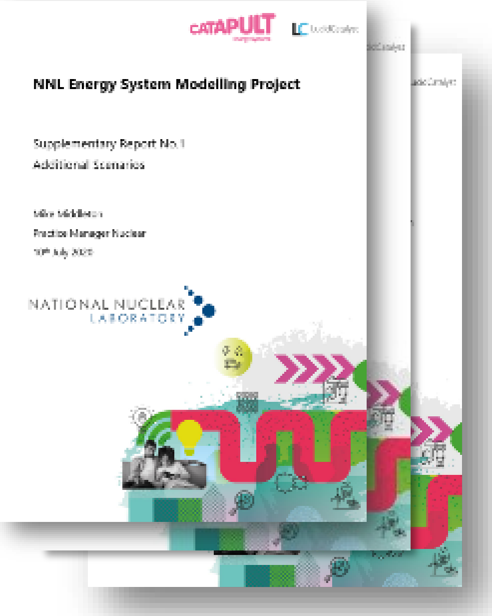
Modelling has shown that nuclear needs to be the centrepiece technology of a net zero energy system

ESME
Energy System
Modelling Environment

INNOVATING TO NET ZERO



NUCLEAR FOR NET ZERO



NNL Energy System Modelling Project

Supplementary Report No.1
Additional Scenarios

UK policy makers have been given clear and direct advice from nuclear experts: Act Now!

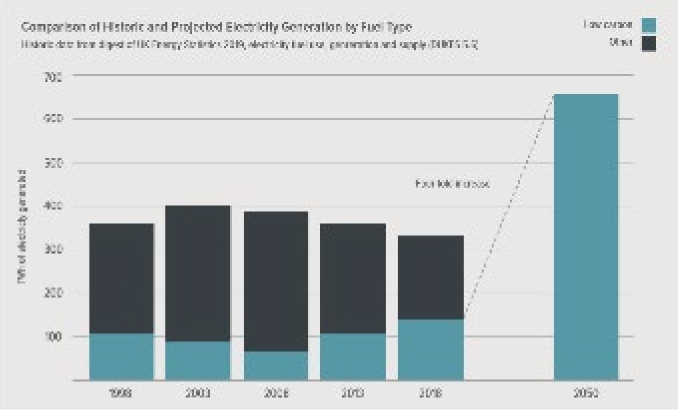
nirab

Supported by niro

Clean Growth Through Innovation - the need for urgent action

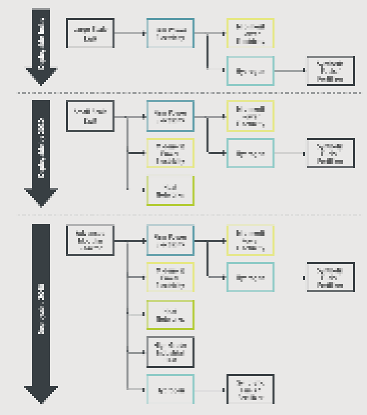
A Report for the Department for Business, Energy and Industrial Strategy (BEIS)

(NIRAB-213-3)

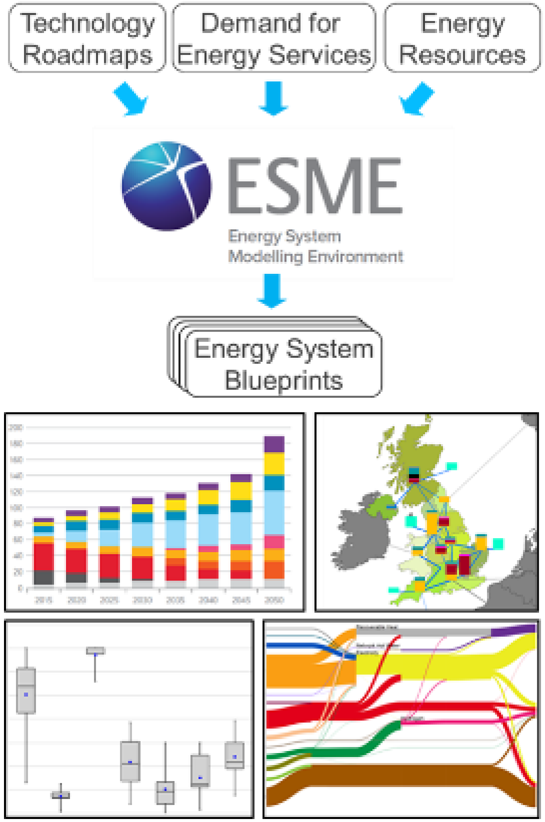


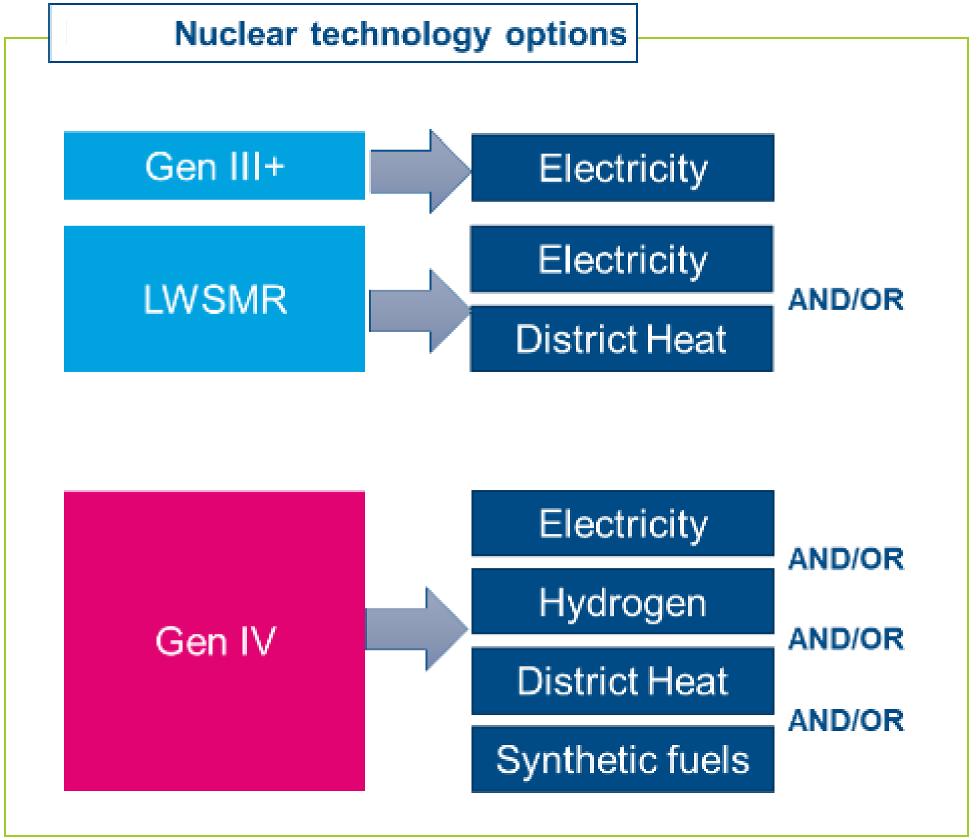
The most recent modelling shows a role for nuclear to provide 50% of electricity (equivalent to around 35 GW electricity generating capacity) in 2050 for a cost optimised energy system

“Over 80% of the UK’s nuclear low-carbon [electricity] generating capacity will be lost in the next decade”

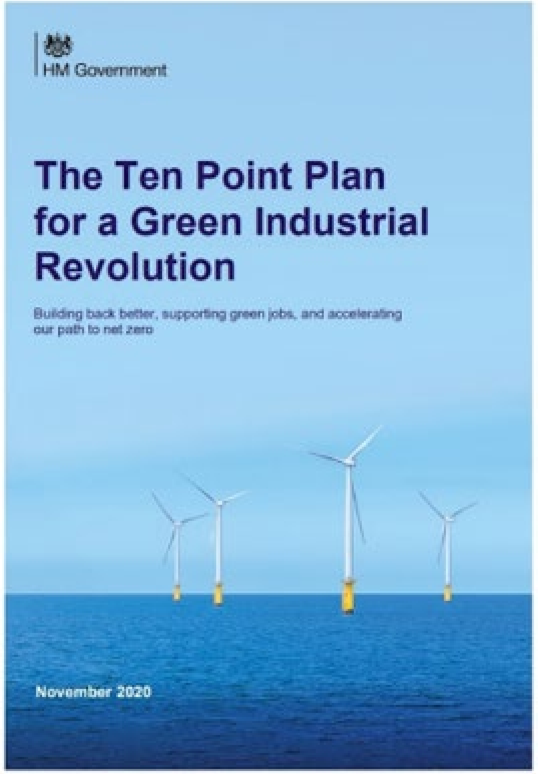


A three-pronged nuclear technology approach gives the UK a chance to hit Net Zero: GW, SMR and Gen IV *together*





The UK government has now acted decisively and recognised the importance of nuclear in decarbonisation



HM Government

The Ten Point Plan for a Green Industrial Revolution

Building back better, supporting green jobs, and accelerating our path to net zero

November 2020

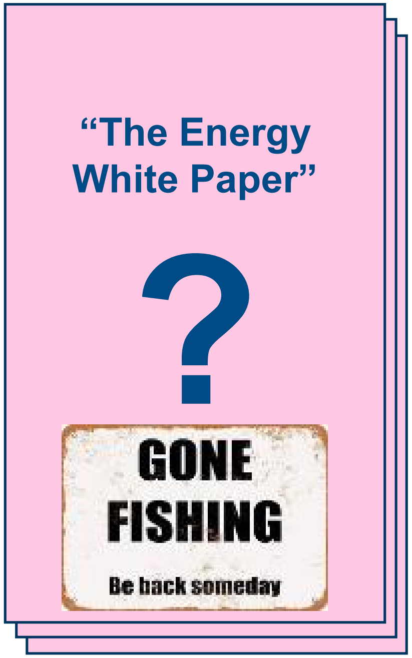
£525m government investment in new nuclear projects:

£215m for Rolls-Royce led UKSMR consortium (matched by additional £300m from UKSMR partners)

£170m for advanced nuclear and a commitment to build a demonstrator by early 2030s

£40m to enable regulations and supply chain

£100m to enable final investment decisions on new GW plant

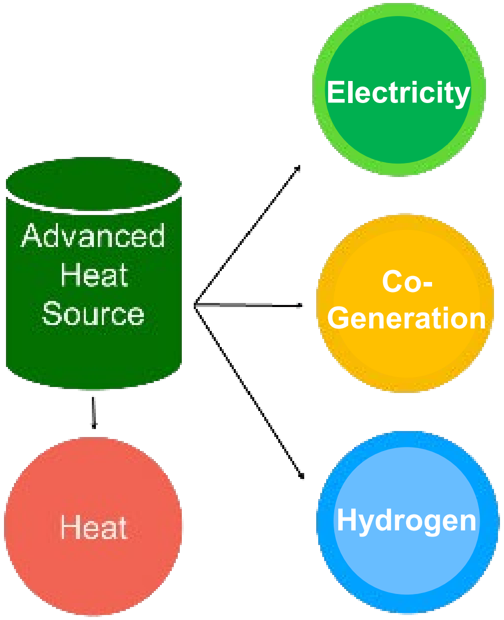


"The Energy White Paper"

Coming soon…

The shift in thinking to recognise nuclear as an enabler for multiple low-carbon energy vectors has been key

Three modes of operation

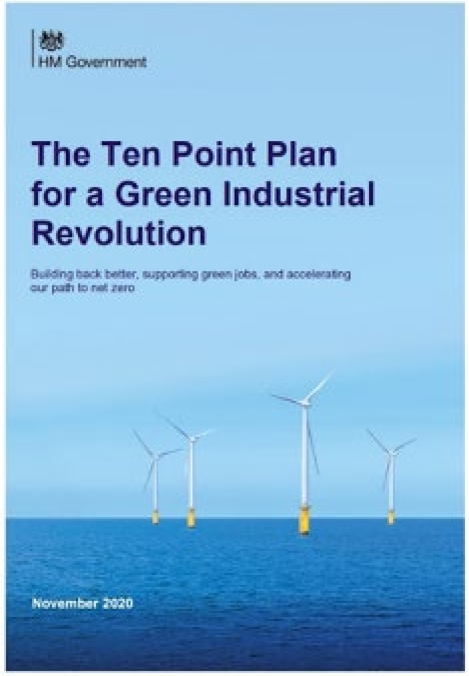


100% output to grid when prices are high

Hydrogen and Power

100% Hydrogen Production

Followed through, the Ten Point Plan could be seen by future generations as a seminal moment in UK history



HM Government

The Ten Point Plan for a Green Industrial Revolution

Building back better, supporting green jobs, and accelerating our path to net zero

November 2020

“The UK was home to the world’s first full-scale civil nuclear power station more than sixty years ago, and this industry now employs around 60,000 people in the UK. We see the ongoing potential of this technology.

Whether a large-scale power plant, or next generation technologies such as Small and Advanced Modular Reactors, **new nuclear *will*** both produce low carbon power and create jobs and growth across the UK.”

Role of Nuclear Energy to Attain Carbon Neutrality in the UNECE region
23 November 2020

polskiatom

Poland nuclear energy development plan

Polish Nuclear Power Programme for electricity generation
High Temperature Gas Reactor programme for nuclear cogeneration

Dr Jozef Sobolewski
National Centre for Nuclear Research

Narodowe Centrum Badań Jądrowych
National Centre for Nuclear Research
ŚWIERK

Polish Nuclear Power Programme

Target

To build 6-9 GWe of installed nuclear power capacity based on large, proven PWR type reactors for electricity generation.

Rationales

Energy security:

- Diversification of fuel base in electricity generation sector.
- Replacement of old coal-fired power plants with zero-emission dispatchable sources.

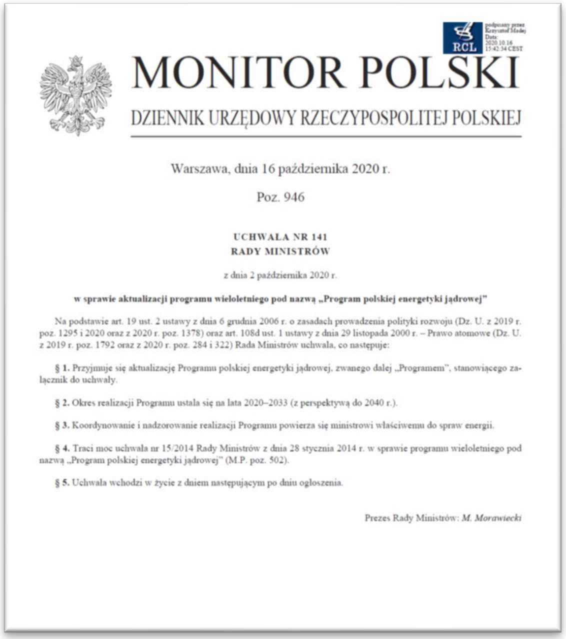
Protection of environment and climate:

- Significant role of nuclear energy in efforts to prevent climate change.
- Nuclear energy is a Polish solution to achieve EU climate and energy policy goals.
- All electricity generation technologies have pros and cons for environment. Energy mix with RES only is unachievable and unrealistic. Mix without NPP means RES and fossils.

Economic benefits:

- Stable price over long period of time
- Can include district heating and hydrogen production (electrolysis).

Programme updated in October 2020



podpisany przez Krzysztof Madej
Data: 2020.10.16 15:42:34 CEST

MONITOR POLSKI
DZIENNIK URZĘDOWY RZECZYPOSPOLITEJ POLSKIEJ

Warszawa, dnia 16 października 2020 r.

Poz. 946

UCHWAŁA NR 141
RADY MINISTRÓW

z dnia 2 października 2020 r.

w sprawie aktualizacji programu wieloletniego pod nazwą „Program polskiej energetyki jądrowej"

Na podstawie art. 19 ust. 2 ustawy z dnia 6 grudnia 2006 r. o zasadach prowadzenia polityki rozwoju (Dz. U. z 2019 r. poz. 1295 i 2020 oraz z 2020 r. poz. 1378) oraz art. 108d ust. 1 ustawy z dnia 29 listopada 2000 r. – Prawo atomowe (Dz. U. z 2019 r. poz. 1792 oraz z 2020 r. poz. 284 i 322) Rada Ministrów uchwala, co następuje:

§ 1. Przyjmuje się aktualizację Programu polskiej energetyki jądrowej, zwanego dalej „Programem", stanowiącego załącznik do uchwały.

§ 2. Okres realizacji Programu ustala się na lata 2020–2033 (z perspektywą do 2040 r.).

§ 3. Koordynowanie i nadzorowanie realizacji Programu powierza się ministrowi właściwemu do spraw energii.

§ 4. Traci moc uchwała nr 15/2014 Rady Ministrów z dnia 28 stycznia 2014 r. w sprawie programu wieloletniego pod nazwą „Program polskiej energetyki jądrowej" (M.P. poz. 502).

§ 5. Uchwała wchodzi w życie z dniem następującym po dniu ogłoszenia.

Prezes Rady Ministrów: *M. Morawiecki*

Narodowe Centrum Badań Jądrowych
National Centre for Nuclear Research
ŚWIERK

Polish Nuclear Power Programme

Key elements of nuclear power implementation.

- Model (ownership relations):
  - Project company (51% State’s Treasury, 49% Strategic co-investor connected with technology supplier).
  - One technology for all NPP’s.
- Technology (reason for large PWR’s):
  - The most extensive experience in construction and operation of NPP.
  - No history of important radiological accidents.
  - Common knowledge of PWR technology by Regulators.
  - More options for NPP siting due to smaller emergency zone.
  - Competitive supplier market.
- Siting: one in North and one in Central of Poland

Program polskiej energetyki jądrowej

Polish Nuclear Power Programme

polskiatom

Schedule

2021 – selection of technology for NPP1 and NPP2

2022 – obtaining of an environmental and siting decision for NPP1

2022 – signing an agreement with the vendor of technology and EPC contractor

2026 – obtaining of a construction permit and start of the construction NPP1

2032 – obtaining of a construction permit and start of the construction of NPP2

2033 – the issuance of an operating licence by the Regulator and the commissioning of the first reactor of NPP1

2035 - 2043 every 2 years – the issuance of an operating license and the commissioning of further 2 reactors at NPP1 and 3 reactors at NPP2.

Status of nuclear cogeneration activities

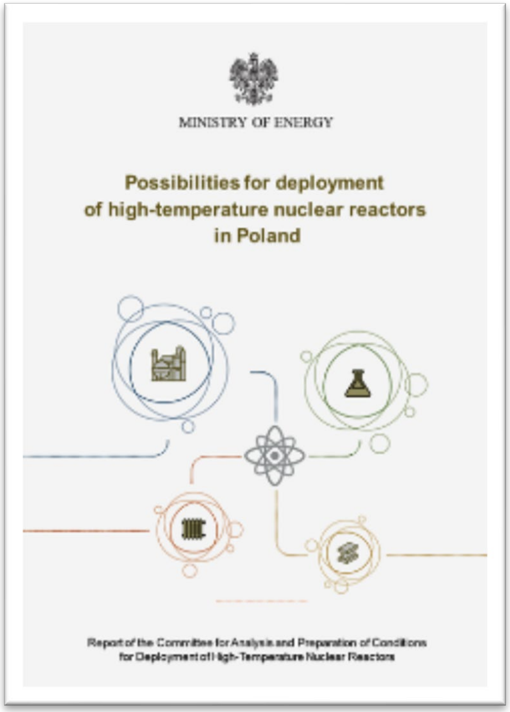
Primary target for HTGR is Polish heat market. Today 100% heat market is dominated by fossil fuels; mostly coal in district heating and coal and gas in industry heat generation. 13 largest chemical plants need 6500 MW of heat at T=400-550°C.

Secondary target is the hydrogen production.

- Minister of Energy appointed Committee for deployment of high-temperature nuclear reactors in Poland in July 2016. Report with results of the Committee's works published in January 2018. Minister accepted the report, took note that deployment of HTGR reactors in Poland is desirable and requested Ministry to prepare further steps.
- Strategy for Responsible Development - the governmental program for Polish economic development - adopted in February 2017, contain e.g.: Deployment of HTR for industrial heat production. The project for this action is: Nuclear cogeneration – preparation for construction of the first HTR of 200-350 MWth supplying technological heat for industrial installation.

Status of nuclear cogeneration activities

- The NOMATEN Center of Excellence has received 7 years (2018-2025) of joint financial support (€37M) from the Foundation for Polish Science (FNP) and the European Commission. NOMATEN focus on the studies and development of novel materials, specifically those designed to work under harsh conditions – radiation, high temperatures and corrosive environments.
- In 2019 Ministry of Entrepreneurship and Technology (now Ministry of Development) qualified HTR in the list of National Smart Specializations. This opens a way for NCNR to conduct research in this field with aid from the EU funds, among other things.
- In frame of national strategy program GOSPOSTRATEG the National Centre for Research and Development accepted the grant of about $5M for joint project of MoE, NCNR and INChT for preparation of law, organization and technical instruments to deploy the HTR reactors in years 2019 - 2022.



MINISTRY OF ENERGY

Possibilities for deployment
of high-temperature nuclear reactors
in Poland

Report of the Committee for Analysis and Preparation of Conditions
for Deployment of High-Temperature Nuclear Reactors

Narodowe Centrum Badań Jądrowych
National Centre for Nuclear Research
ŚWIERK

Status of nuclear cogeneration activities

What next with HTGR in Poland:

In January 2020 The Ministry of Science and Higher Education has published the Polish Map of Research Infrastructure, which contains a list of 70 key research infrastructures. One of the high priority project is a construction of European High Temperature Experimental Reactor (EUHTER) in Poland. We plan to put this project on the list of European Strategy Forum on Research Infrastructures.

- We have running projects connected to HTGR: GEMINI+, GOSPOSTRATEG-HTR, and cooperation agreement with JAEA.
- We have strong positive signals for HTGR deployment coming from Polish Government, and also from Polish Parliament.
- We have also interest from Polish industry, but most of them hold distance due to long development work and lack of positive signals from EU.
- We are working on a new version of national strategic energy program (PEP2040) containing elements of HTGR program.
- We are working on preparation of EUTHER program (design and construction of small experimental HTGR, being also the technology demonstrator) for implementation based on national finance sources.
- You are invited to visit SNETP/NC2I webpages for more information (https://snetp.eu/).

polskiatom

Poland nuclear energy development plan

Thank you

Narodowe Centrum Badań Jądrowych
National Centre for Nuclear Research
ŚWIERK

Closing Remarks

King Lee

Director Harmony Programme, World Nuclear Association & Vice-Chair Group of Experts on Resource Management & Group of Experts on Cleaner Electricity Systems

24 November 2020 (Tuesday)

11h00 – 13h00 Sub-regional workshop on attaining carbon neutrality (via Interprefy)

Join to discuss & learn about:

- **Role of CCUS to attain Carbon Neutrality in East Europe and Central Asia**
  - **Country Cases – Kazakhstan, Russian Federation, North Macedonia and Albania**

- **Role of Nuclear Energy to attain Carbon Neutrality in East Europe and Central Asia**
  - **Country Cases – Belarus, Uzbekistan, Russian Federation (TBC), Ukraine (TBC)**