WEBINAR

HIGH-LEVEL ECONOMIC PANEL

Harnessing the renewed global support for nuclear to help achieve net zero

Chair:
Tim Yeo
Chairman
New Nuclear Watch Institute

Host:
Michael Freeman
Senior Lawyer, Nuclear Team
Pinsent Masons

17 June 2021

Speakers:

Yves Desbazeille
Director General
FORATOM

Diane Cameron
Head of Division, Nuclear Technology Development and Economics
OECD NEA

Dr Bertrand Magné
Energy Economist, Energy, Economic and Environmental (3E) Analysis Unit
International Atomic Energy Agency

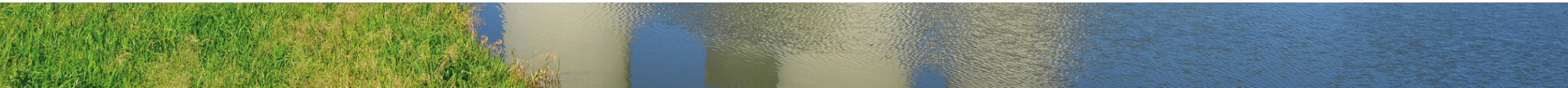
Sama Bilbao y León
Director General
World Nuclear Association

Nuclear energy's role in mitigating climate change – European Union's perspective

Yves Desbazeille
FORATOM Director General

17/06/2021

NUCLEAR ENERGY AT EU LEVEL



What does nuclear contribute to Europe's economy?

106

NUCLEAR REACTORS
IN OPERATION IN THE EU

100

€ BILLION/YEAR

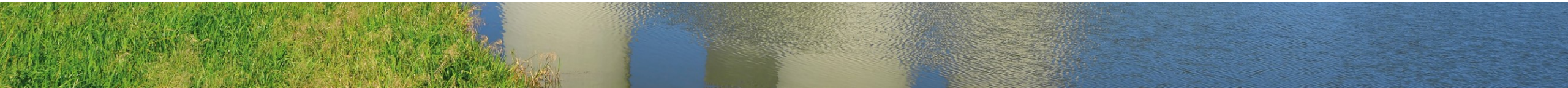
1.1 million

JOBS

26%

EU ELECTRICITY
PRODUCTION

FUTURE OF NUCLEAR IN EU

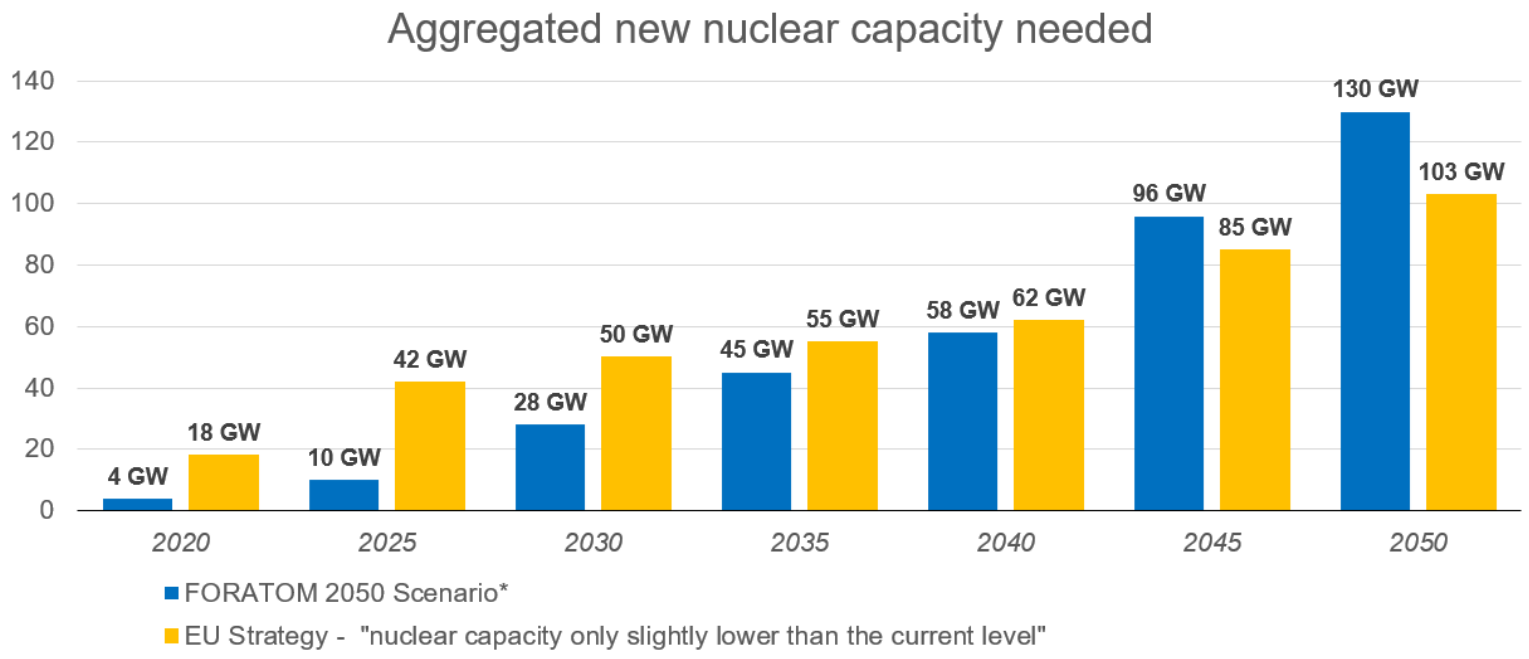


Nuclear energy in the EC strategy

EC Communication:

"Renewables together with nuclear energy will be the backbone of a carbon-free European power system"

- Nuclear will **remain an important component** in the EU 2050 energy mix
- Capacity of nuclear in 2050 – **between 99-121 GW**
- Share of nuclear in the electricity mix in 2050 – **ca. 15%**
- *"The consumption of **natural gas** is expected to be severely reduced by 2050 in all scenarios"*



Key Question: how to make it a reality?

DEVELOPMENTS AT EU LEVEL

Key policies that should recognise the value of Nuclear towards meeting EU goals

EU Green Deal


Sustainable Finance Initiative


Security of supply at EU level


EU Economic Revival – Next Generation EU

Hydrogen & Energy System Integration Strategies

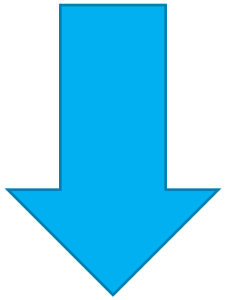
EU Industrial Strategy

Strengthening the EU ETS

…and many more!!

Sustainable Finance: Taxonomy

- **Original Aim**: Redivert private investment towards more sustainable activities
- **How:** By producing a list of sectors classified as ‘sustainable’ (Taxonomy)



Ultimate Goal

Align all EU finance and policies to support these so-called “taxonomy-compliant activities”

Sustainable Finance: Taxonomy Status of nuclear

Technical Experts Group (nominated in 2018) recognised they did not have the right expertise on nuclear

EC mandated its nuclear experts - Joint Research Center (JRC) - to assess nuclear against the taxonomy with a view to its potential inclusion.

7 June: Taxonomy Delegated Act adopted– nuclear not included

21 April: EC communication announcing a 'complementary DA' to be put forward later this year

Situation creates significant uncertainty for the sector and could potentially lead to market-distortions

JRC report

Technical Expertise on nuclear

EC's Joint Research Centre (JRC) report

Experts groups review

2020 | **2021**

June | July | Aug | Sept | Oct | Nov | Dec | Jan | Feb | March | April | May | June

18 June
DG FISMA official announcement about this group

September
EC issues mandate to JRC & work begins

DNSH report (6 months)

15 March
Report submitted by JRC to Commission

30 March
JRC report published and submitted to two expert groups for opinion

JRC report review (3 months)

- Euratom Article 31 group of experts (independent radiation protection and public health experts) (DG ENER)
- Sub-Group of experts from the Scientific Committee on Health, Environmental and Emerging Risks (SCHEER, DG Sante)

Rapid assessment of the JRC conclusions

- JRC tasked with assessing the ‘Do No Significant Harm’ (DNSH) aspects of nuclear
  - Including long-term management of high-level radioactive waste and spent nuclear fuel
  - In line with Articles 17 & 19 of Taxonomy Regulation
- DNSH criteria:
  - Sustainable use and protection of water and marine resources
  - Transition to a circular economy
  - Pollution prevention & control
  - Protection and restoration of biodiversity and ecosystems
- Nuclear already recognised by TEG as contributing to Climate Mitigation objectives

Rapid assessment of JRC conclusions

- Non-radiological effects and potential impacts are dominated by mining and milling phases
- **According to the evidence, nuclear does NOT cause more harm to human health and the environment than any of the other power technologies deemed to be taxonomy compliant**
  - Nuclear's non-radiological impacts comparable to those of hydropower & RES
- Potential water impacts (consumption and thermal pollution) must be addressed appropriately during site selection, facility design and plant operation phases

FORATOM's view

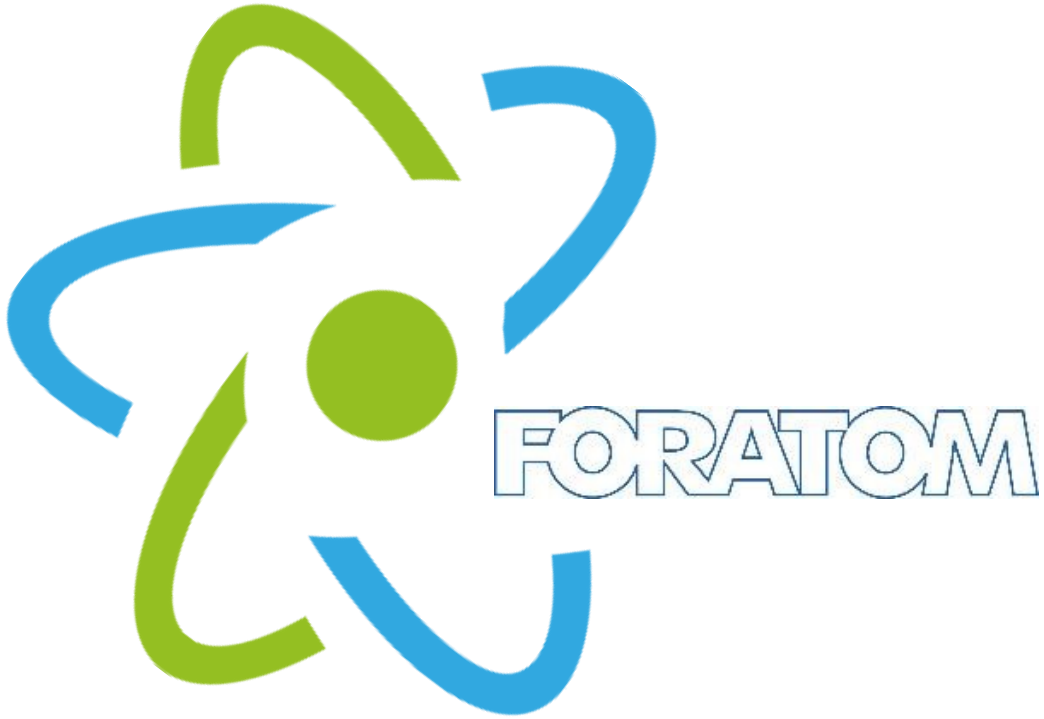
FORATOM has taken note of the Commission's plans to include nuclear under a complementary Delegated Act (CDA).

Communication states that CDA will be consistent with the conclusions of the Joint Research Centre's report (which confirmed that nuclear is as sustainable as other taxonomy-compliant power technologies) and the opinion of the two expert groups.

Shows that, on paper, Commission is willing to recognise that its taxonomy needs to be based on the science if it is to be credible and successful.

BUT: Nuclear remains a controversial topic and unfortunately attempts are still being made to leave nuclear off the list for political reasons....

Thank you

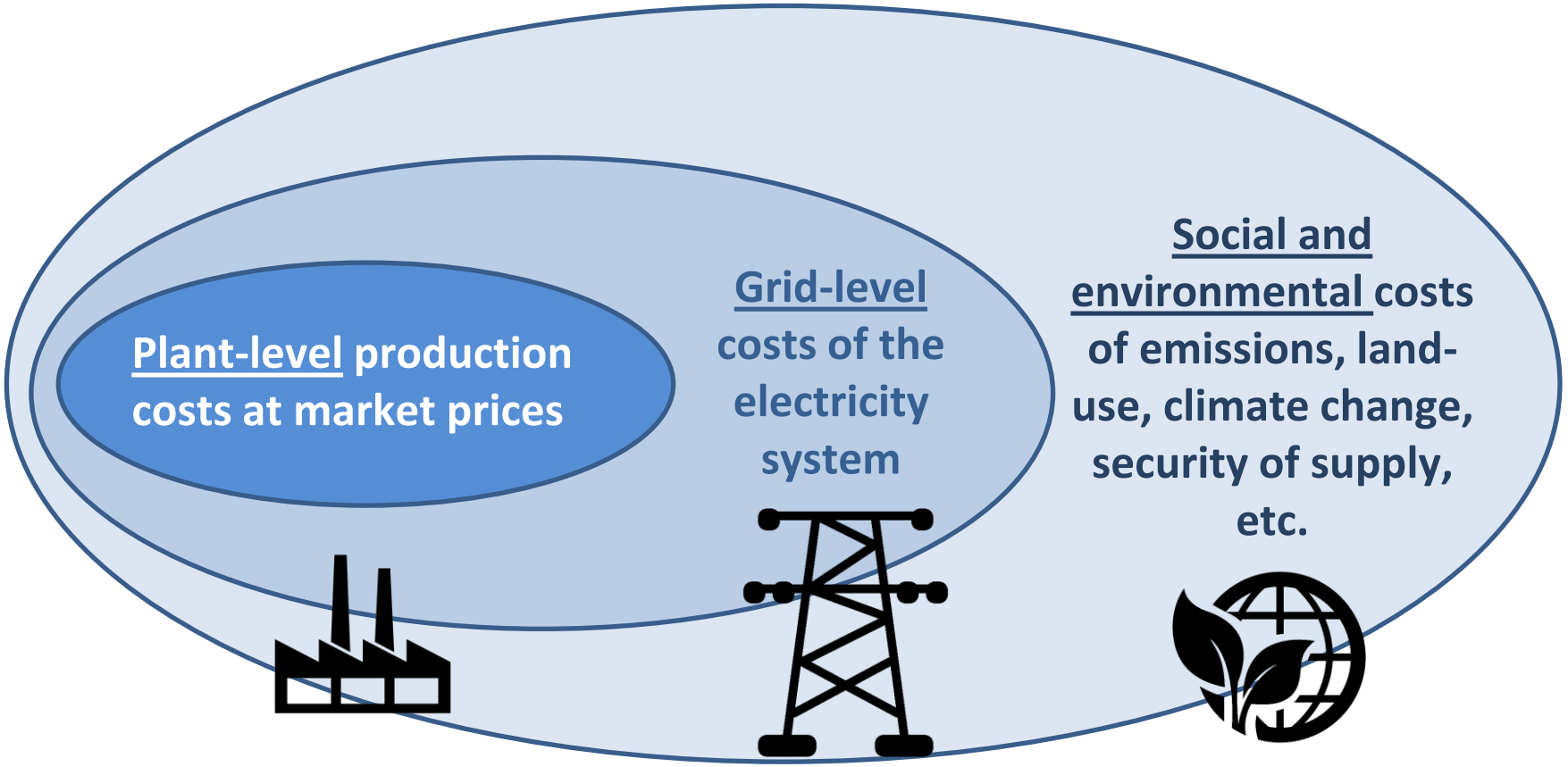


Towards an Understanding of the Economics of Nuclear Energy in a Carbon-constrained Future

Diane Cameron
Head of Division
Nuclear Technology Development and Economics
OECD Nuclear Energy Agency

New Nuclear Watch Institute Webinar
17 June 2021

The costs of electricity: from plant-level to system costs

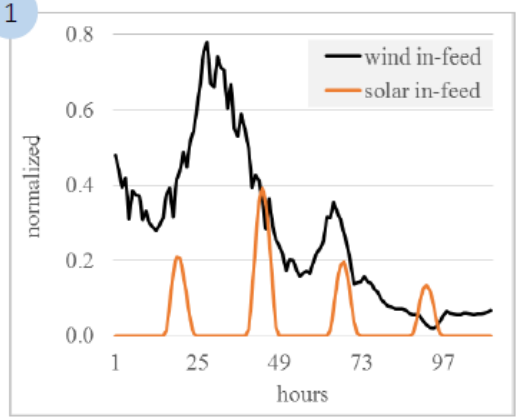


The actual cost of electricity should reflect not only plant-level **GENERATION** costs but also grid-level **SYSTEM** costs and **SOCIAL & ENVIRONMENTAL** costs

What do we mean by system costs?

- Total system costs = plant-level generation costs + grid-level system costs
- System costs are mainly due to characteristics intrinsic to variable generation

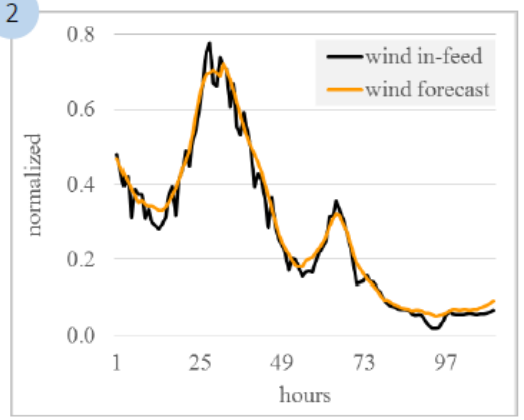
1



VREs are not always available

Profile costs (Changing mix)

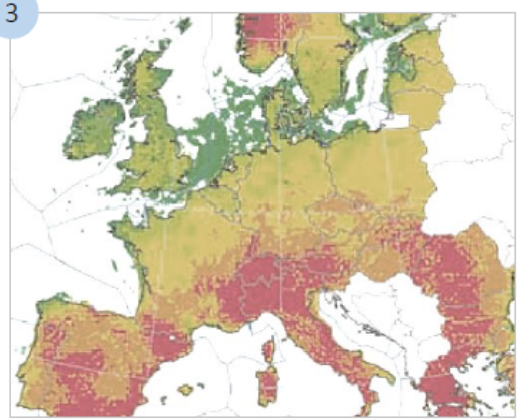
2



VREs are difficult to predict

Balancing costs (Short-term variations)

3



Good VRE sites are distant from load centers

Transmission and distribution costs

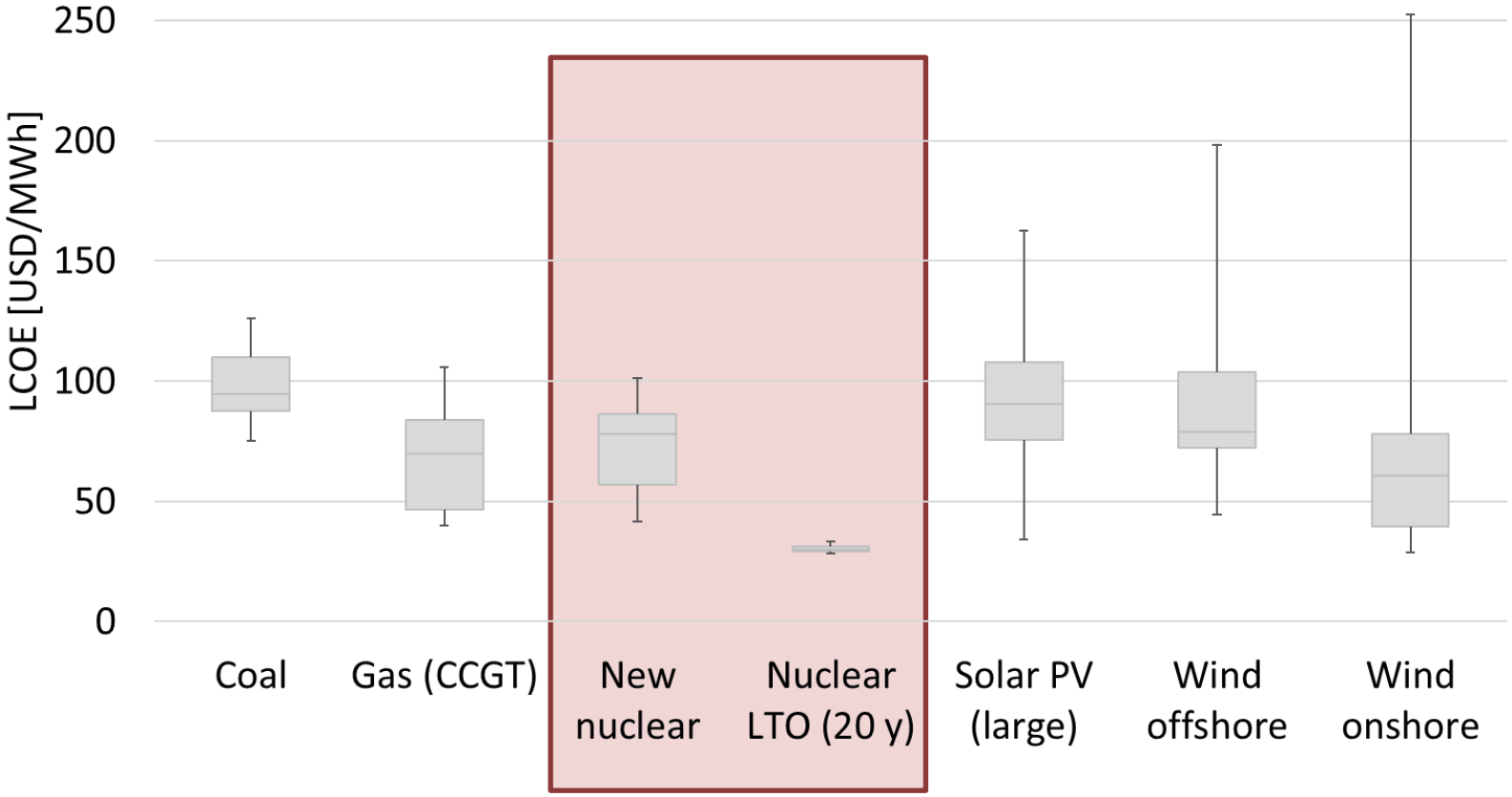
System costs depend on:

- 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.

Source: L. Hirth

Nuclear power competitiveness
Key results from the IEA/NEA – Projected Cost of Electricity 2020

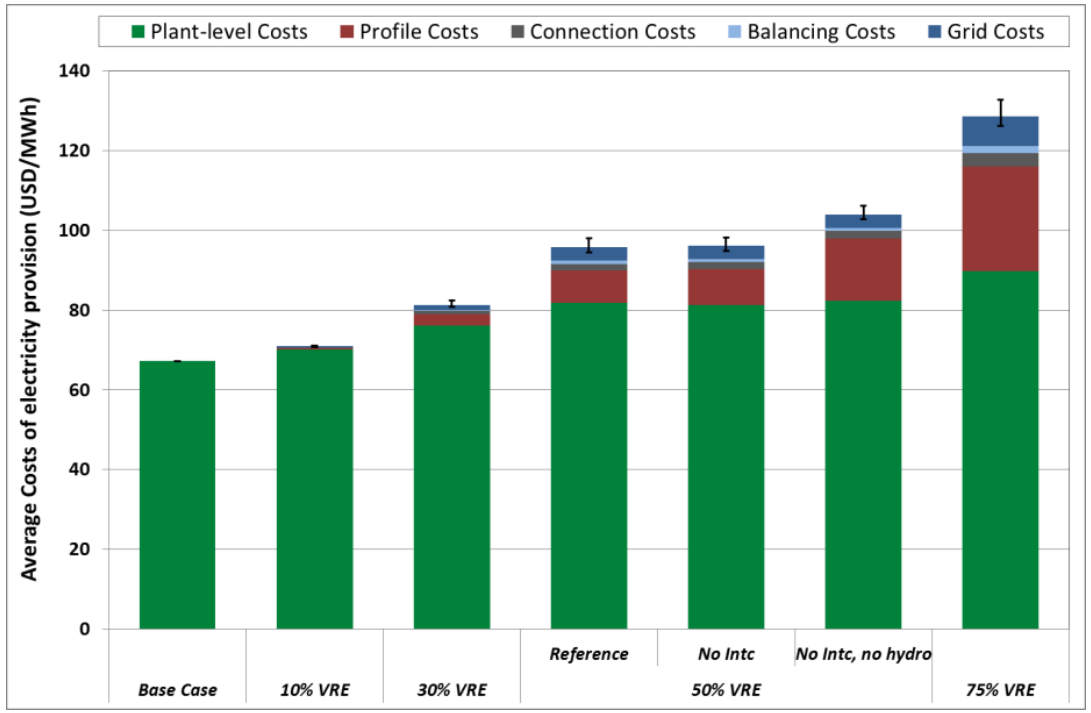


Source: IEA/NEA (2020) with cost of capital of 7% and CO2 price @ 30 USD/tCO2

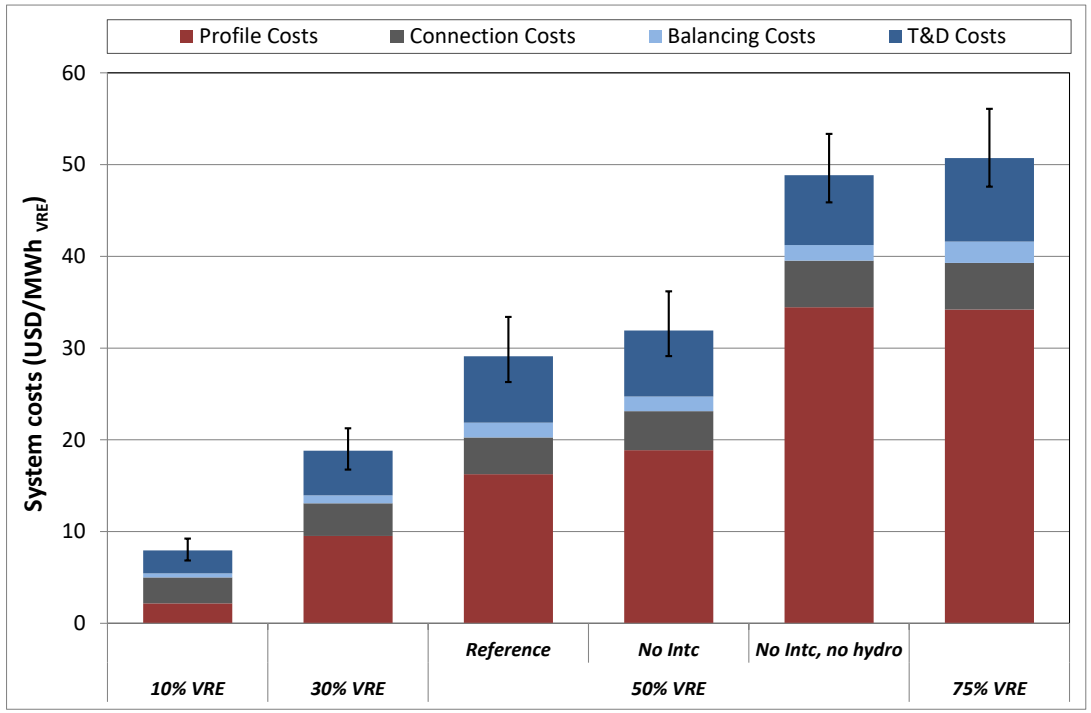
Nuclear LTO one of the most competitive solutions. Costs reductions expected for new nuclear that will improve competitiveness. **Policy framework critical** in both cases.

As variable renewables share increases system costs grow quickly

Total Costs

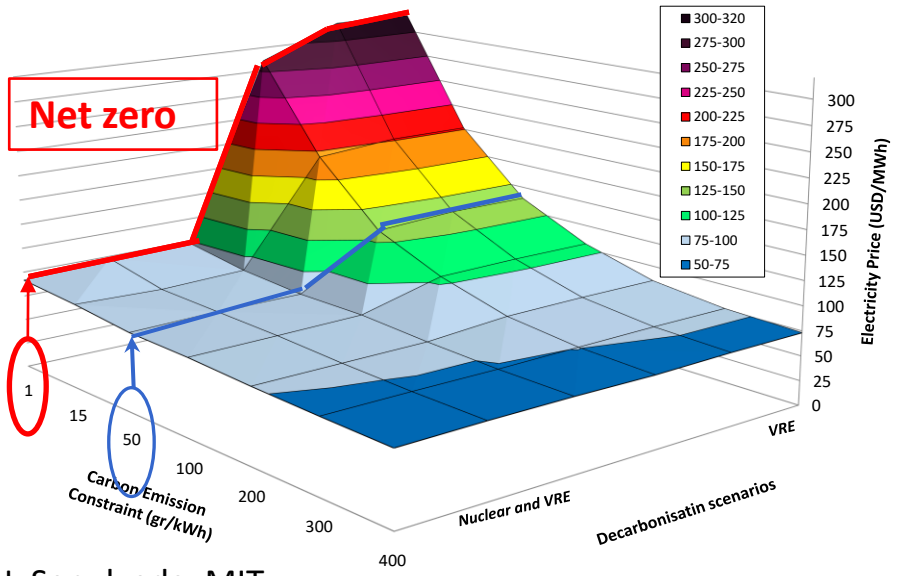


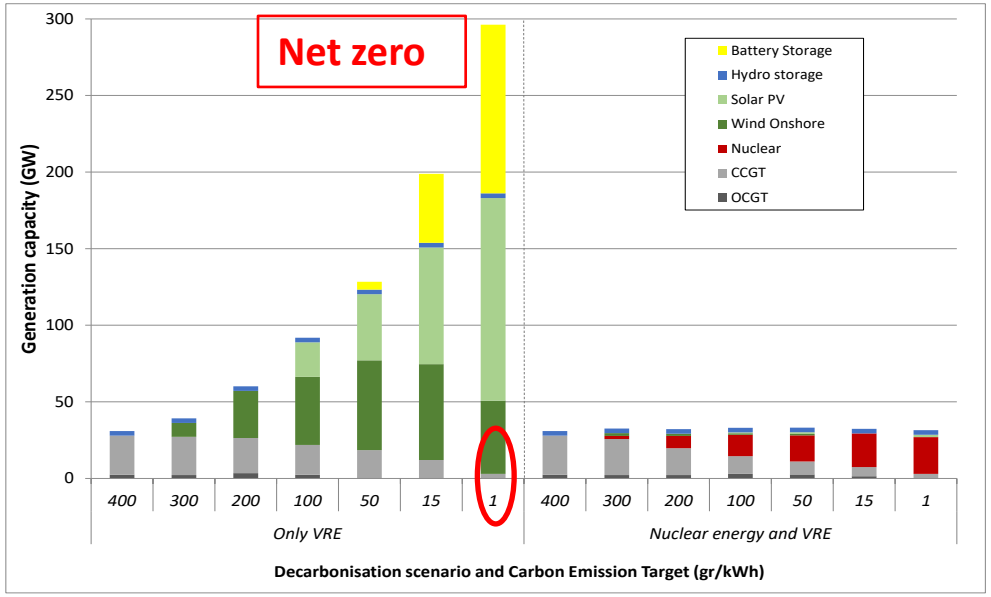
Breakdown of System Costs



System costs are significant and increase with VRE generation share
Profile costs are the dominant component

System Costs Are a Function of (1) Carbon Targets and (2) VRE Targets

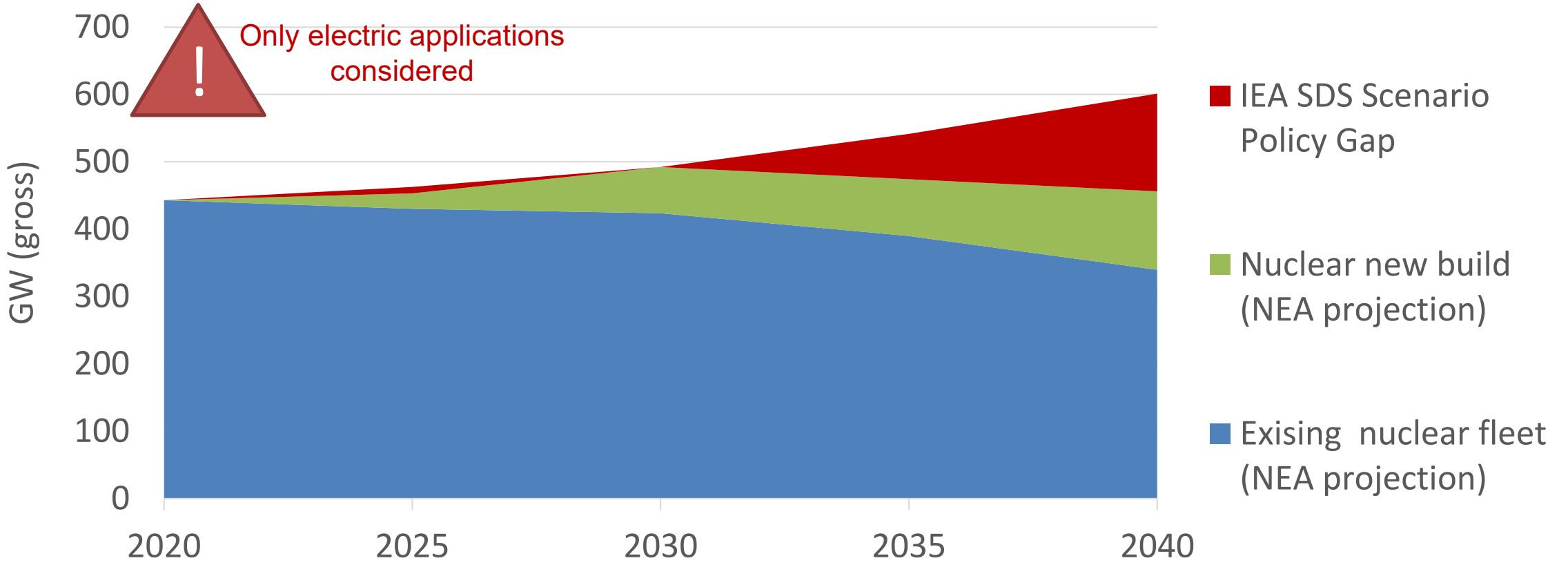




Source: N. Sepulveda, MIT

The cost of electricity increases with the stringency of the carbon constraint, especially in scenarios where only variable renewables are deployed.

Nuclear power outlook in IEA's *Tracking Clean Energy Progress 2020*



Meeting IEA SDS scenario requires to foster both **existing nuclear reactors** though long term operations and to **accelerate new-build** (Gen-III large reactors and SMRs)

Thank you

More information @ www.oecd-nea.org

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Aligning policy objectives to tap the full climate mitigation potential of nuclear technologies

New Nuclear Watch Institute - High Level Economic Panel

Harnessing the renewed global support for nuclear to help achieve net zero

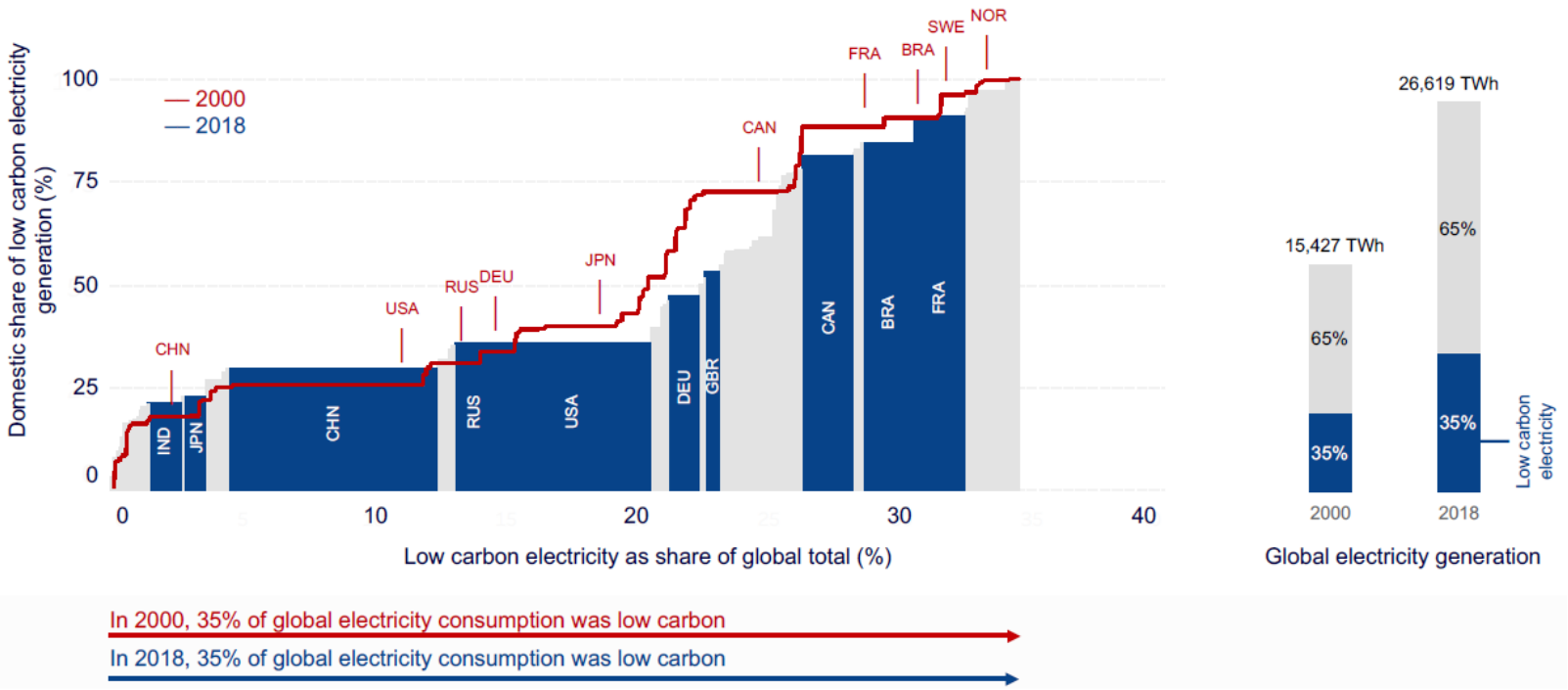
17 June 2021

Dr. Bertrand Magné
IAEA Planning and Economic Studies Section

Where do we stand in the energy transition?

Domestic vs global distribution of low carbon electricity by country , 2000-2018

Top 10 countries are highlighted



- The switch to clean electricity is manifest in many markets but remains **too slow for net-zero** emission targets to be met on time

- **35% percent of global electricity was supplied with low carbon sources in 2018**. This share barely evolved in more than thirty years.

Historically, the major contributors to low carbon electricity drew on nuclear energy and hydropower. But there is **a need for nuclear technologies to go past historical economic and environmental performance,** to face a new policy landscape and address the pressing climate emergency

Source: IAEA (Forthcoming) *Transitions to low carbon electricity systems: Key economic and investment trends - Changing course in a post-pandemic world*

The pandemic response creates a great opportunity to accelerate an orderly transition

- COVID **recovery packages** (≈ $12 trillion) with **green focus**
- Business movement towards **transparency** (Science-based targets)
- Progressive **greening** of the **finance** sector (New instruments such as green bonds; climate-related financial disclosure)
- **Aligning short term actions to build back better and meet long-term targets**

  COVID response • NDC (2030) • Carbon neutrality (≈Mid century)
  [To date, 59 countries and 54% of global GHG emissions have communicated a net-zero target]
- **Social and inequality concerns** inherent to the transition must be tackled to ensure successful and just outcomes

These drivers provide should favourable grounds to nuclear developments

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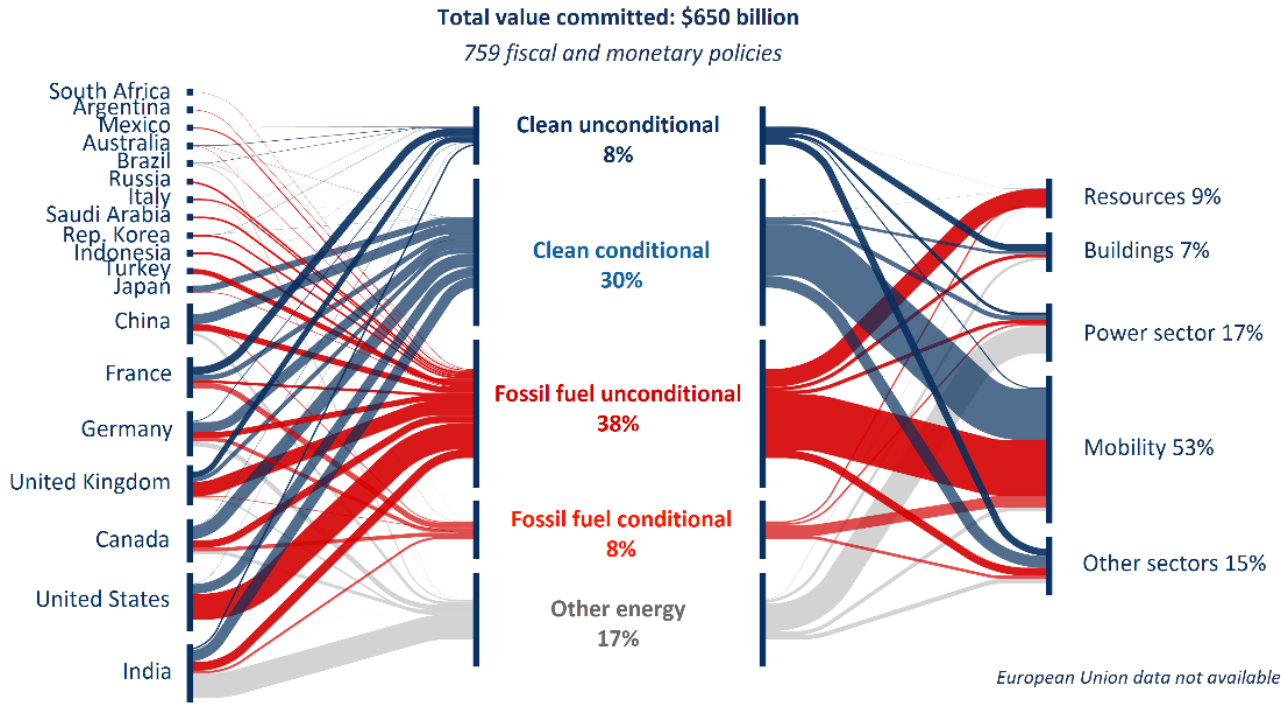
COVID-19 recovery packages:
A missed opportunity, including for nuclear developments?

Public money commitments made by G20 countries to fossil fuels, clean and other energy in recovery packages, as of 19 May 2021



- To date, **public announcements** to organize the recovery around clean energy opportunities remain **largely at odds with climate change** and sustainable development strategies
- 14 G20 members with operating nuclear power capacities
- **Clean energy investments**, including nuclear, **pay off**
  - IEA (2021) Clean Energy Investing - Global Comparison of Investment Returns
  - IMF (2021) Building Back Better - How Big Are Green Spending Multipliers?
- **Leading time of new constructions compatible with recovery** ?
- Prospects for stronger economy in the mid-term give further incentives for a **focus on innovation stimulation**?

Out of the 759 policy measures put in place by G20 countries, only **13 relate directly to nuclear power** for a total provision of $1 billion, **or 0.9% of total power sector commitments** (mostly R&D in France, UK, Canada; “Unlock green jobs”)

Source: IAEA (Forthcoming) *Transitions to low carbon electricity systems: Key economic and investment trends - Changing course in a post-pandemic world*

How nuclear technologies will deliver low carbon energy to balance global emissions and removals by 2050

Nuclear power today

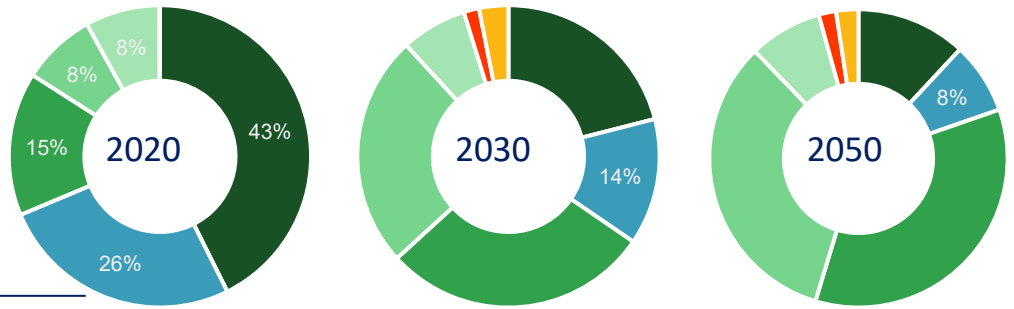
- Nuclear power and hydro provide an **essential foundation for clean energy transitions** [IEA Net Zero by 2050, 2021]
- **Climate objectives** will be met with nuclear power in about **30 countries** where nuclear power currently supplies **over 40% of low carbon electricity** needs
- Nuclear helps **stabilizing power grids**, thus favouring the integration of solar and wind
- Nuclear has a **strong record of resilience** in the face of **extreme weather events** (The equivalent of 2% of global electricity was lost in 30 years globally)

Nuclear power tomorrow

- By **2030**, **nuclear electricity rises by a quarter**, driven by lifetime extensions at existing plants (a cost-effective mitigation option) and new constructions
- By **2050**, **renewables and nuclear** power **displace most fossil fuel use**. The IEA foresees a **doubling of nuclear electricity** [IEA, 2021]
- **New nuclear designs** (incl. small modular reactors and other advanced designs) are moving towards **full-scale demonstration** to provide sources of **flexible and dispatchable power, heat, clean hydrogen…**

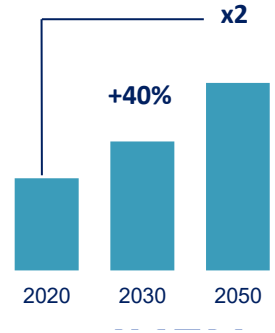
*Nuclear power is currently the **second largest source of low carbon electricity** produced globally*

Breakdown of low carbon electricity



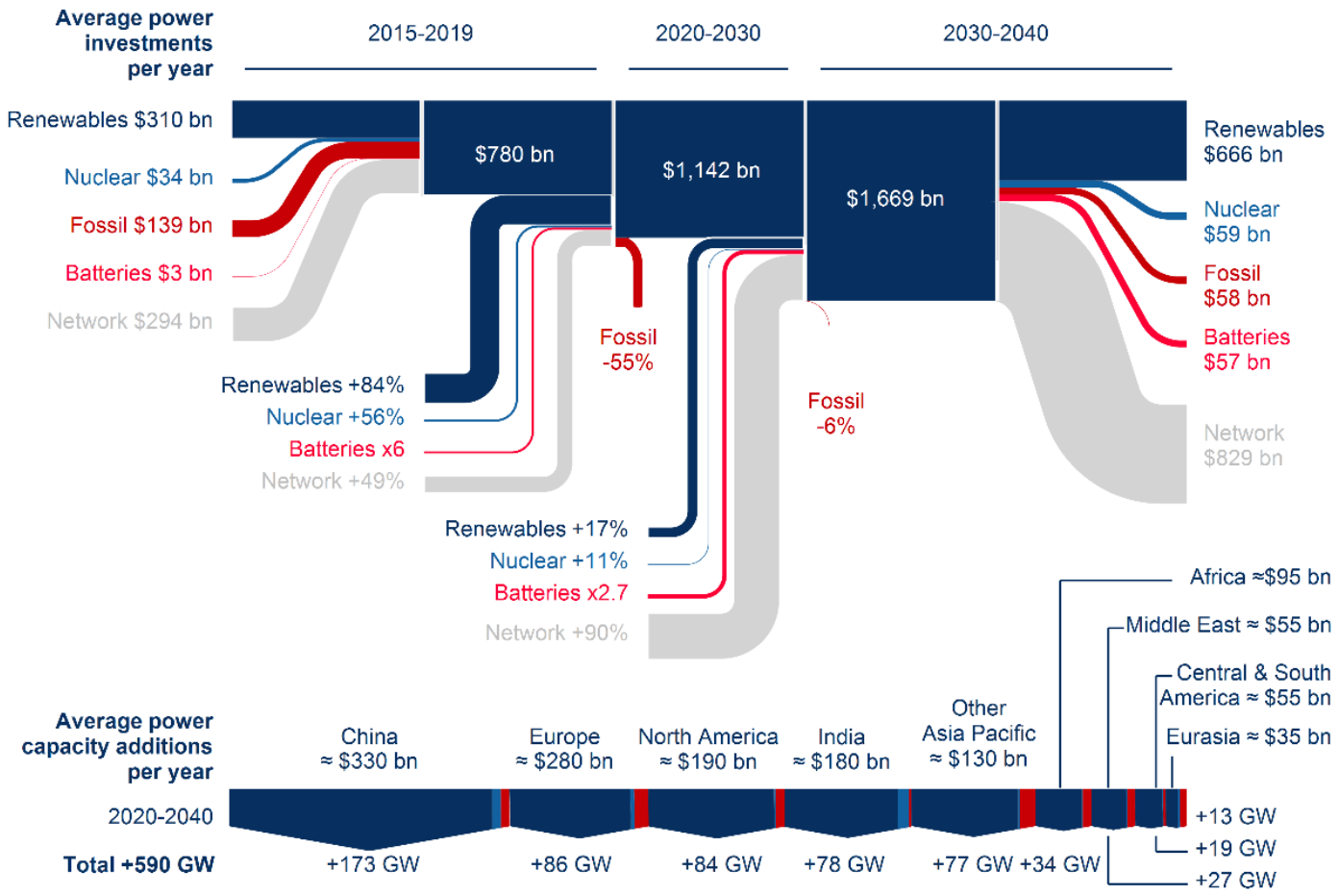
IEA (2021) Net Zero by 2050

Nuclear electricity production



Current levels of spending are misaligned with the climate mitigation potential of nuclear power

Global cumulative investments in low carbon technologies
Low-carbon power-sector requirements in line with the Paris Agreement



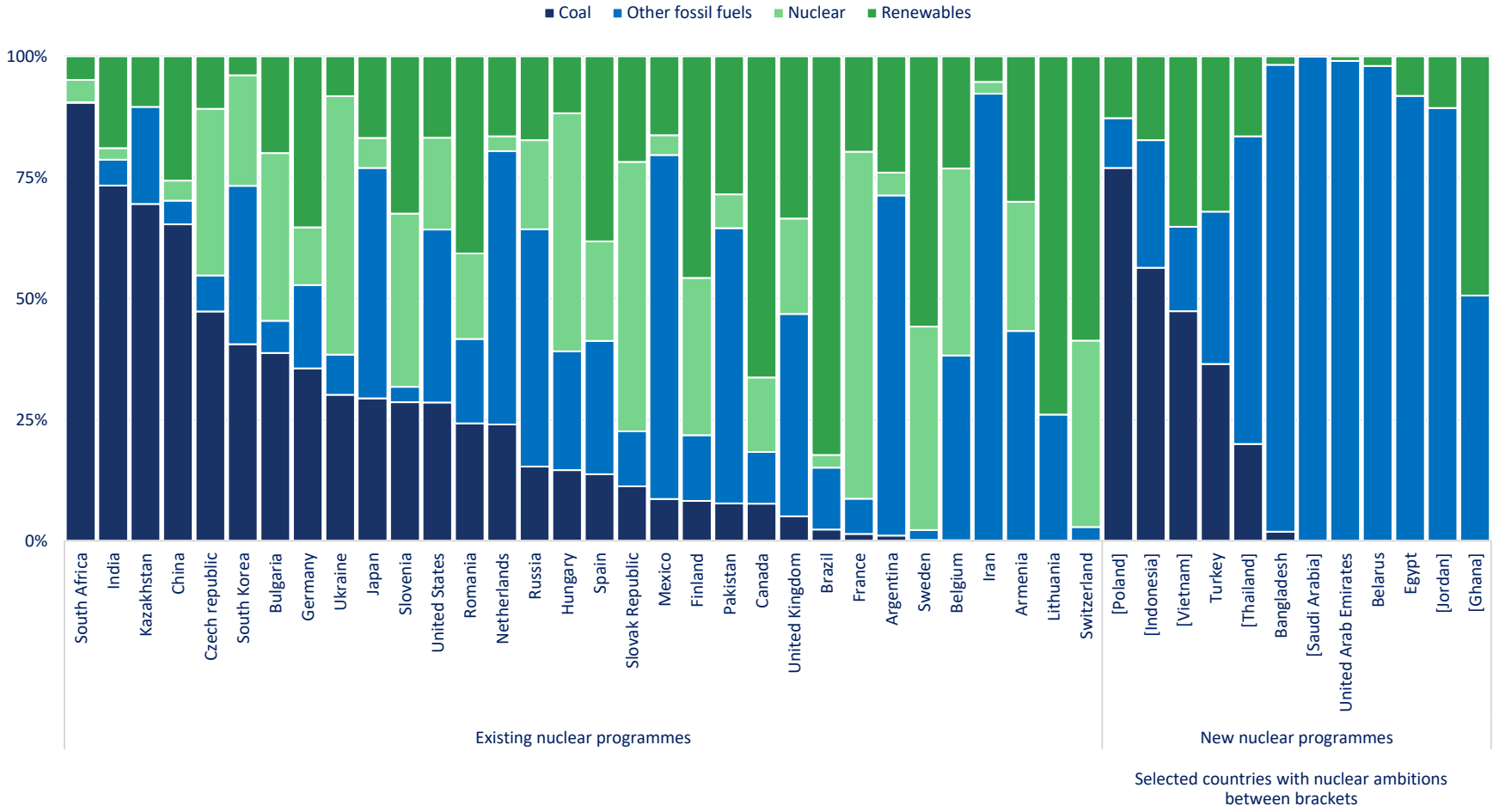
- About **$35 billion** are invested each year in **nuclear projects** (≈10% of global clean power investments)
- **Immediate need to increase nuclear investments by at least 50%**
- The majority of climate investments will need to be realized in emerging markets
- Nuclear projects are gaining interest among some institutional investors, incl. pension funds, as well as private investors seeking the decarbonization of their portfolios and support of technological innovation

Financing new nuclear projects may be **challenging** in a context of **drained public resources** in the near term

Source: IAEA (Forthcoming) *Transitions to low carbon electricity systems: Key economic and investment trends - Changing course in a post-pandemic world; Investment data derived from IEA Sustainable Development Scenario (2020)*

The opportunity to displace coal… and other fossil fuels

Power mixes in countries with nuclear programmes, 2018



- **Coal accounts for a large share of electricity supply in a limited number of countries**
- **Proposed nuclear projects** in China, India as well as Poland, Czech Republic or the Slovak Republic will **displace coal**
- **Good prospects for gas substitution**, particularly in emerging economies with increasing needs, incl. countries building new nuclear programmes
- Other rationale: **Ghana** is considering nuclear to provide reliable power, **foster the productive use of energy** and meet industrialization objectives

Current constructions in Bangladesh, Belarus, Turkey and the UAE, in addition to the extension of 15 existing programmes, confirm the **nuclear attractiveness across the full spectrum of income**

Source: IEA (2020) *Extended Energy Balances*

The opportunity to support hydrogen deployment

Identified projects for nuclear-based hydrogen

Operator	Country	Electrolyser capacity	Hydrogen output
Energy Harbor	USA	2 MW (Low-temp. electrolysis)	800 - 1,000 kg per day
Xcel Energy	USA	? (High-temp. steam electrolysis)	?
Arizona Public Service	USA	20MW	10 ton per day
Exelon	USA	1MW (PEM Electrolyser)	?
Bruce Power	Canada	1-5MW	?
EDF	UK	Heysham: 1MW (PEM Electrolyser) + 1MW (Alkaline) Sizewell (Demonstrator): 2MW	800 kg per day (max)
Rosatom	Russia	?	≈ 21 m3 per hour
Vattenfall	Sweden	4.5 MW[2]	?

- **Very few projects to date, mostly at conception phase**
- Modest capacity, in comparison with RE-based hydrogen
- Need to demonstrate the business case
- Requires some form of public support

- **Pre-requisites for rapid development**
- Electricity generated at competitive cost with H2 price target: <$2 per kg
- Creation of demand to absorb large production volumes in the mid term
- Integration with clean energy clusters to address local (industrial) demand and limit shipping costs

The nuclear industry has yet to find its niche in the supply of new services, including opportunities in a nascent hydrogen economy

Source: IAEA analysis

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A dynamic yet highly-competitive policy landscape

➔ **Domestic and international implementation of carbon penalties affect all investment decisions**

- Price of EU ETS allowances at all-time highs, likely to deter gas investments in the mid-term
- Border tax adjustments with implications for local supply chains will further incentivize the demand for low carbon power

➔ **The inclusion of nuclear in taxonomies to channel sustainable investments could encourage potential investors**

- Nuclear technologies are compatible with sustainable development [EU Joint Research Centre, 2021] *"Nuclear energy does not do more harm to human health or to the environment than other electricity production technologies"*
- **Political negotiations to follow the scientific evaluation** of nuclear as sustainable energy asset
- Negotiation outcome leading to conditional inclusion?

➔ **Very high targets for RE deployment at risk of crowding out public resources for nuclear investments**

- UN High-Level Dialogue on Energy (2021): Commitment to "*rapidly scale-up deployment of available energy transition solutions to reach 8000 GW of renewables by 2030 with due consideration to different contributions by individual countries*"

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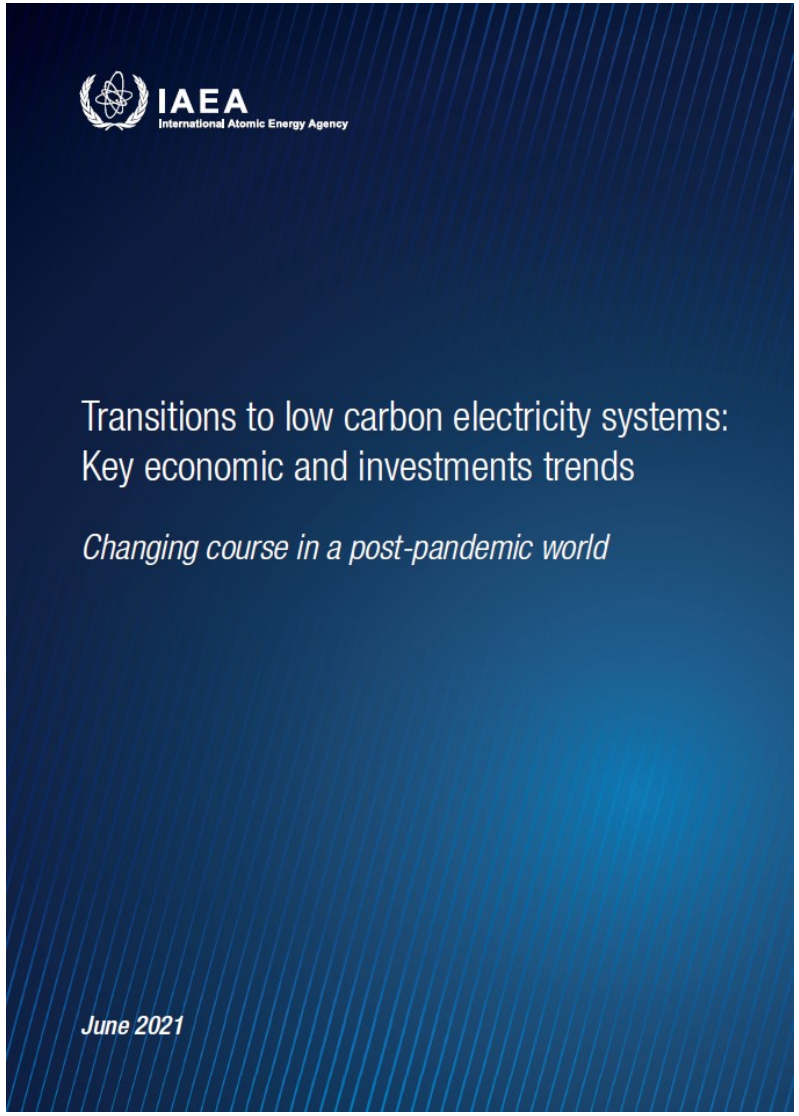
Evidence on the nature and pace of the ongoing energy transition



Content

32 pages – 11 sections

Policy overview for informed decision-makers

- State of play in the energy transition
- Key features of future electricity systems
- Required efforts towards carbon neutrality
- Impact of the pandemic / Recent initiatives

Available for download at:

IAEA Topical Booklets and Overviews | IAEA

Thank you

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Nuclear Energy cost-effectively decarbonizes energy systems

Dr. Sama Bilbao y Leon
Director General

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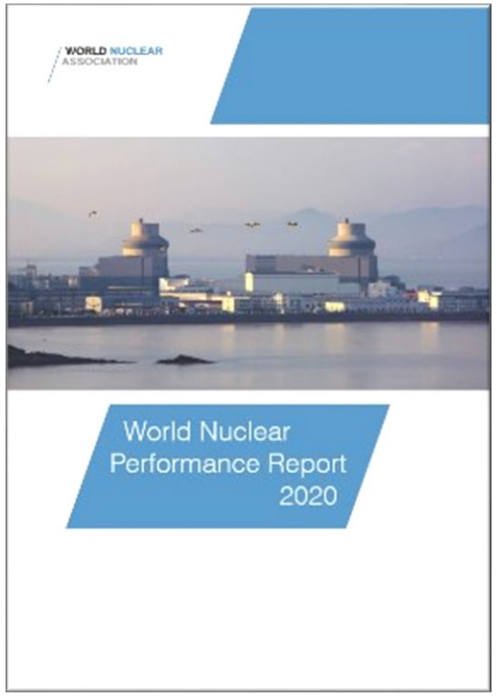
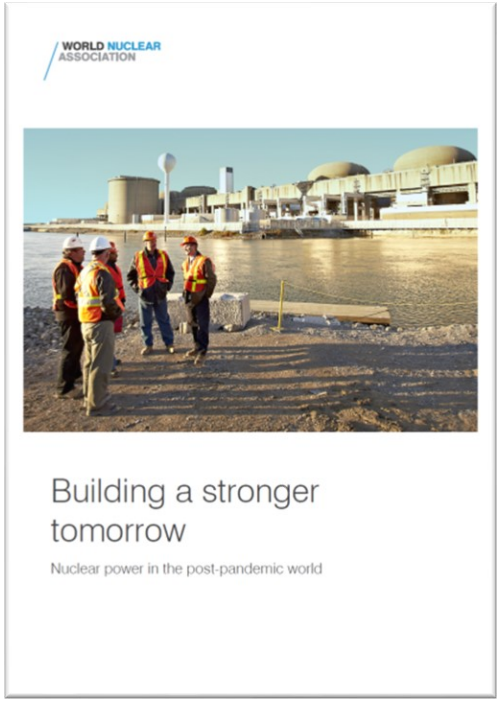
World Nuclear Association is the voice of the global nuclear industry

Nuclear Performance



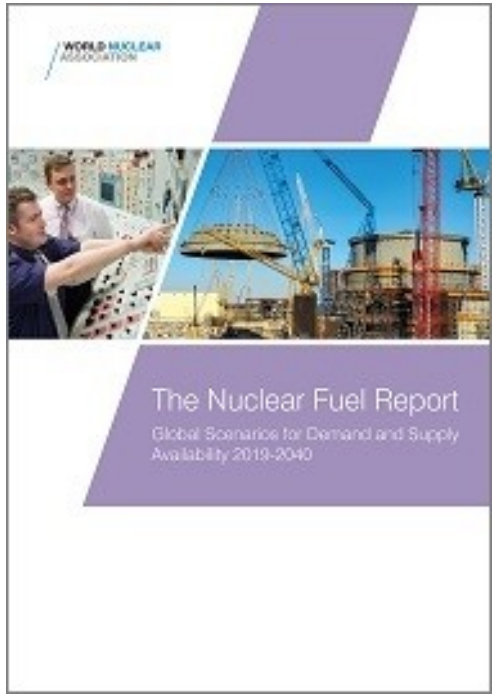
https://www.world-nuclear.org/our-association/publications/global-trends-reports/world-nuclear-performance-report.aspx

COVID-19 recovery



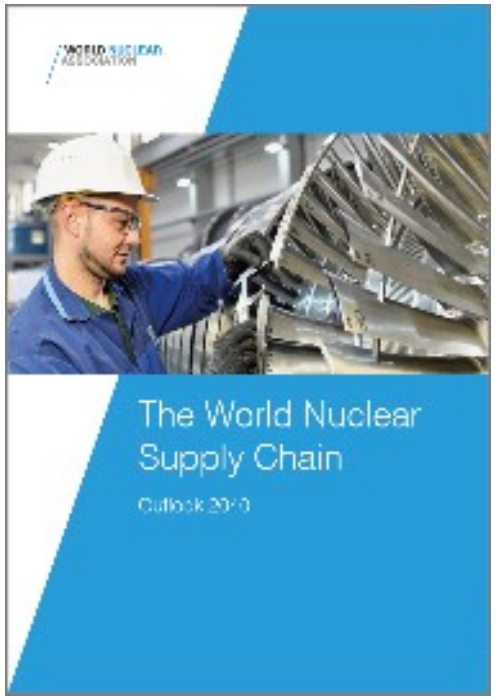
https://world-nuclear.org/our-association/publications/policy-papers/building-a-stronger-tomorrow.aspx

Nuclear Fuel



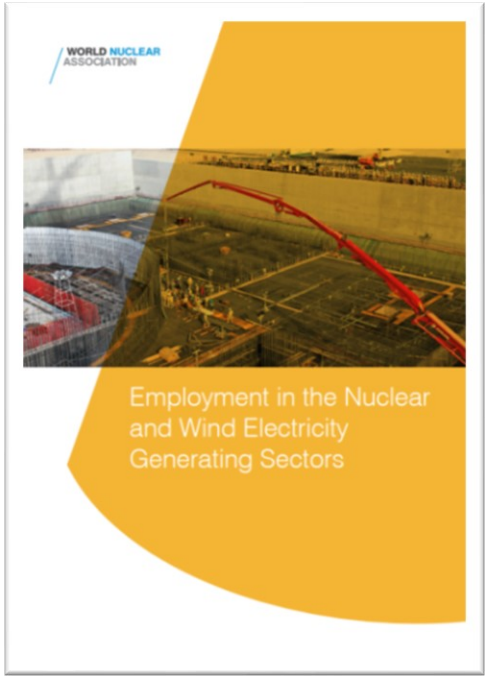
https://world-nuclear.org/shop/products/the-nuclear-fuel-report-global-scenarios-for-deman.aspx

Supply Chain



https://world-nuclear.org/shop/products/the-world-nuclear-supply-chain-outlook-2040.aspx

Nuclear jobs



https://www.world-nuclear.org/our-association/publications/technical-positions/employment-in-the-nuclear-and-wind-electricity-gen.aspx

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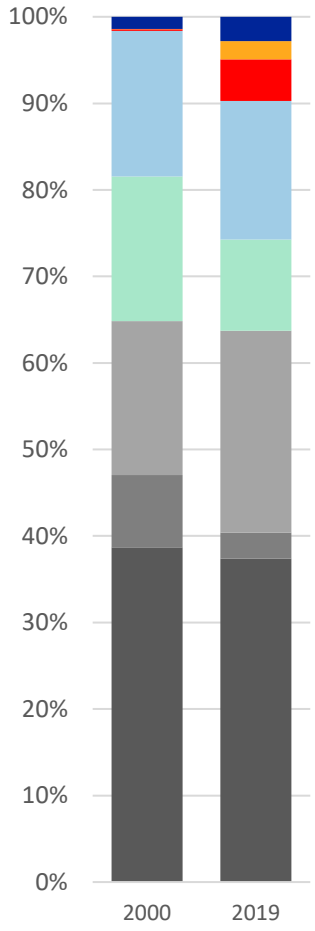
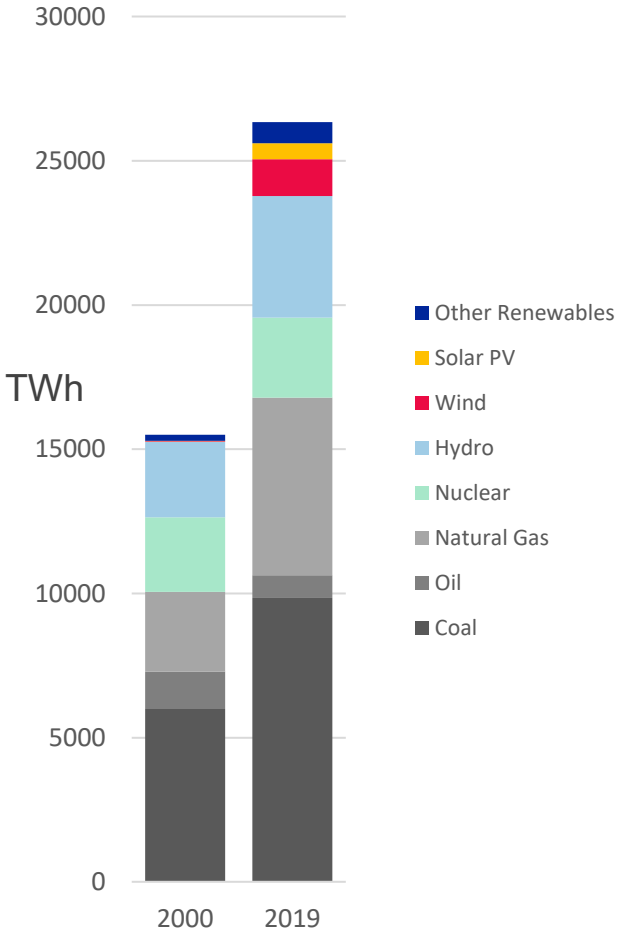
The enormity and the urgency of the climate change challenge are staggering

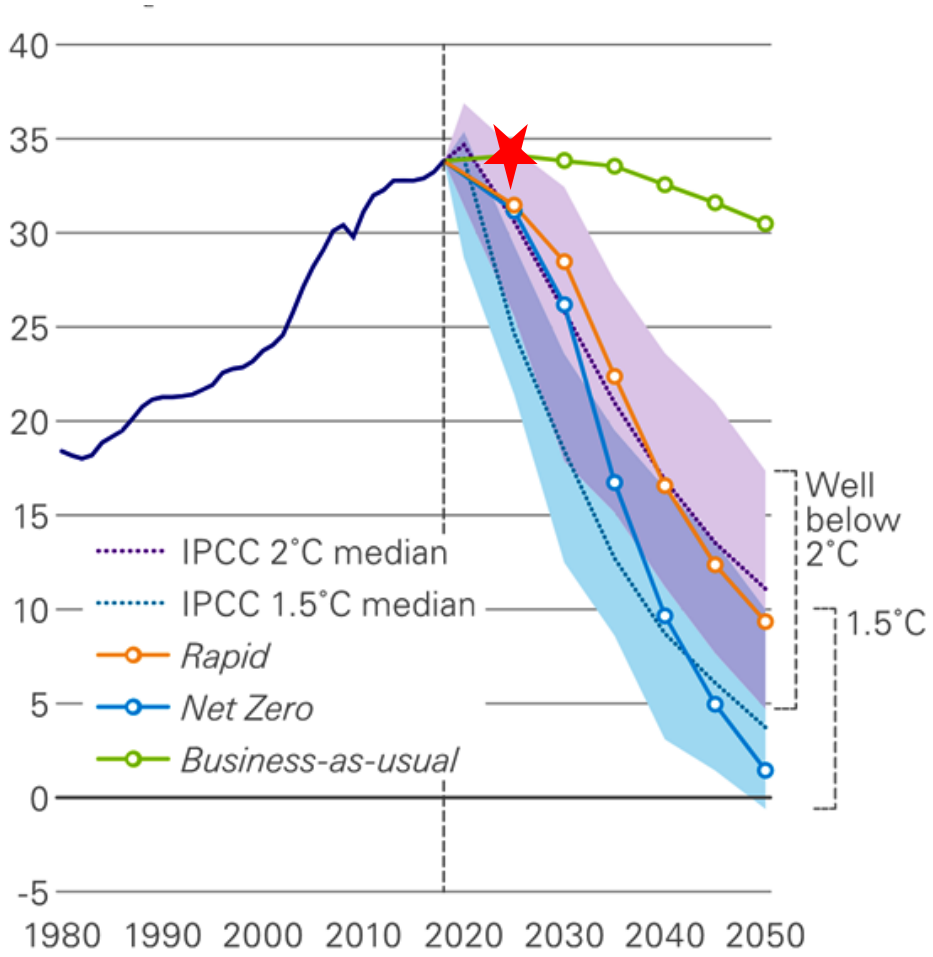


The share of fossil electricity generation has not significantly reduced since 2000



Electricity generation from fossil fuels in 2019 higher than total generation in 2000

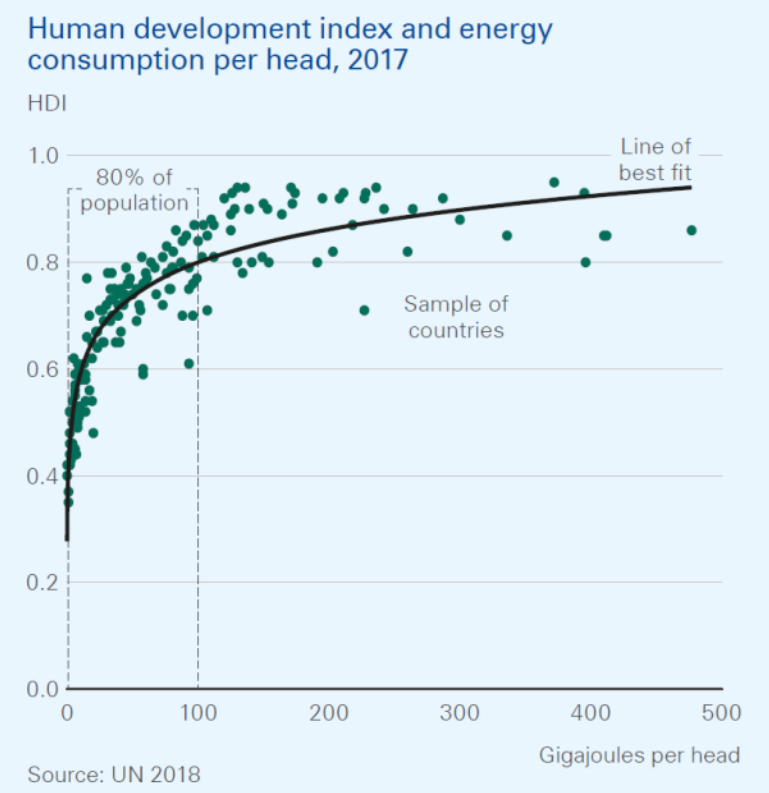
IEA: World Energy Outlook 2020



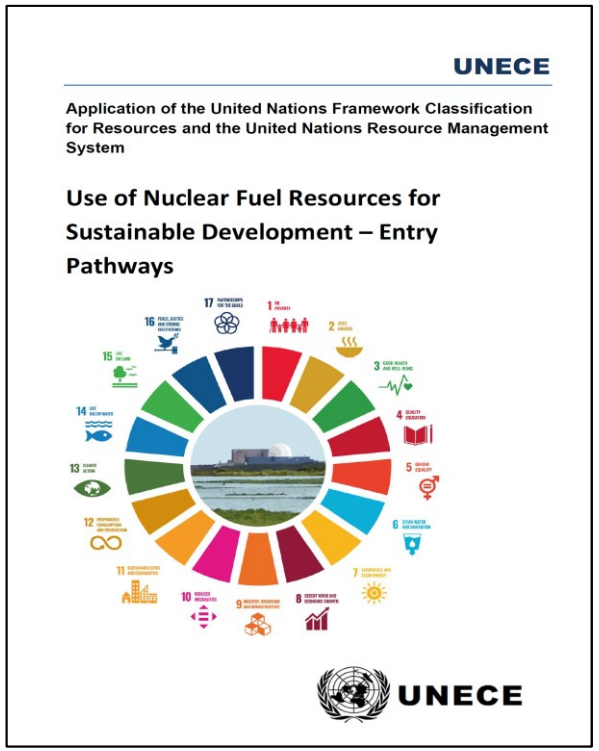
CO_2 emissions must decline over next 30 years.

BP Energy Outlook 2020/IPCC

Less developed nations are focused on both clean energy and socio-economic development



Source: BP Energy Outlook 2019



Source: UNECE, 2021 https://unece.org/sustainable-energy/publications/nuclear-entry-pathways

Around 80% of the world's population today have an average energy consumption of less than 100 GJ per head.

Nuclear energy is an indispensable tool for achieving the global sustainable development agenda.

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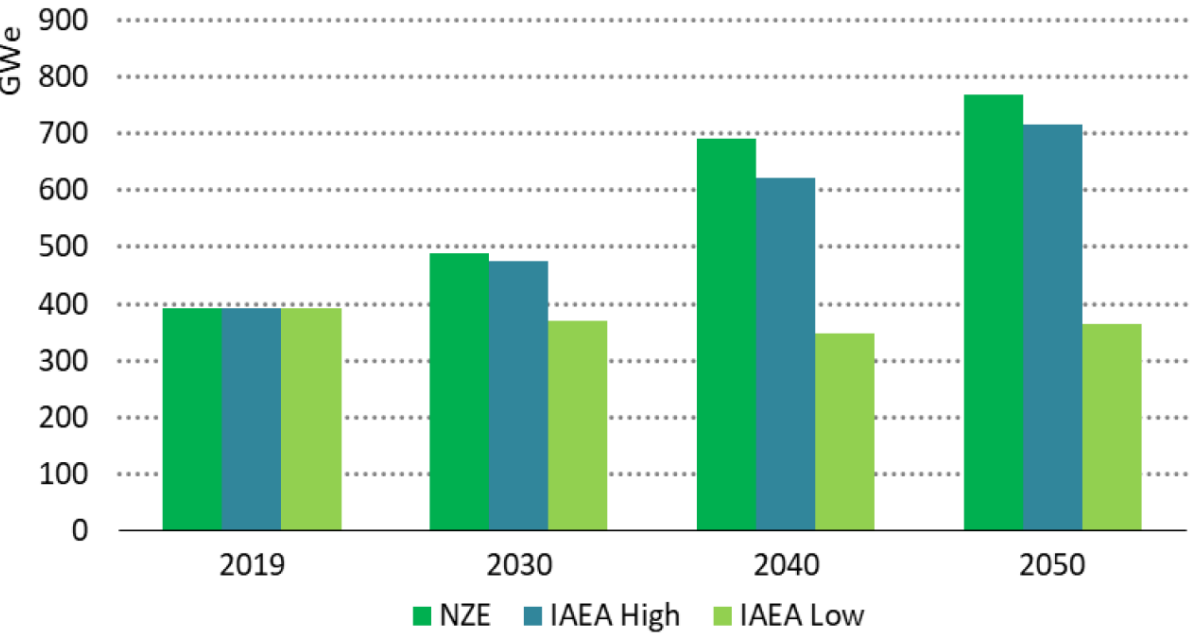
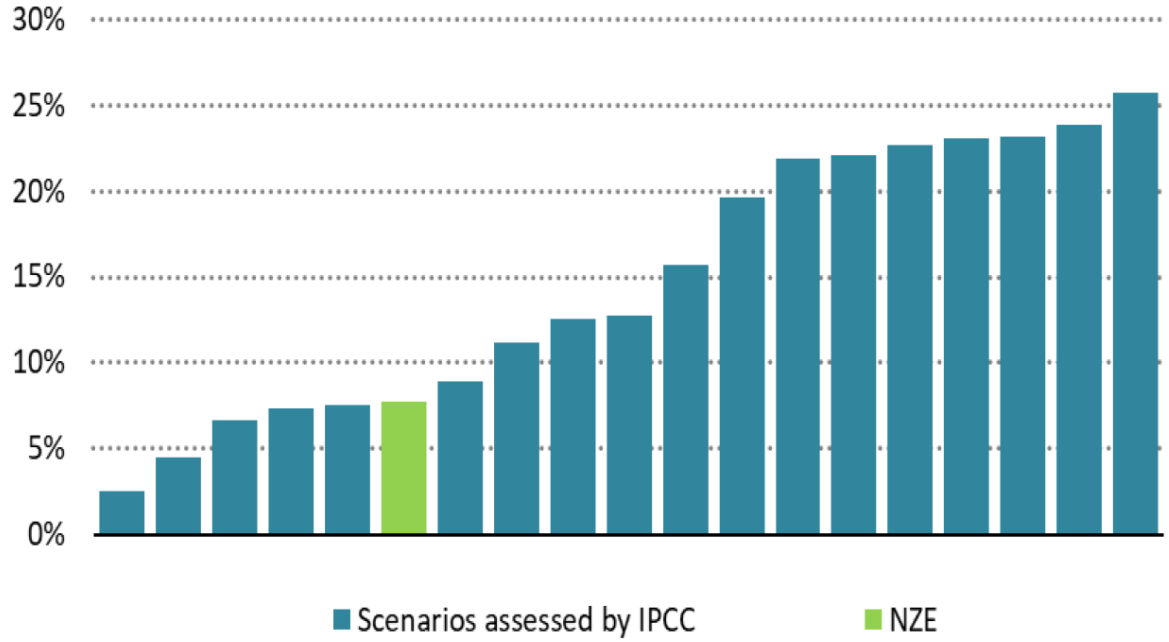
Nuclear energy is essential for deep decarbonization

World nuclear installed capacity (net)



Share of nuclear in world electricity generation



Source: IEA 2021

- Nuclear energy needs to grow rapidly if we are to satisfy energy demand, achieve climate targets and help the world meet the sustainable development goals.
- According to IEA Net-Zero Scenario, nuclear power doubles over the next three decades, contributing to the full decarbonisation of electricity, though its share of electricity generation falls to 8% in 2050

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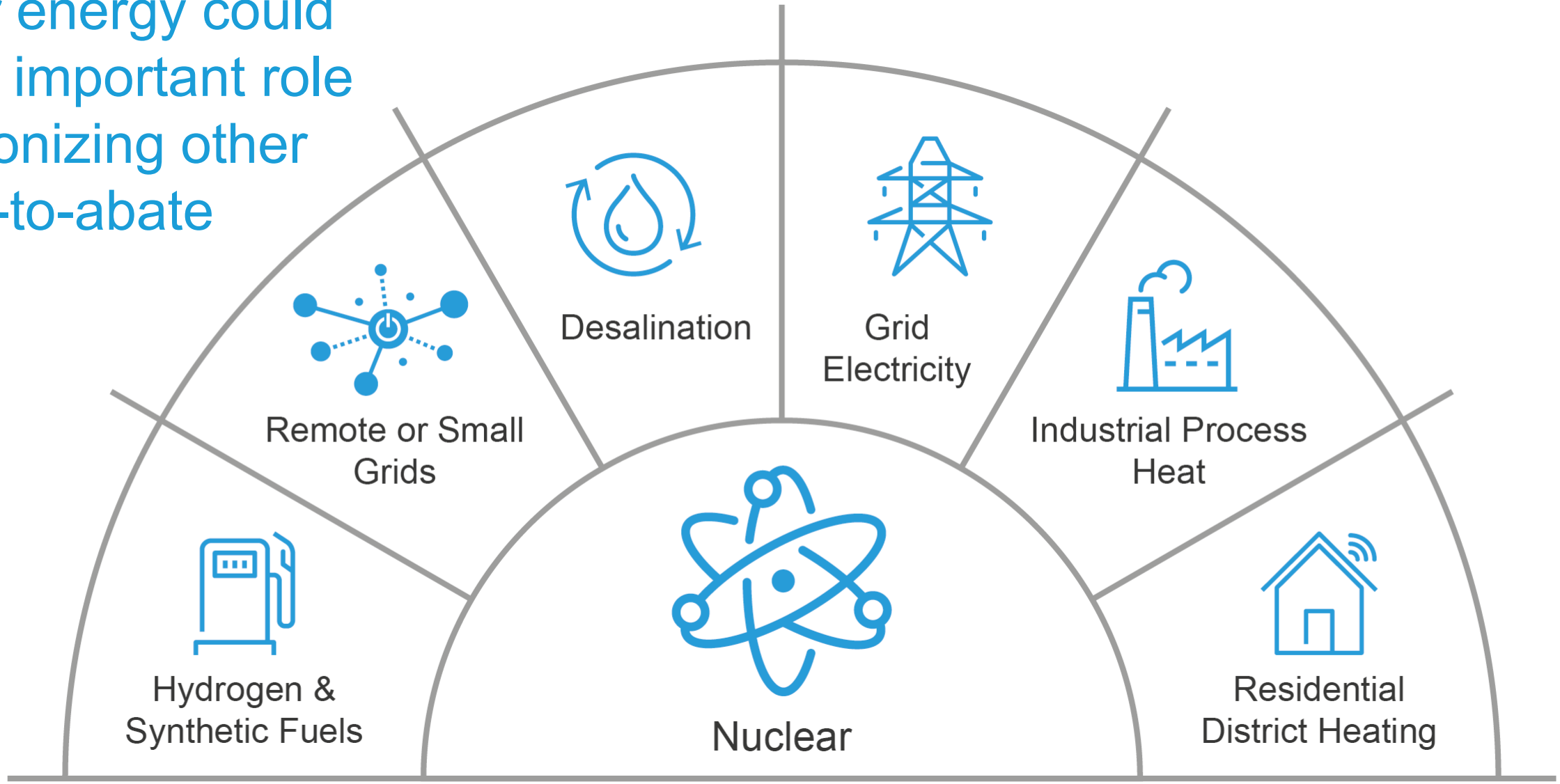
As the only low-carbon source that can produce electricity and heat, nuclear energy could play an important role decarbonizing other difficult-to-abate sectors



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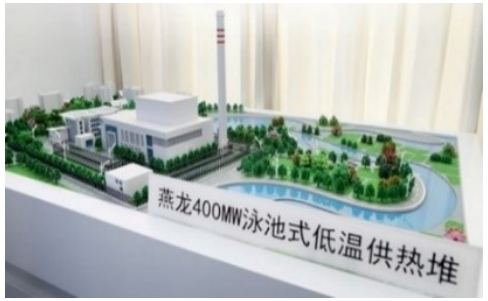
Lots of excitement about new nuclear projects, large and small

Barakah 1
APR-1400
UAE

Fuqing 5
Hualong One
China

Ostrovets 1
VVER V-491
Belarus

Akademik Lomonosov
KLT-40S
Russia



Yanlong DHR, China
400 MWth Pool Low Temp District Heating
Under Development

NuScale, US
77 MWe PWR
Design Licensed

HTR-PM, China
2x110 MWe HTGR
Under Commissioning

Terrestrial, Canada, US, UK
190 MWe IMSR
Under Development

BWRX300, US
300 MWe BWR
Under Review

Aurora/Oklo, US
1.5 MWe Heatpipe FNR
Under Review

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SMRs may be a game-changer for nuclear energy

More Affordable: Business Model

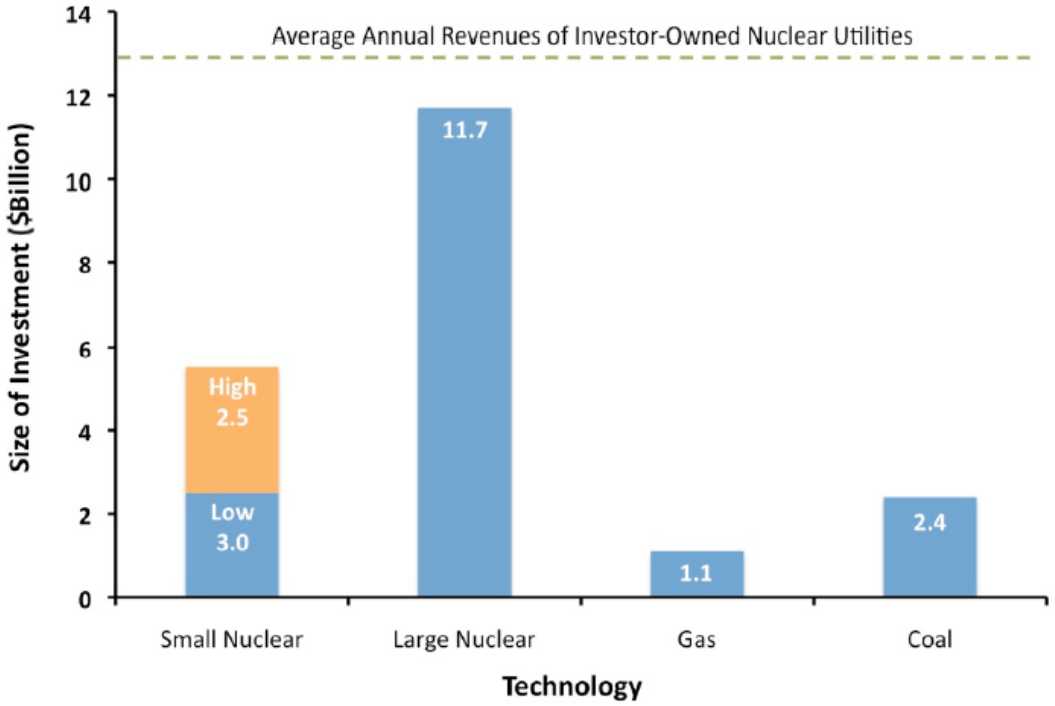
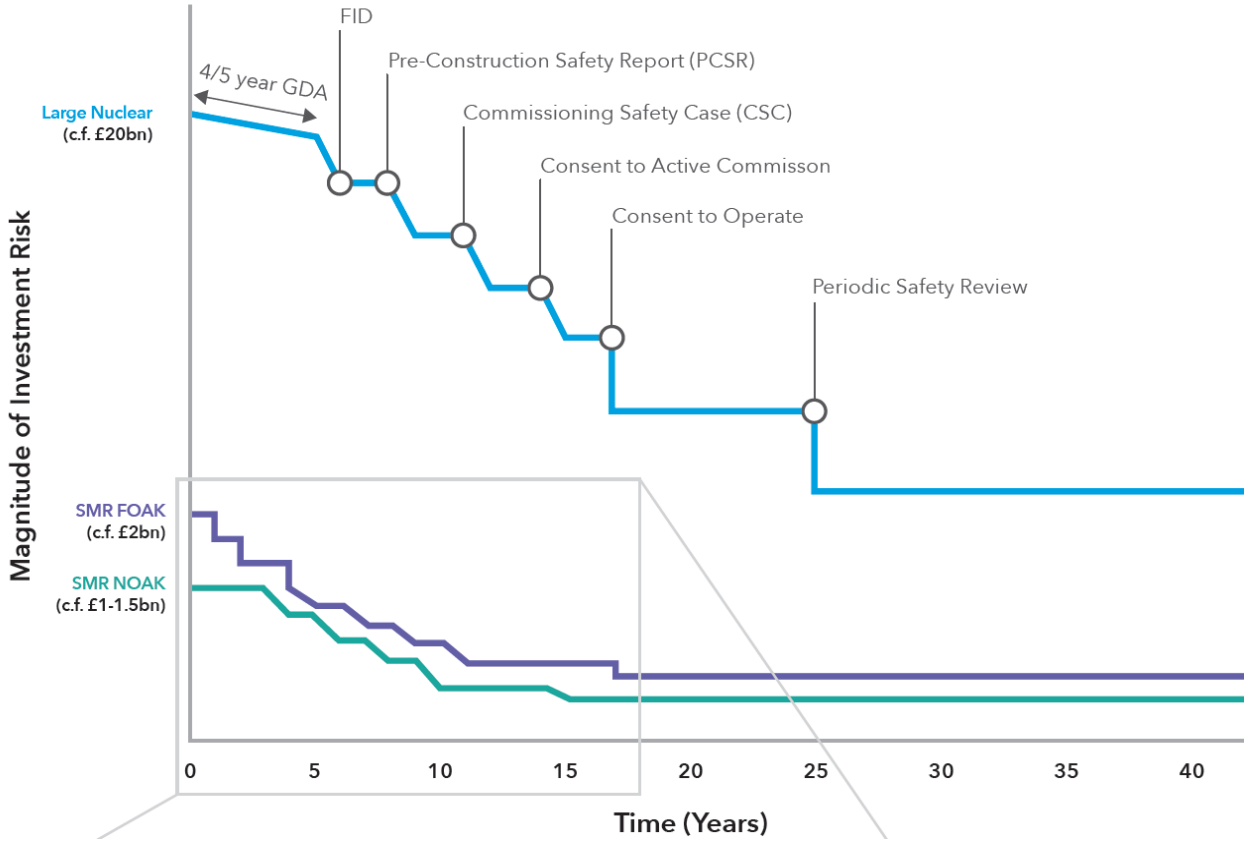


FIGURE 1 Comparison of Size of Investment (i.e., Overnight Cost) with Average Annual Revenues of Investor-Owned Nuclear Utilities[17]

Source: "Small Modular Reactors – Key to Future Nuclear Power Generation in the U.S.", University of Chicago, Nov 2011

Less Risky: Financing



Source: BEIS Market framework for financing small nuclear 2018

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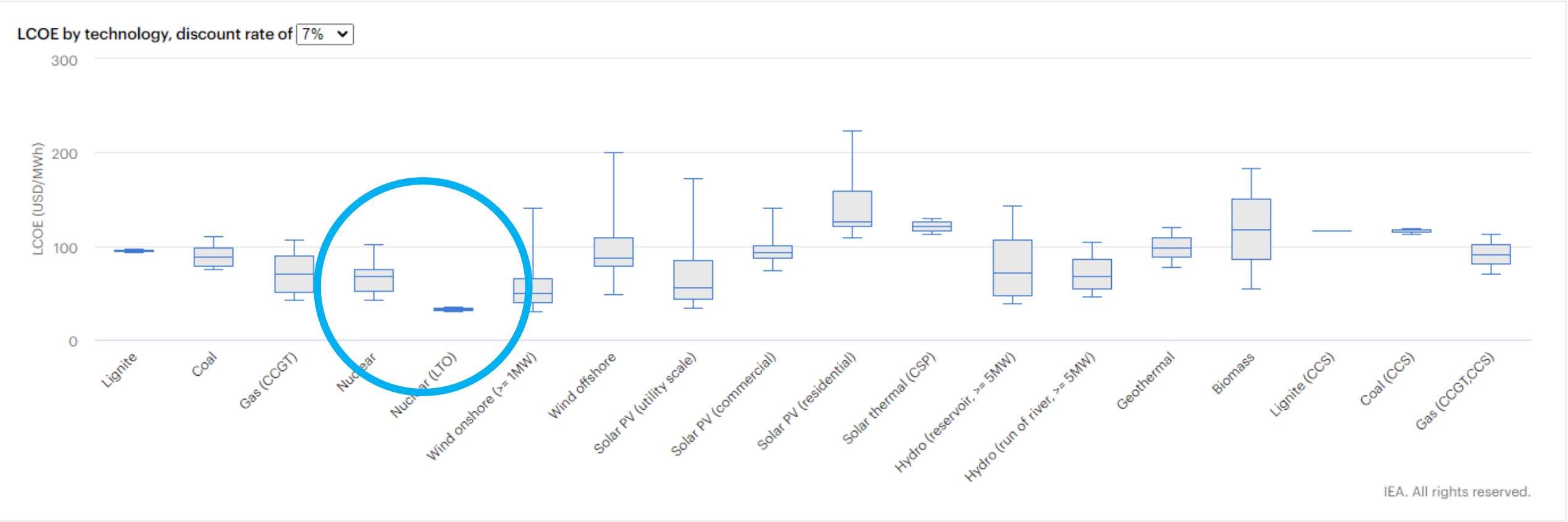
Existing nuclear and new nuclear are competitive low-carbon solutions



Source: IEA/NEA 2020 with cost of capital of 7% and CO2 price @ 30 USD/tCO2
https://www.oecd-nea.org/jcms/pl_51110/projected-costs-of-generating-electricity-2020-edition

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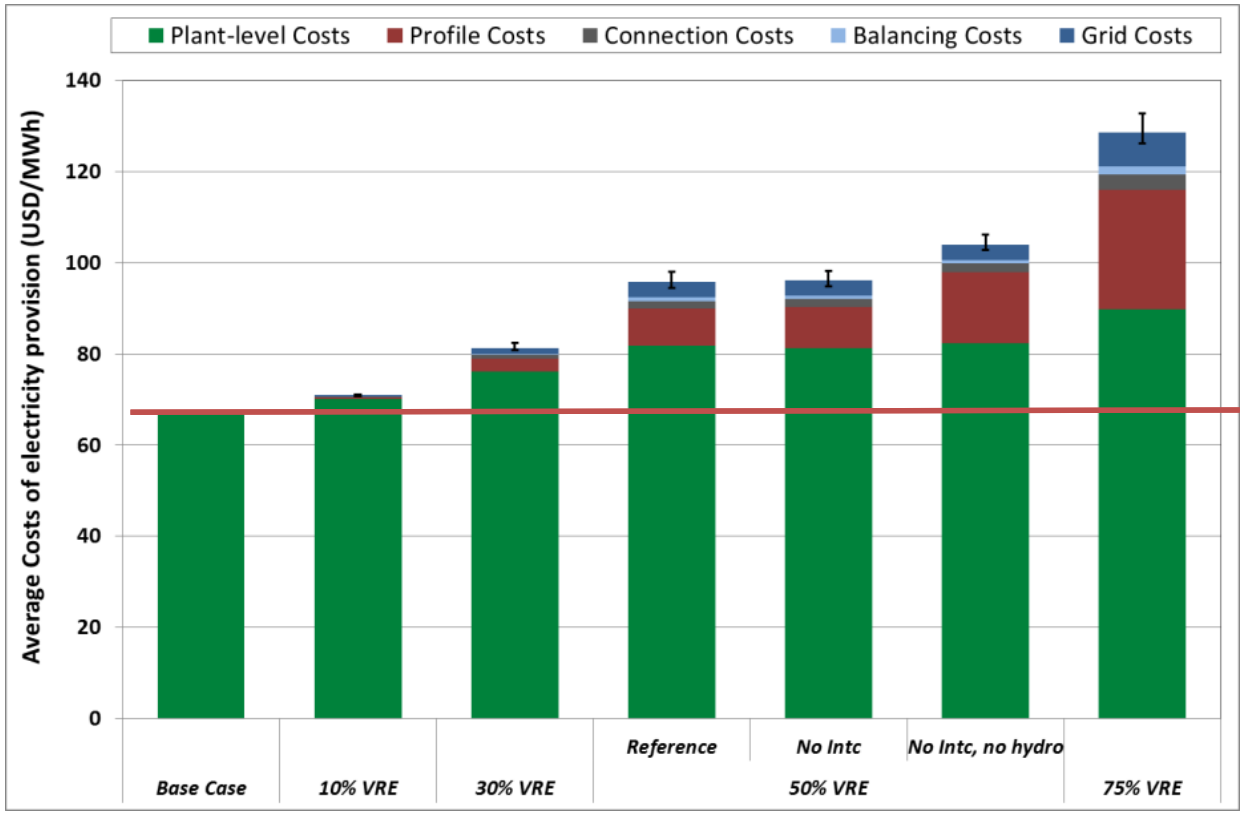
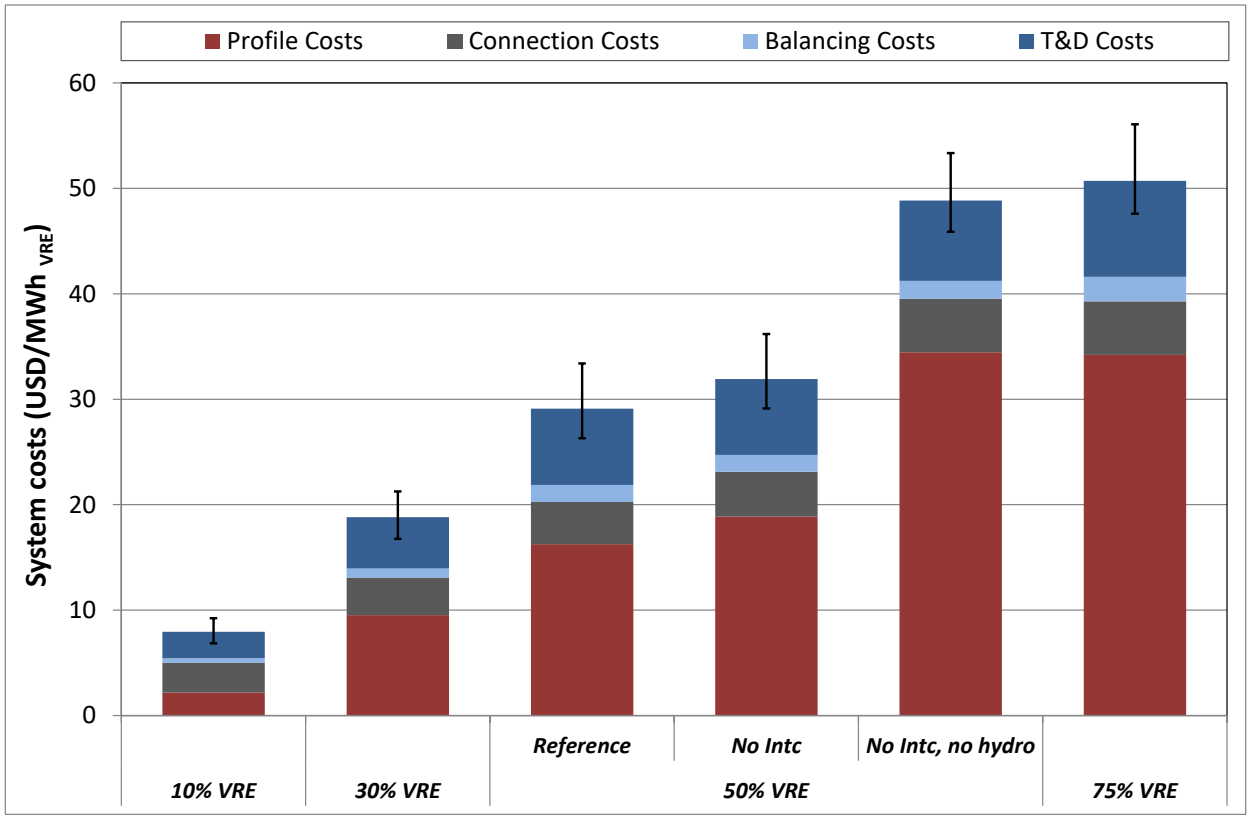
Nuclear energy contributes to the least cost solutions for the low carbon energy systems of the future

Total System Costs



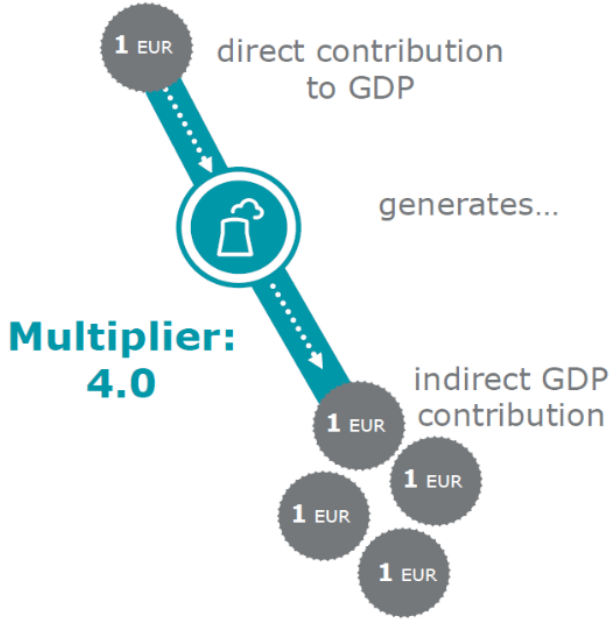
Added Costs per MWh of VRE



Source: OECD/NEA, 2019 https://www.oecd-nea.org/jcms/pl_15000/the-costs-of-decarbonisation-system-costs-with-high-shares-of-nuclear-and-renewables

Investment in nuclear generates high value jobs, drives economic development and develops cleaner energy systems

Nuclear projects provide many socio-economic benefits throughout the wider economy



Impact of the Nuclear sector on the EU economy in 2019.
Source: Foratom, Impact Report -Vision to 2050

Nuclear sector pay is typically the highest for any energy technology

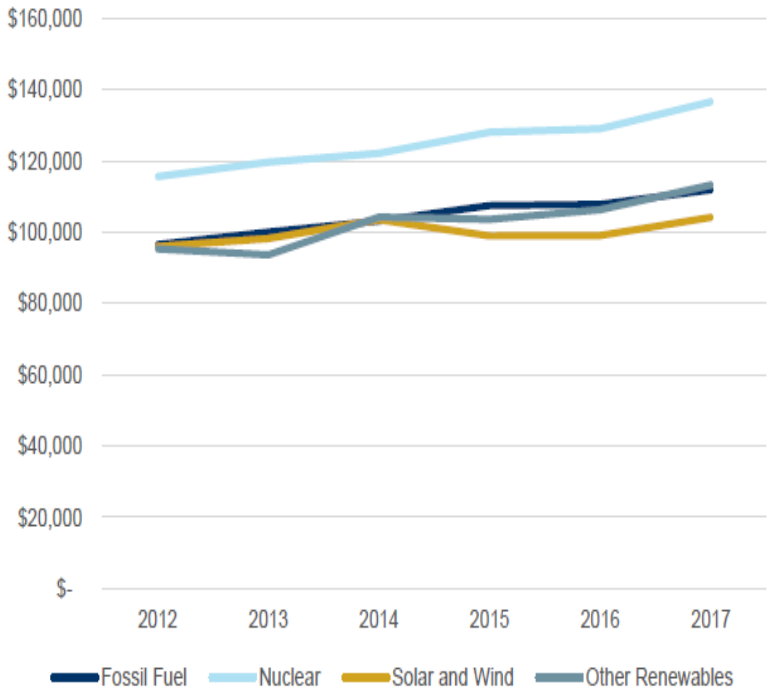


Figure. Average US energy worker pay trends.
Source: Oxford Economics, 2019, Nuclear Power Pays

Thousands of nuclear jobs from one power project

Source: Building a stronger tomorrow https://world-nuclear.org/our-association/publications/policy-papers/building-a-stronger-tomorrow.aspx

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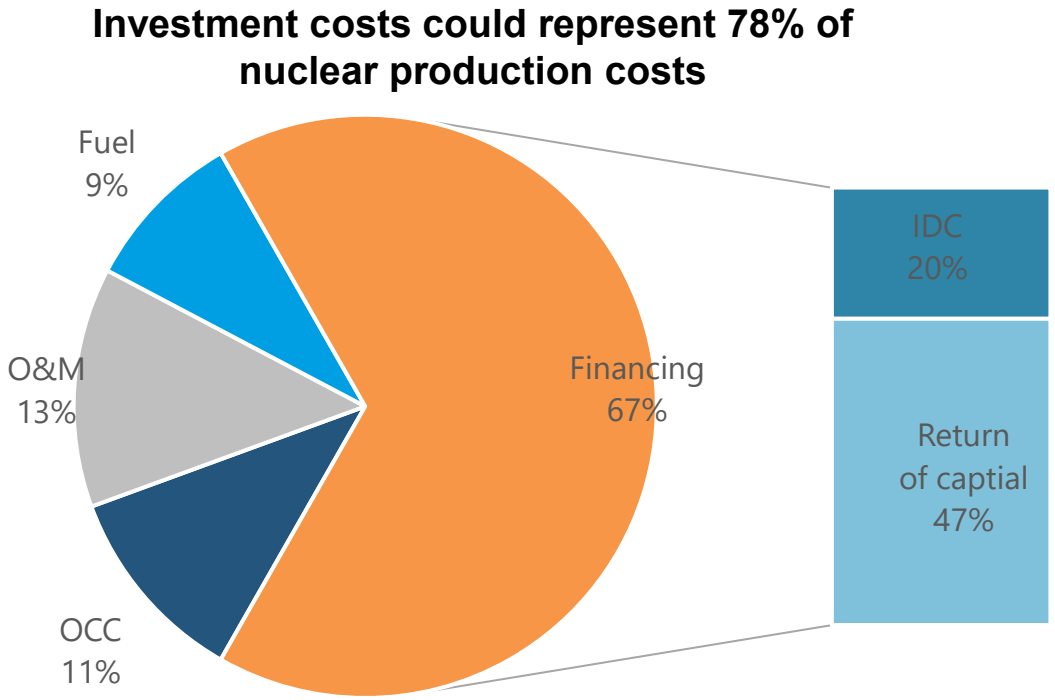
Government support needed to instil confidence and incentivise long term planning and investment



Source: NEA, 2020 https://www.oecd-nea.org/jcms/pl_30653
Note: Calculations based on OCC of USD 4 500 per kilowatt of electrical capacity (/kW_e), a load factor of 85%, 60-year lifetime and 7-year construction time at a real discount rate of 9%.

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 impacts risk premium	Specific conditions can be specified for the allocation of certain risks (e.g. cost sharing and cap with hybrid RAB model)

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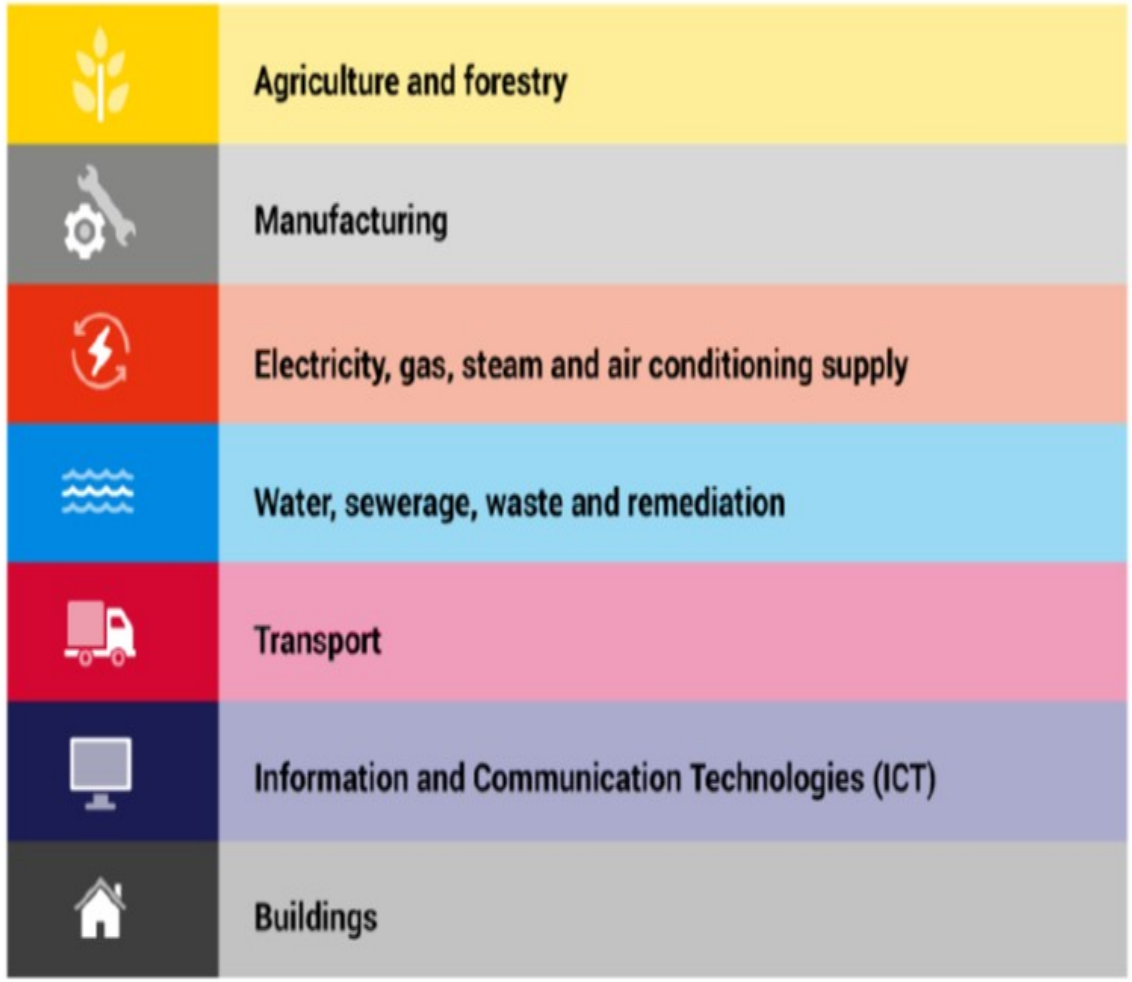
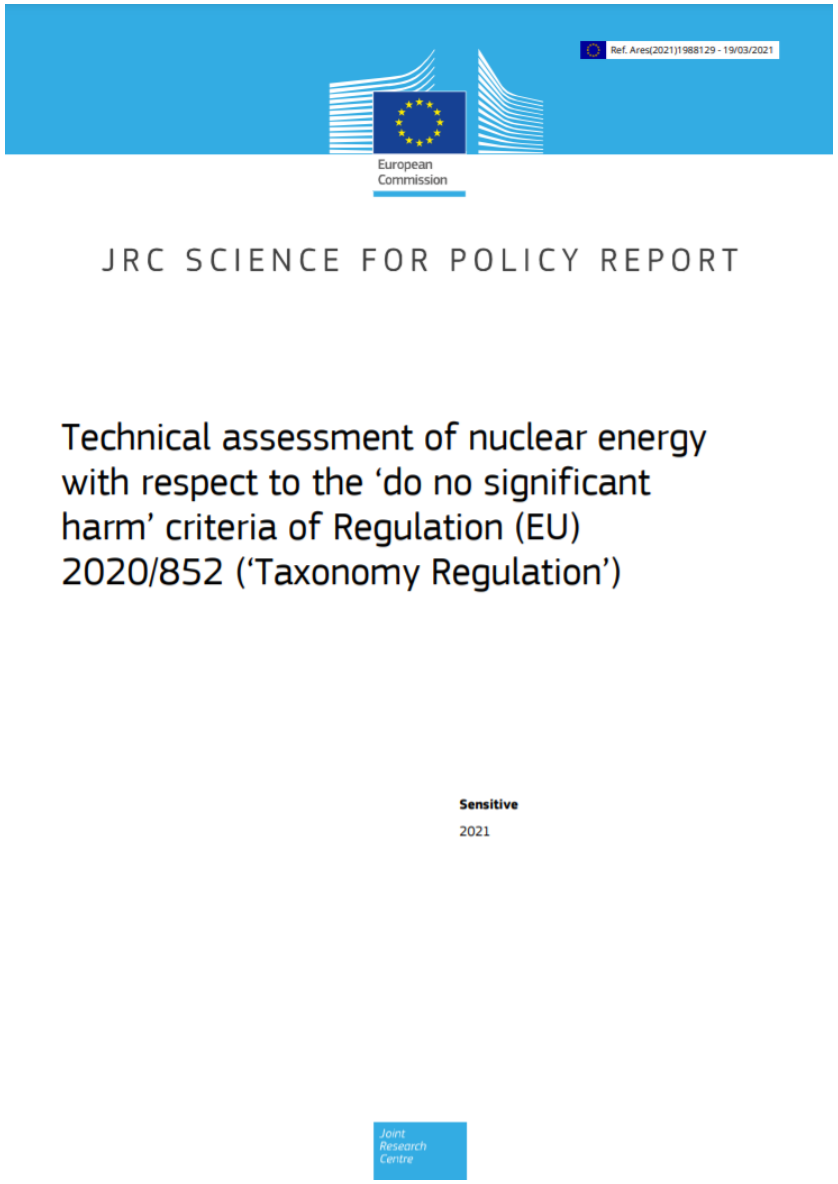
Environmental, Social and Governance (ESG) Criteria for Financing are used to guide investment decisions

- ESG Criteria, or sustainable financing criteria, are used by investors to assess the environmental and societal impact of an investment in a company.
  - Environment criteria consider the company's energy and resource use, pollution and waste generation.
  - Social criteria evaluate a company's treatment of its employees, it's supply chain partnerships and its relationship with its local communities as well as society writ large.
  - Governance criteria assess the transparency and ethical soundness of a company's operations, governance and accounting practices.

- There is no single set of globally accepted ESG criteria.
- ESG criteria are rarely based on in-depth socio-economic impact analyses or comprehensive life-cycle environmental impact assessments.
- ESG criteria are often not technologically neutral and, in many cases, explicitly exclude some sectors, such as nuclear energy

EU Taxonomy: A potential model for other ESG financing systems



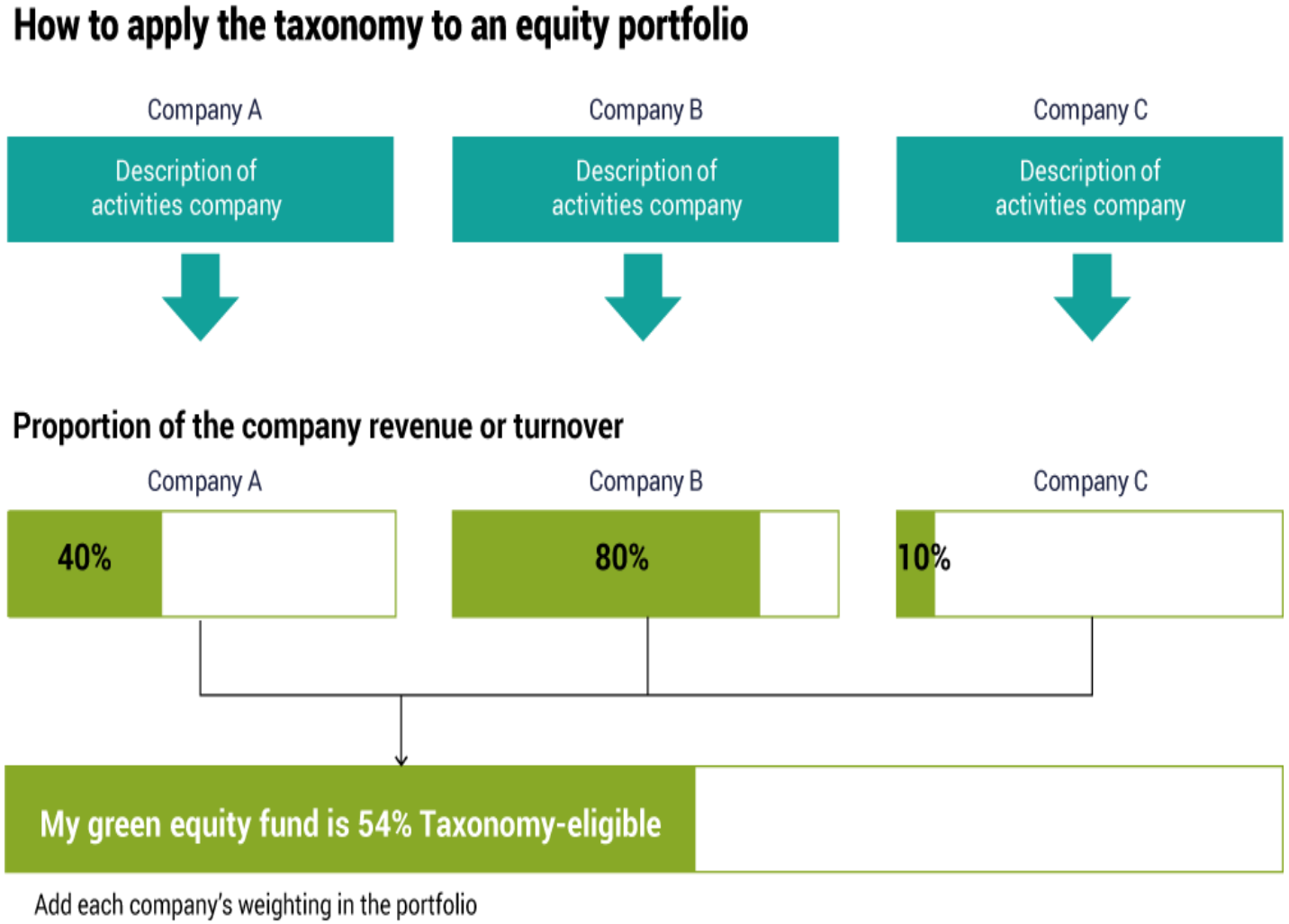


Source: JRC, 2021 https://ec.europa.eu/info/sites/default/files/business_economy_euro/banking_and_finance/documents/210329-jrc-report-nuclear-energy-assessment_en.pdf

The Taxonomy in practice: Equities

For each relevant product, investors would disclose:

- if and how the Taxonomy has been used to determine the sustainability of an investment; and
- the proportion of investments funding Taxonomy-eligible activities.



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Excluding nuclear from the EU Taxonomy could have grave consequences for the Global Nuclear Industry

1. The nuclear industry would lose access to sustainable finance products and instruments in the EU

1.1. All financial products marketed in the EU claiming to be “EU sustainable” would not be able to bundle nuclear companies.

1.2. Nuclear projects (new build and long-term operations) would be excluded from EU funds, development financing or loans at preferential rates.

2. All economic activities that use nuclear energy may be penalized by bearing a non-EU Taxonomy compliant part in their products

3. International sustainable finance standards and norms under preparation would most likely follow EU Taxonomy definitions

4. Nuclear energy would be formally labelled as a non-sustainable energy source

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There are quite a few efforts to develop ESG taxonomies

NGFS
Central Banks and Supervisors Network for Greening the Financial System

https://ec.europa.eu/info/business-economy-euro/banking-and-finance/sustainable-finance/international-platform-sustainable-finance_en

https://www.ngfs.net/sites/default/files/medias/documents/ngfs_climate_scenarios_phase2_june2021.pdf

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The Harmony programme is a global initiative of the nuclear industry coordinated by World Nuclear Association.

Sama.BilbaoyLeon@world-nuclear.org

WEBINAR

HIGH-LEVEL ECONOMIC PANEL

Harnessing the renewed global support for nuclear to help achieve net zero

Chair:
Tim Yeo
Chairman
New Nuclear Watch Institute

Host:
Michael Freeman
Senior Lawyer, Nuclear Team
Pinsent Masons

17 June 2021

Speakers:

Yves Desbazeille
Director General
FORATOM

Diane Cameron
Head of Division, Nuclear Technology Development and Economics
OECD NEA

Dr Bertrand Magné
Energy Economist, Energy, Economic and Environmental (3E) Analysis Unit
International Atomic Energy Agency

Sama Bilbao y León
Director General
World Nuclear Association