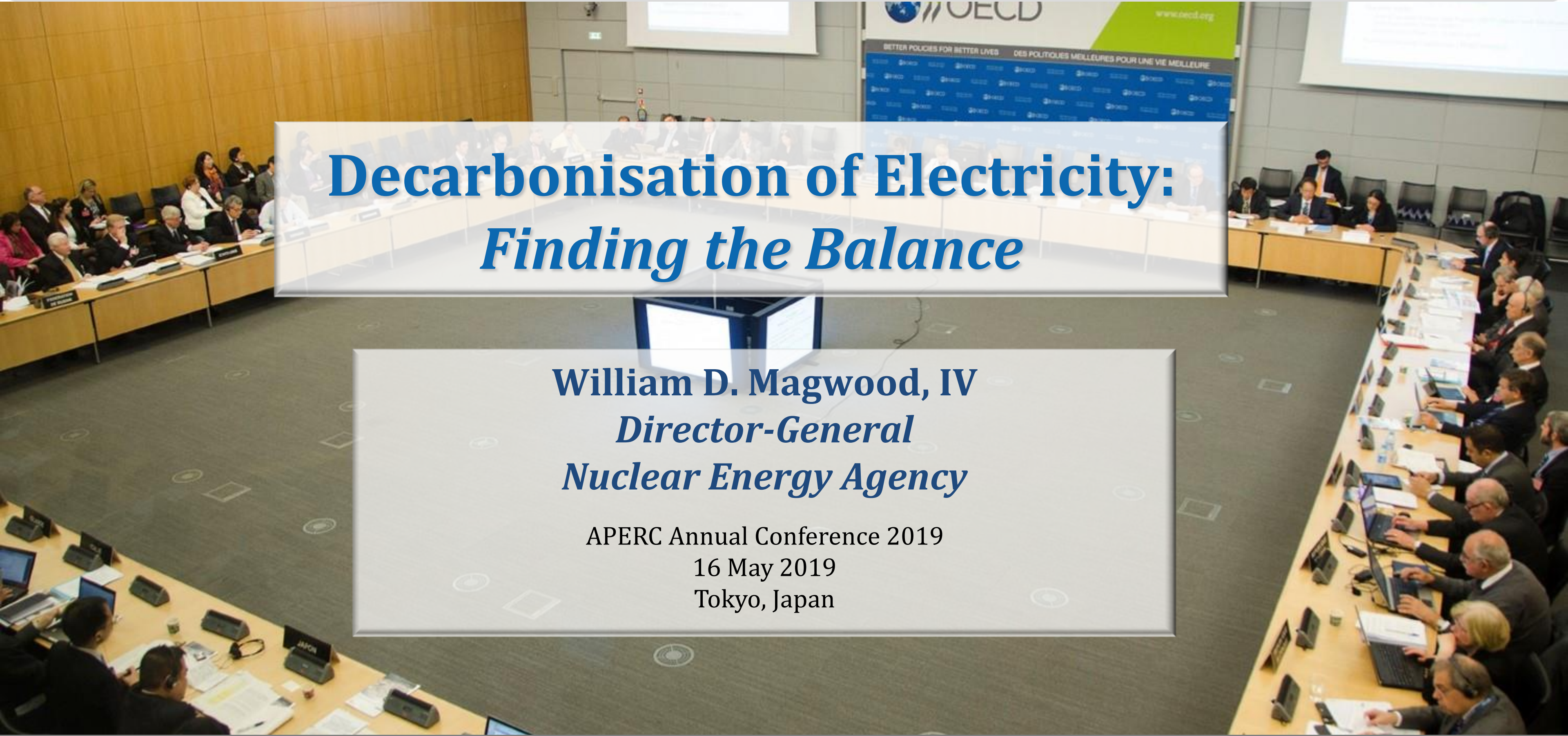

Decarbonisation of Electricity:
Finding the Balance

William D. Magwood, IV
Director-General
Nuclear Energy Agency

APERC Annual Conference 2019
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Tokyo, Japan

The NEA: 33 Countries Seeking Excellence in Nuclear Safety, Technology, and Policy

- 33 member countries + strategic partners (e.g., China, India, etc.)
- 8 standing committees and 80 working parties and expert groups
- The NEA Data Bank - providing nuclear data, code, and verification services
- 23 international joint projects

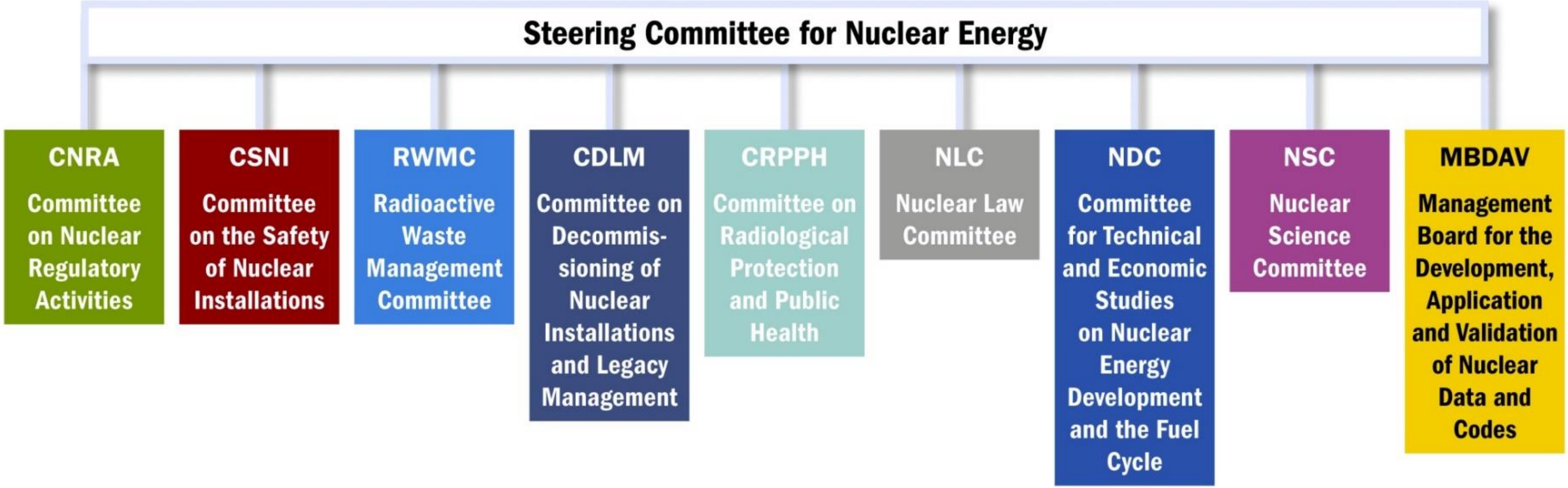
The NEA Serves as a Framework to Address Global Challenges

The Role of the NEA is to:

- Foster international co-operation to develop the scientific, technological and legal bases required for a safe, environmentally friendly and economical use of nuclear energy for peaceful purposes.
- Develop authoritative assessments and forge common understandings on key issues as input to government decisions on nuclear technology policy.
- Conduct multinational research into challenging scientific and technological issues.

33 NEA countries operate more than 80% of the world's installed nuclear capacity

NEA Standing Technical Committees



The NEA's committees bring together top governmental officials and technical specialists from NEA member countries and strategic partners to solve difficult problems, establish best practices and to promote international collaboration.

NEA Work on Nuclear Technology Development and Economics

Committee for Technical and Economic Studies on Nuclear Energy Development and the Fuel Cycle (NDC)

- Working Party on Nuclear Energy Economics (WPNE)
- High-level Group on the Security of Supply of Medical Radioisotopes (HLG-MR)
- Joint NEA/IAEA Group on Uranium (UG)
- Ad Hoc Expert Group on the Estimation of Potential Losses Due to Nuclear Accidents, Liability Issues and Their Impact on Electricity Costs
- Ad Hoc Expert Group on Climate Change: Assessment of the Vulnerability of Nuclear Power Plants and Cost of Adaptation (NUCA)
- Ad Hoc Expert Group on the Role and Economics of Nuclear Co-generation in a Low-carbon Energy Future (COGEN)
- Expert Group on the Economics of Extended Storage of Spent Nuclear Fuel (EGEES)
- Expert Group on Back-end Strategies (BEST)
- Expert Group on Advanced Reactor Systems and Future Energy Market Needs (ARFEM)
- Expert Group on Uranium Mining and Economic Development (UMED)
- Ad Hoc Expert Group on Maintaining Low-Carbon Generation Capacity through LTO of Nuclear Power Plants: Economic, Technical and Policy Aspects (EGLTO)
- Ad Hoc Expert Group on Reducing the Costs of Nuclear Power Generation (REDCOST)

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The Work of NDC:
Cross-cutting and strategic issues in the intersection between **Technology, Innovation, Economics and Policy:**

- Nuclear techno-economics and finance in the context of overall energy markets
- Security of supply, energy and environmental policy, climate change and sustainability
- Fuel cycle issues – from uranium resources to used fuel
- Developments in technology, human resources and supply chain relative to existing plants, new build and LTO
- Medical radioisotopes

Major NEA Separately Funded Activities

NEA Serviced Bodies

- **Generation IV International Forum (GIF)** with the goal to improve sustainability (including effective fuel utilisation and minimisation of waste), economics, safety and reliability, proliferation resistance and physical protection.
- **Multinational Design Evaluation Programme (MDEP) -** initiative by national safety authorities to leverage their resources and knowledge for new reactor design reviews.
- **International Framework for Nuclear Energy Cooperation (IFNEC) -** forum for international discussion on wide array of nuclear topics involving both developed and emerging economies.

23 Major Joint Projects

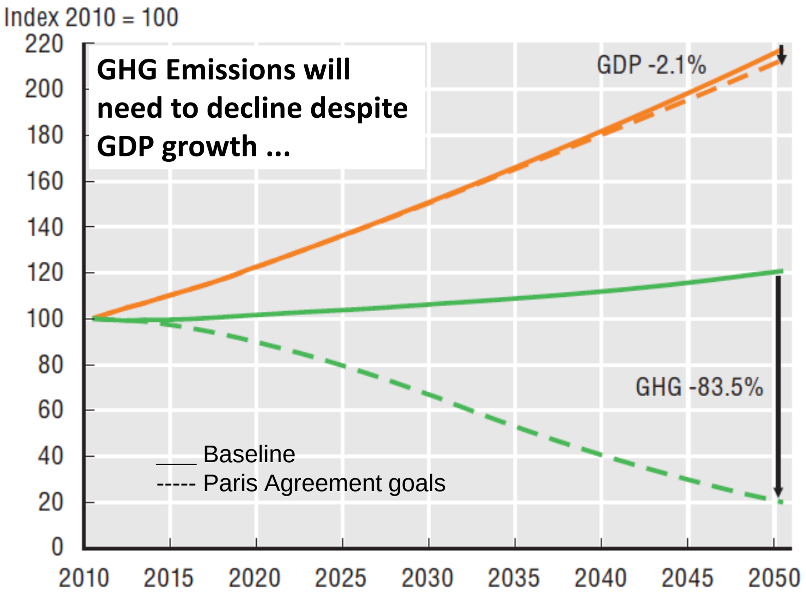
(Involving countries from within and beyond NEA membership)

- **Nuclear safety research** and experimental data (e.g., thermal-hydraulics, fuel behaviour, severe accidents).
- **Nuclear safety databases** (e.g., fire, common-cause failures).
- **Nuclear science** (e.g., thermodynamics of advanced fuels).
- **Radioactive waste management** (e.g., thermochemical database).
- **Radiological protection** (e.g., occupational exposure).
- **Halden Reactor Project** (fuels and materials, human factors research, etc.)

COP 21 and Energy Production

- UN-sponsored meeting concluded with 195 countries agreeing to develop approaches to limit global warming to below 2°C.
- Energy represents 60% of global CO_2 emissions - ¾ of global electric power production today is based on fossil fuels.
- Many countries – including China and India indicate that nuclear will play a large role.

Paris Agreement Implies a 50 gCO2/kWh Target

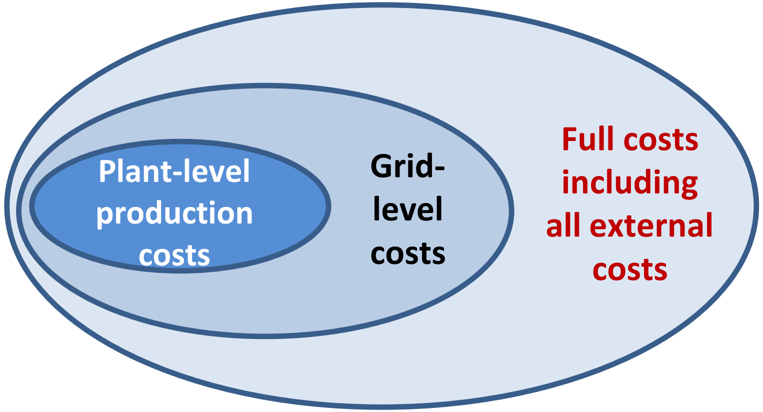


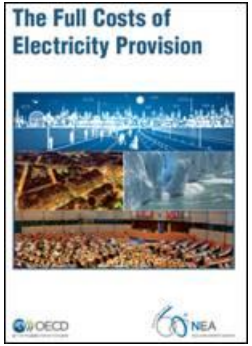
Source: OECD Environmental Outlook

- Paris Agreement is intended to hold "increase in global average temperature to well below 2°C".
- Current emission intensity is **570 gCO2/kWh** - target is **50 gCO2/kWh**
- Electricity contributes 40% of global CO2 emissions and will play key role. Annual emissions from electricity will need to decline 73% (global) and 85% (OECD countries).

All Costs Should be Reflected in Decisions

- **Market prices and production costs account for an important share of the overall impacts of electricity.**
- **However, the market value of electricity is not the whole story:**
  - "Grid-level" Costs
  - Atmospheric pollution, climate change risks and land-use
  - Impacts on security of supply and societal costs
- **The price of electricity in today's markets does not accurately reflect the FULL COSTS of electricity, which include the impacts on society and the environment.**

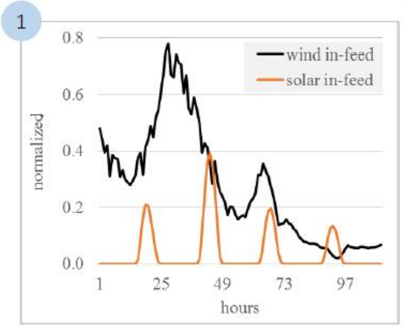




http://www.oecd-nea.org/ndd/pubs/2018/7298-full-costs-2018.pdf

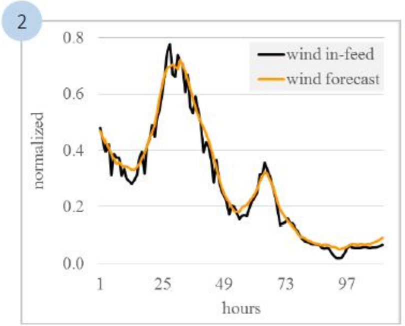
Assessing the True Costs of Electricity

- **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



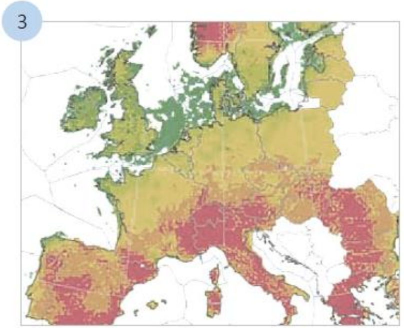
VREs are not always available

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

Source: L. Hirth

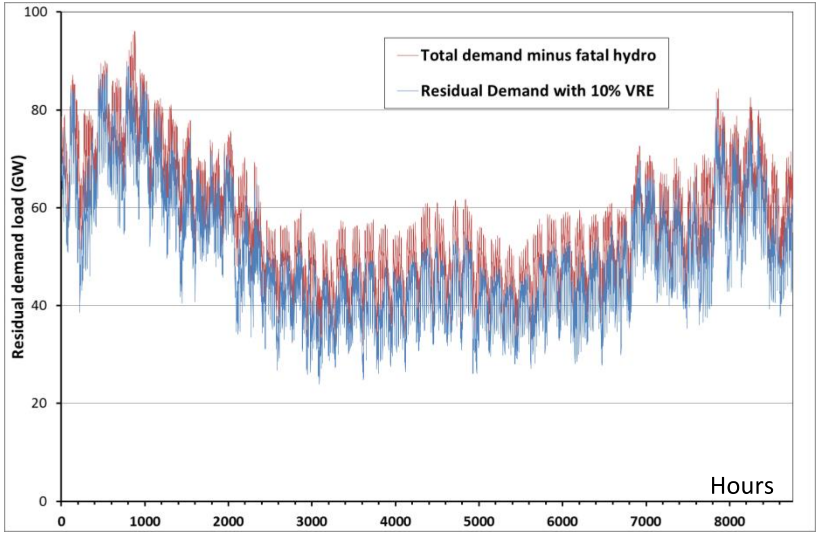
System costs depend on:

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

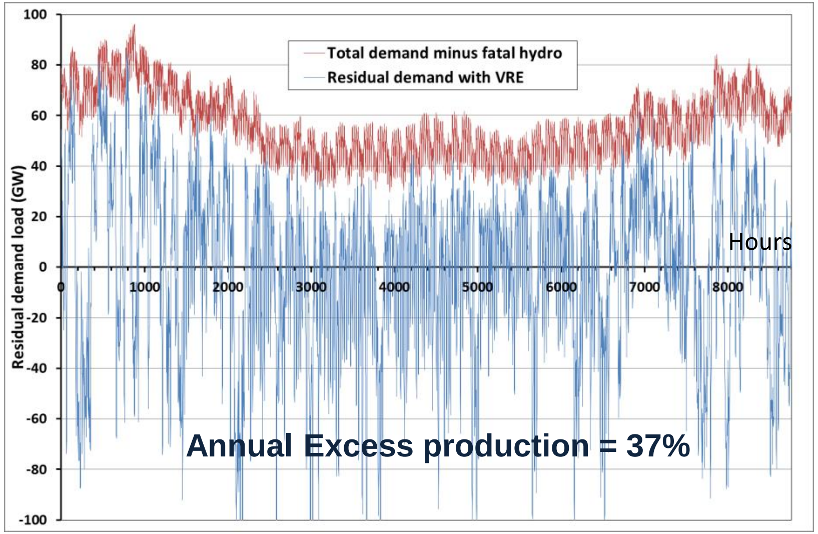
Additional impacts on load factors of dispatchable generators and prices.

Conclusion: High VRE Result in Large Inefficiencies

10% Variable Renewables



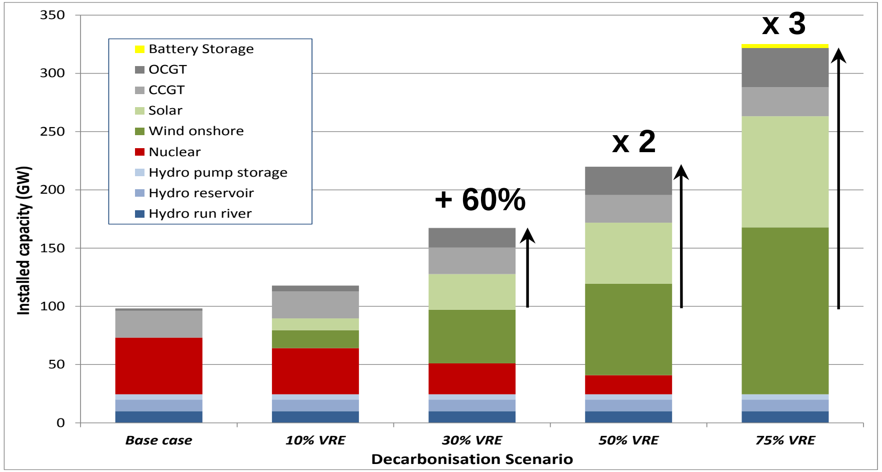
75% Variable Renewables



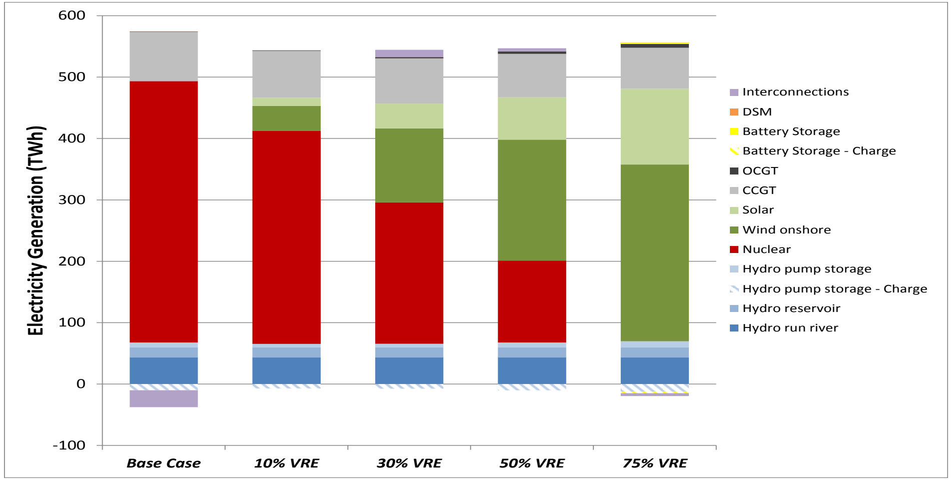
- High VRE penetration result in challenges for system management.
- Residual demand (**BLUE** line) – the available market for dispatchable generation becomes volatile and unpredictable.

Conclusion: VREs Require Large Excess Capacity to Meet Demand

Installed Capacity



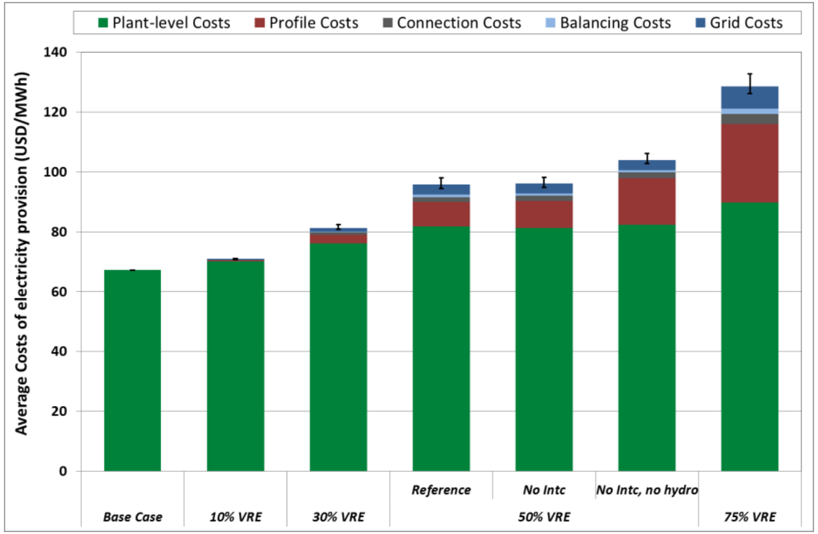
Electricity Generation



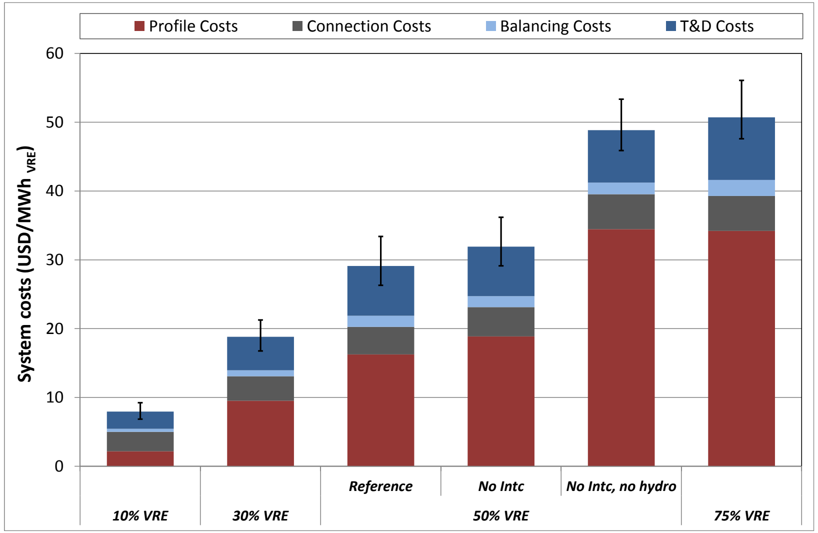
- Rising VRE share results in significantly larger capacity needs.
- Due to carbon constraint, coal no longer included, but gas provides flexibility. Battery storage deployed only at high VRE penetration levels.

Conclusion: As VRE Share Increases System Costs Grow Quickly

Total Costs



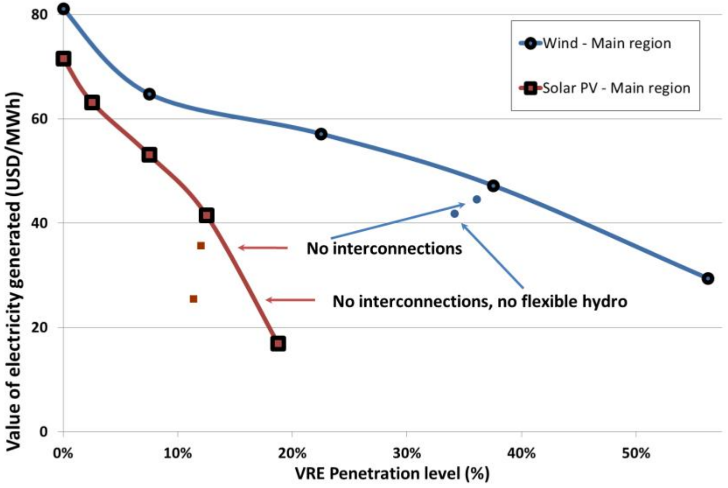
Breakdown of System Costs



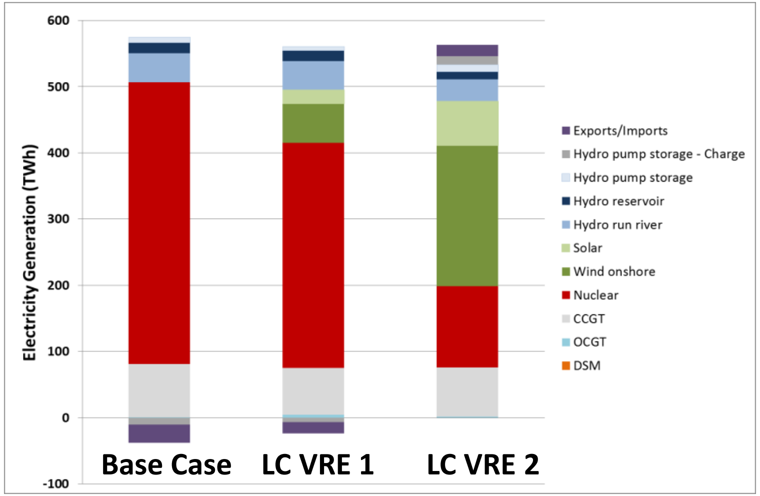
- System costs are large and increase with VRE generation share - Profile costs are the dominant component.

Conclusion: Market Value of VREs Decreases with Increasing Share

Declining Market Value of VRE

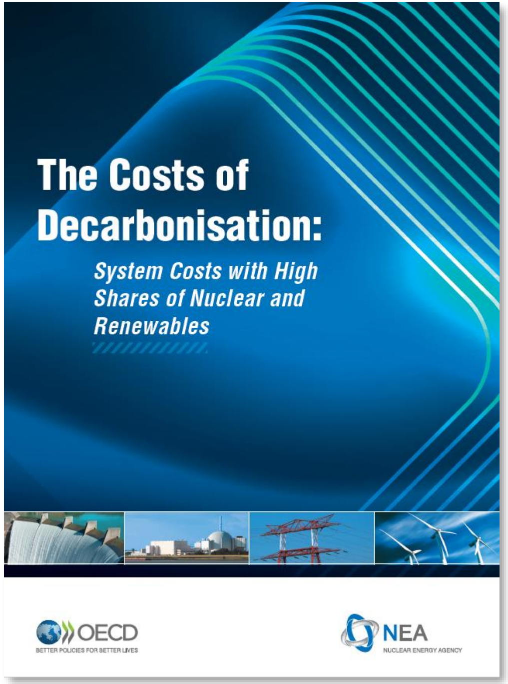


Even Low Cost VRE Limited Market Entry



- VREs earn less than average market prices due to auto-correlation during production hours.
- Future expected cost declines of VRE may offset systems costs. The level of market penetration will depend strongly on local conditions.

Policy Recommendations for Cost-efficient Decarbonisation



Decarbonising the electricity sector in a cost-effective manner while maintaining security of supply requires:

- Recognising and allocating system costs to the technologies that cause them
- Encouraging new investment in all low-carbon technologies by providing stability for investors
- Enabling adequate capacity, transmission and distribution, and flexibility
- Implementation of carbon pricing – the most efficient approach for decarbonising electricity

Concluding Thoughts

- 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 impractical.
- 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 cost competitive.
- Nuclear technology must evolve to be compatible with the energy framework of the future—with lower costs and higher flexibility.

Thank you for your attention

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