System integration costs - discussion

Task 25: Design and Operation of Energy Systems with Large Amounts of Variable generation

Hannele Holttinen, Operating Agent Task25

Partner, Recognis

DTU seminar June 24, 2019

Contents

- Integration costs:
  - relevance;
  - discussion challenges of isolating and categorising costs
- Approaches for assessing system integration costs
- Recommendations

IEA Wind Task 25

- Design and operation of energy systems with large amounts of variable generation
- Started in 2006, now 17 countries + WindEurope participate, international forum for exchange of knowledge

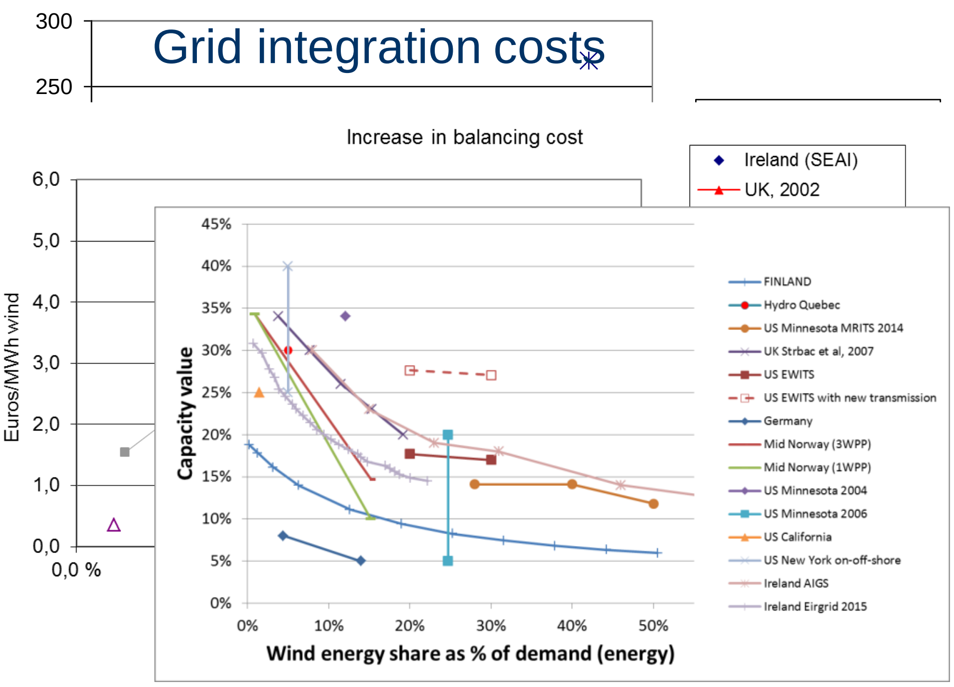
Country	Institution
Canada	NRCan (Thomas Levy); Hydro Quebec (Alain Forcione)
China	SGERI (Wang Yaohua, Liu Jun)
Denmark	DTU (Nicolaos Cutululis); Energinet.dk (Antje Orths)
Finland (OA)	VTT (Hannele Holttinen, Juha Kiviluoma)
France	EdF R&D (E. Neau); TSO RTE (J-Y Bourmaud); Mines (G. Kariniotakis)
Germany	Fraunhofer IEE (J. Dobschinski); FfE (S. von Roon); TSO Amprion (P. Tran)
Ireland	UCD (D. Flynn); SEAI (J. McCann)
Italy	TSO Terna Rete Italia (Enrico Maria Carlini)
Japan	Tokyo Uni (J. Kondoh); Kyoto Uni (Y. Yasuda); CRIEPI (R. Tanabe)
Mexico	INEEL (Rafael Castellanos Bustamante, Miguel Ramirez Gonzalez)
Netherlands	TUDelft (Simon Watson)
Norway	NTNU (Magnus Korpås); SINTEF (John Olav Tande, Til Kristian Vrana)
Portugal	LNEG (Ana Estanquiero); INESC-TEC (Bernando Silva)
Spain	University of Castilla La Mancha (Emilio Gomez Lazaro)
Sweden	KTH (Lennart Söder)
UK	Imperial College (Goran Strbac); Strathclyde Uni (Olimpo Anaya-Lara)
USA	NREL (B-M. Hodge, M. O'Malley); ESIG (J.C. Smith); DoE (J. Fu)
WindEurope	European Wind Energy Association (Daniel Fraile)

IEA Wind Task 25 – What Does It Do?

- State-of-the-art: review and analyze the results so far latest report 2019
- Formulate guidelines- Recommended Practices for Integration Studies Update 2018 with solar PV
- Fact sheets and wind power production time series
- Literature list
- https://community.ieawind.org/task25/

Recommending methods for integration costs – work of IEA WIND Task 25

- Comparing studies for Balancing costs, Grid infra costs, and Capacity value of wind;
  - Depend on share of VRE and flexibility available
- Recommended practices on methods: **Outcome was that we cannot find a correct way to draw estimates of integration costs**



Relevance of the question – with declining cost of energy of wind and PV

Wind and PV becoming mainstream

Confidence of system operators, focus more on total system integration of more renewables

Interest in balancing costs decline in the US and EU

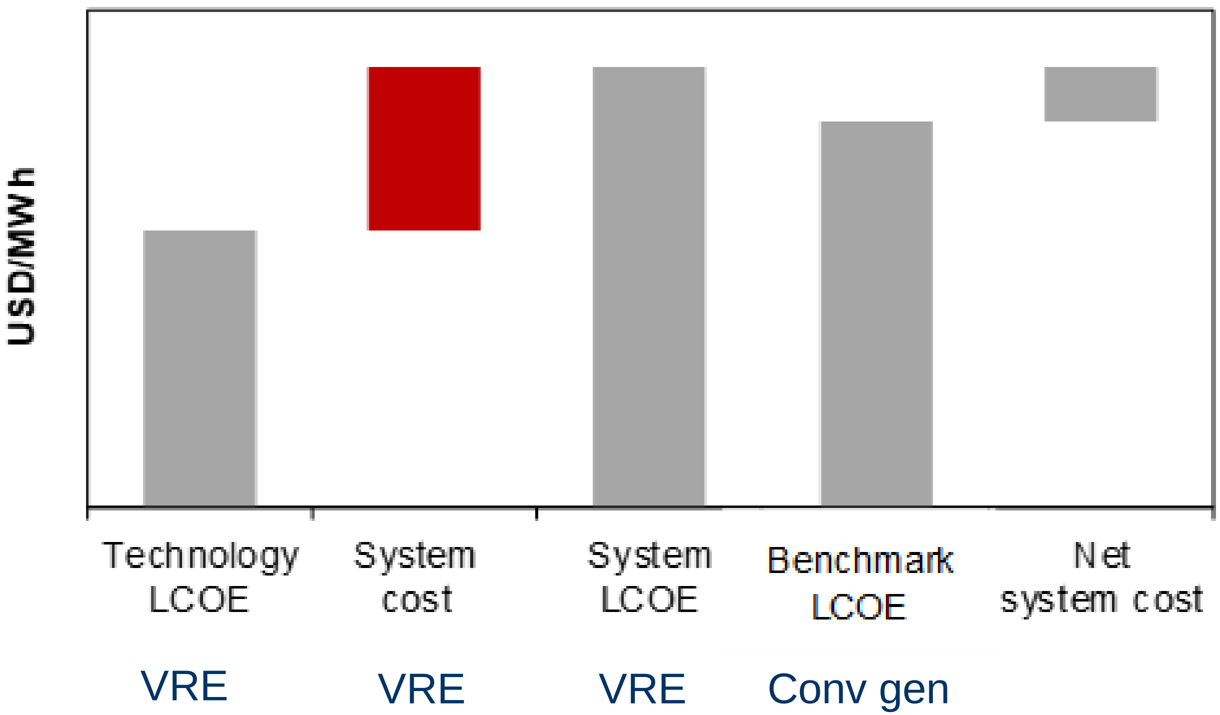
More interest to invest in new countries

Comparison to other investment options relevant

A new interest in integration costs in some countries

Shift of interest from original integration costs as a tariff charged, for more complex system operation towards more integrated assessments

A nice to have: LCOE + system integration cost to compare VG with others



System cost defined relative to scenario with less VRE and using benchmark technology.
Valid for specific system and VRE share only.

(Benchmark technology can also include system cost)

LCOE levelised cost of energy

Challenge 1: isolating system costs

- How much cheaper would it be for the power system to use VRE, if VRE was *non-variable*?
- To answer, need to strip away the impact of variability from *all other* impacts VRE bring to the power system
  - generating electricity at very low short-run marginal cost and displacing other generation
  - **So far no suitable benchmark used**
  - Recent thinking: a 100%-load-correlated generator that satisfies the condition: total cost in residual system drop 1:1 with the increase of the generator

Challenge 1: extracting and allocating the cost

- **Extracting the cost** from system cost: Impacts of VRE are a result of an interaction – system specific and time specific
    - Flexibility and operational practices matter
- **Allocation** is difficult: any flexibility build out to manage variability will have benefits for all

Related challenge: system boundary

- Neighbouring areas: Result from previous comparisons: assumptions of the interconnector use to neighboring systems has a large impact on results
- System boundary in future: decarbonizing challenge leading to electrification: energy sector coupling, flexibility from heat and transport and industry sectors

Challenge 2: categorising effects

→ Grid cost, balancing cost and long term capacity cost (profile cost)

- **Grid costs** can be separated
- Allocation problem:
  - How to allocate a cost of an asset that is used by all users, and increases reliability of system, to one single cause to build that asset?
  - Especially when multiple reasons to build.

Challenge 2: categorising effects to balancing

- Balancing: costs for short term variability and uncertainty in balancing and operating reserves
- How to choose the non VRE case

→ generator behaving like load, reducing cost of remaining system 1:1

- Quantifying impact of VRE, as main impact is reduction of use of fuel and operational costs

→run UCED without any extra reserves needed = flexibility part of profile costs

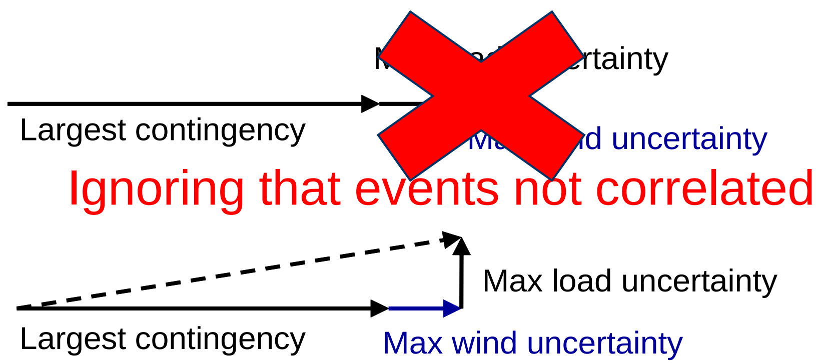
→ Balancing cost as uncertainty = cost of increased reserve allocation and use of them

- Allocating costs to VRE may still be questionable

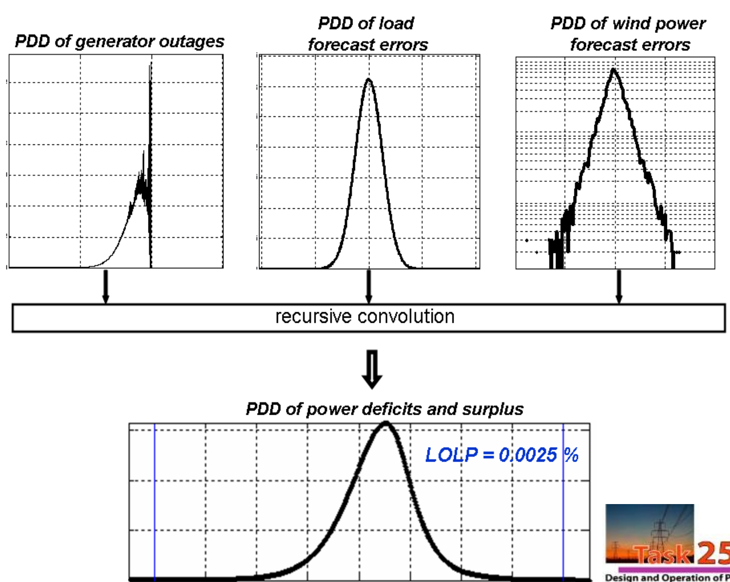
Balancing costs

System copes with variability and uncertainty of loads – and sudden failures of large thermal power plants. Combining variability and uncertainty of all sources is key.

From simple rule of thumb:



To probabilistic analyses:



Experience: sharing balancing will help more than wind adds

- Sharing balancing task with neighbouring system operators in Germany has resulted in reduction of use of frequency control, while wind and solar have increased
- Denmark integration of close to 50% wind share is based on using Nordic hydro power system flexibility

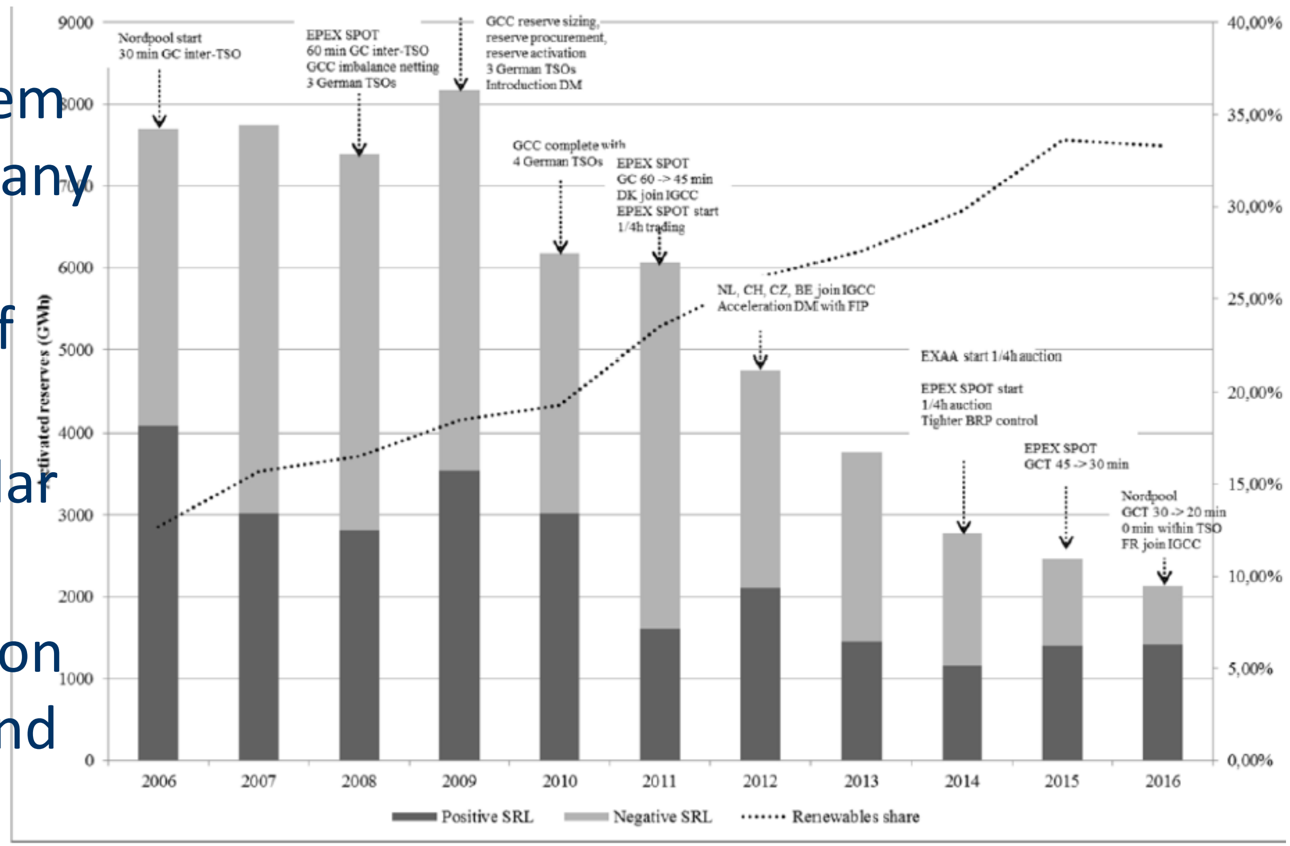


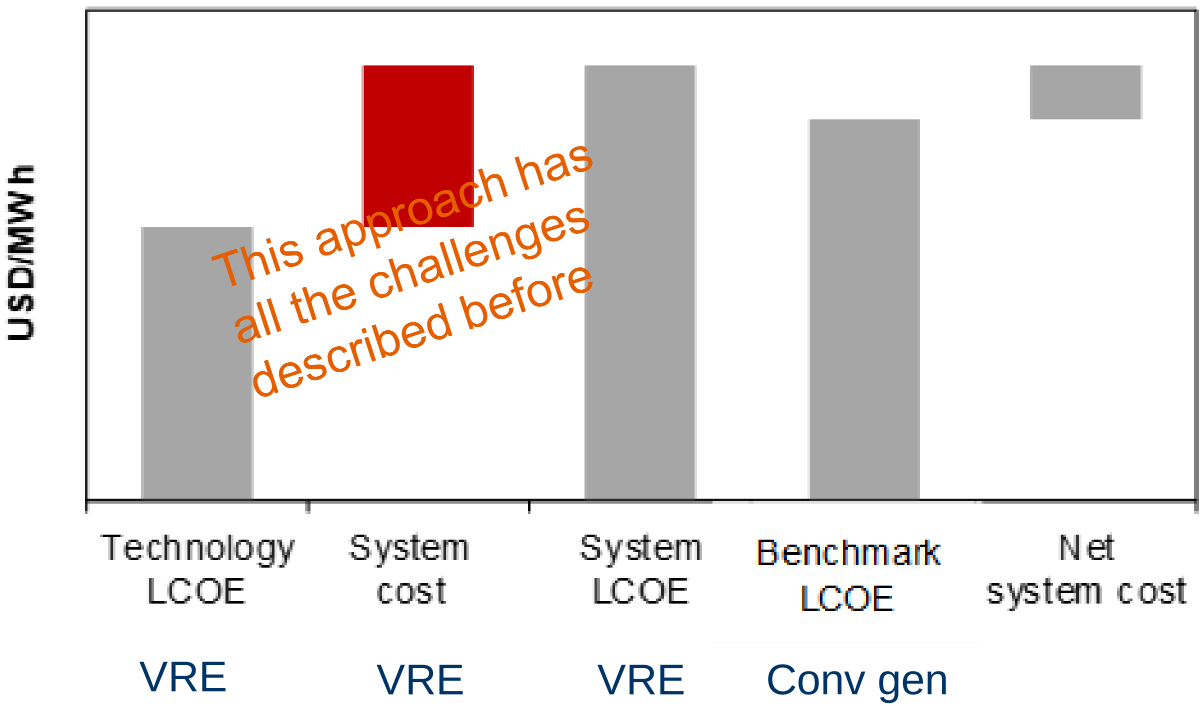
Figure 13: Total activated German Secondary Reserves (or aFRR) per year marked with events considered in this paper.

Rena Kuwahata, Peter Merk, WIW17

Challenge 2: categorising effects to long term capacity

- Simplified assessment, only peak load contribution of VRE – converted to a cost of peakers added to system to cover for lower capacity value of VRE
- Full profile costs: Lower cost to meet demand from non-VRE sources, but higher specific cost /MWh
  - The short term reduction of utilisation rate is a ”private cost” not to be covered by VRE
  - Long run costs for the new generation mix – from a generation mix optimised for VRE: a system cost of VRE in comparison to an alternative way of covering the load
  - Extracting this cost: double counting with balancing impacts

Approaches for integration costs: LCOE + system integration cost comparison

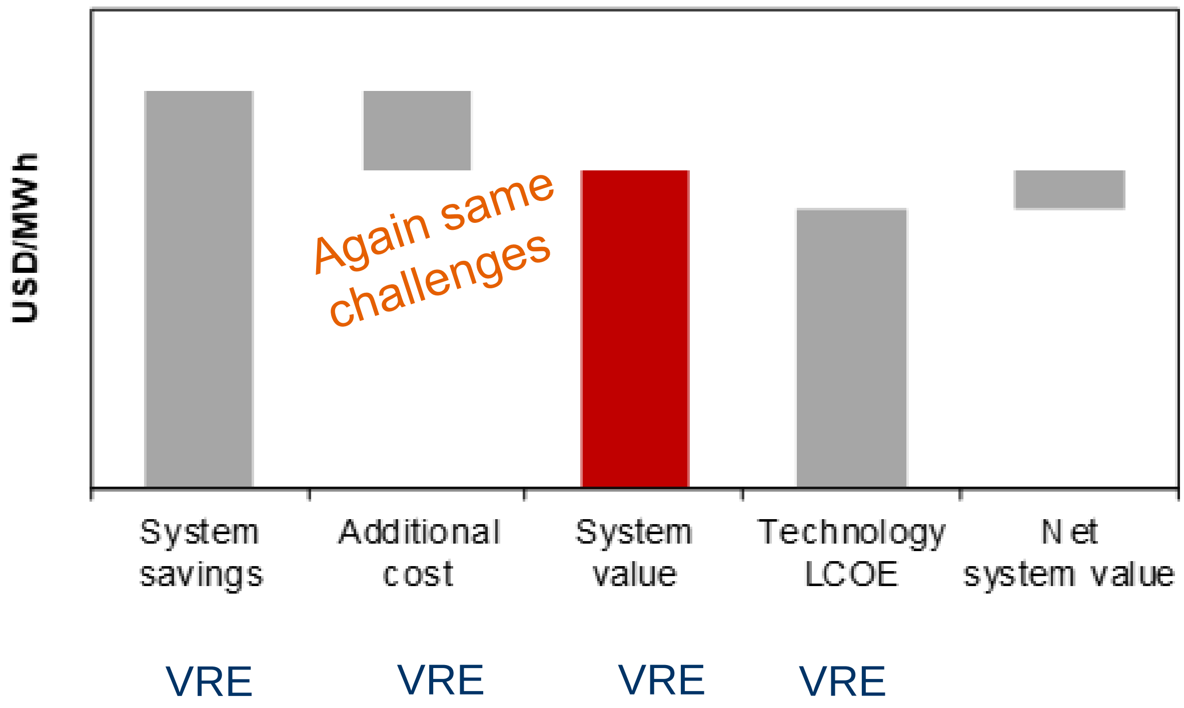


System cost defined relative to scenario with less VRE and benchmark. Valid for specific system and VRE share only.

(Benchmark technology can also include system cost)

LCOE levelised cost of energy

Approaches for integration costs: system value larger than for alternative



System value defined relative to scenario with less VRE (plus environmental). Valid for specific system and VRE share only.

Check if value larger than LCOE of VRE

Approaches for integration costs

- Avoiding the challenges linked to system integration cost calculations by changing the question:

How much cheaper or more expensive will it be for the power system to rely on a certain amount of VRE generation compared to an alternative scenario?

- Calculate total system costs for different scenarios

Assessing costs and benefits between scenarios or comparing the total cost

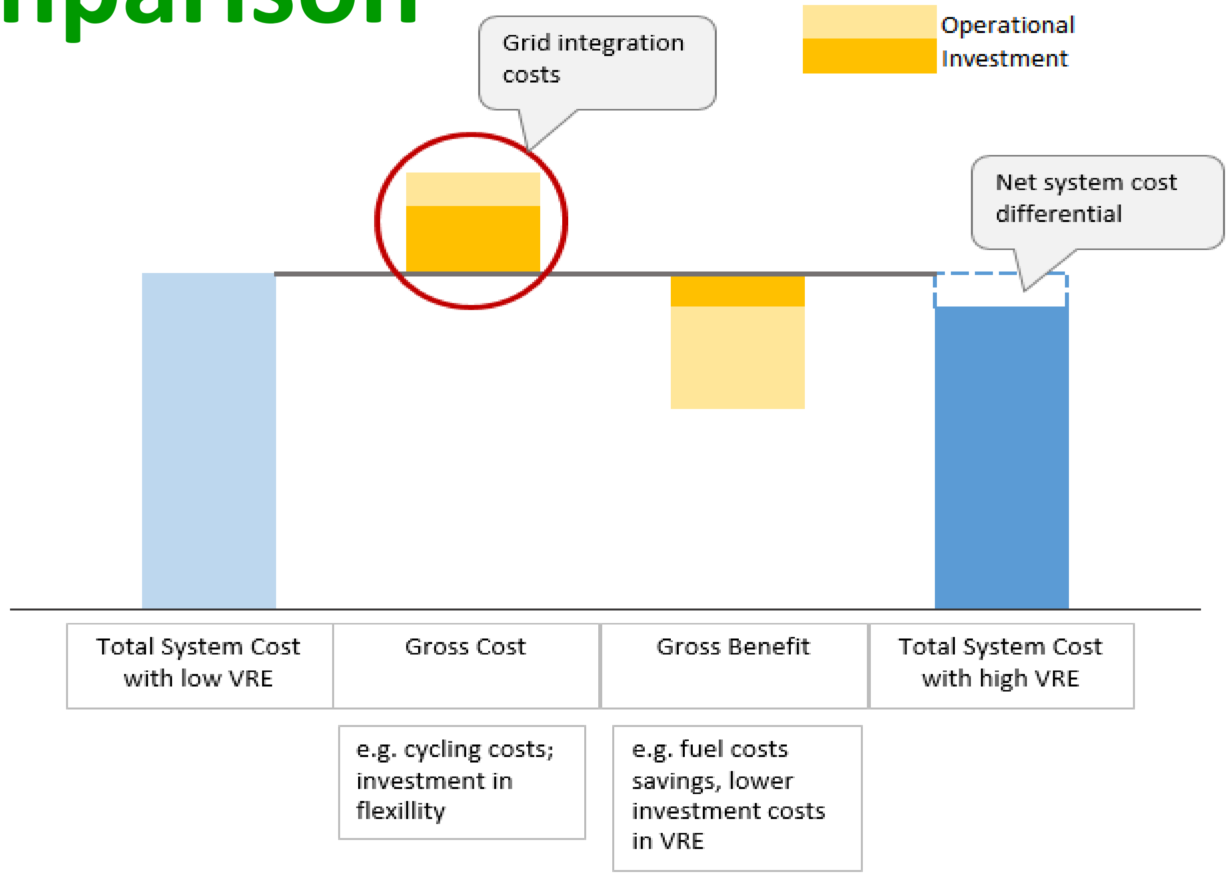
iea

Task 25
Design and Operation of Power Systems with
Large Amounts
of Wind Power

Recommended approach – total system cost comparison

- Compare the all-in system costs of different scenarios
  - avoid the pitfalls of introducing a *non-variable* VRE benchmark technology.
- does not provide a direct quantification of different VRE related effects – although some of them can be extracted from simulation results

Recommended – total system cost comparison



Compare the all-in system costs of different scenarios – CAPEX & OPEX. Results still depend strongly on what is chosen as reference scenarios for the comparison.

Summary – from integration costs to total cost comparisons

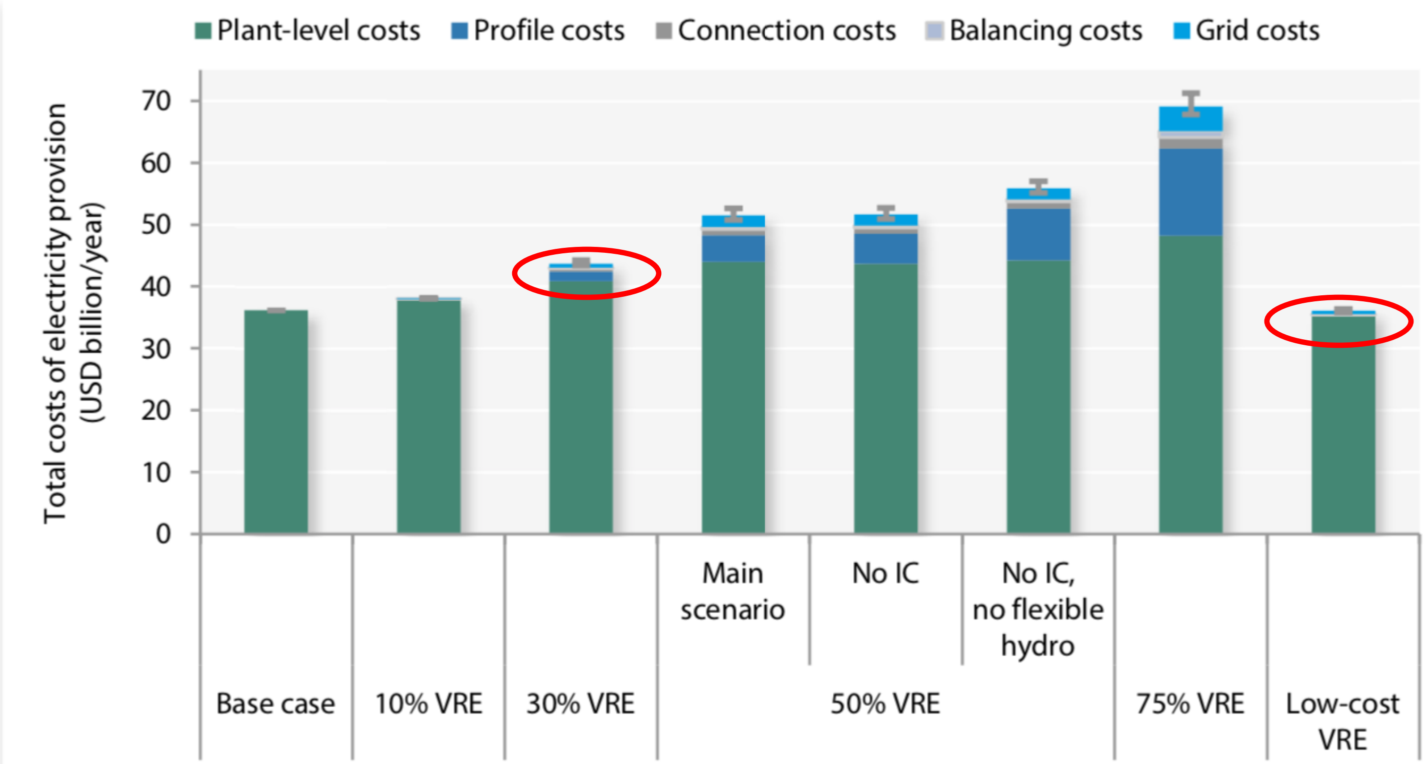
- Capturing “system integration cost” component is a challenge
  - Isolating/extracting integration from other costs, no good benchmark exists
  - Defining system boundaries – energy sector coupling
  - Dividing costs to variability, uncertainty, location
- Recommended to calculate total system costs – including operational and investment costs.
  - comparing different future scenarios for the system

Summary – from cost of integration to cost of inflexibility

- Even for total cost approach, results are system and share of VRE -specific
  - Assumptions about future systems – and system boundaries crucial: Flexibility of generation fleet (including VRE) and demand; storages and operational practices
  - Marginal effects may be interesting in addition to average impacts
- Markets reflect the system costs:
  - system value as market income decrease, the profile cost
  - balancing costs allocated in a cost reflective, transparent imbalance settlement for wind generation.
  - Grid costs in connection fees and tariffs

NEA system costs report 2019

Figure ES7. **Total cost of electricity provision including all system costs**
(USD billion per year)



Why are the system costs for 30 % VRE systems different?

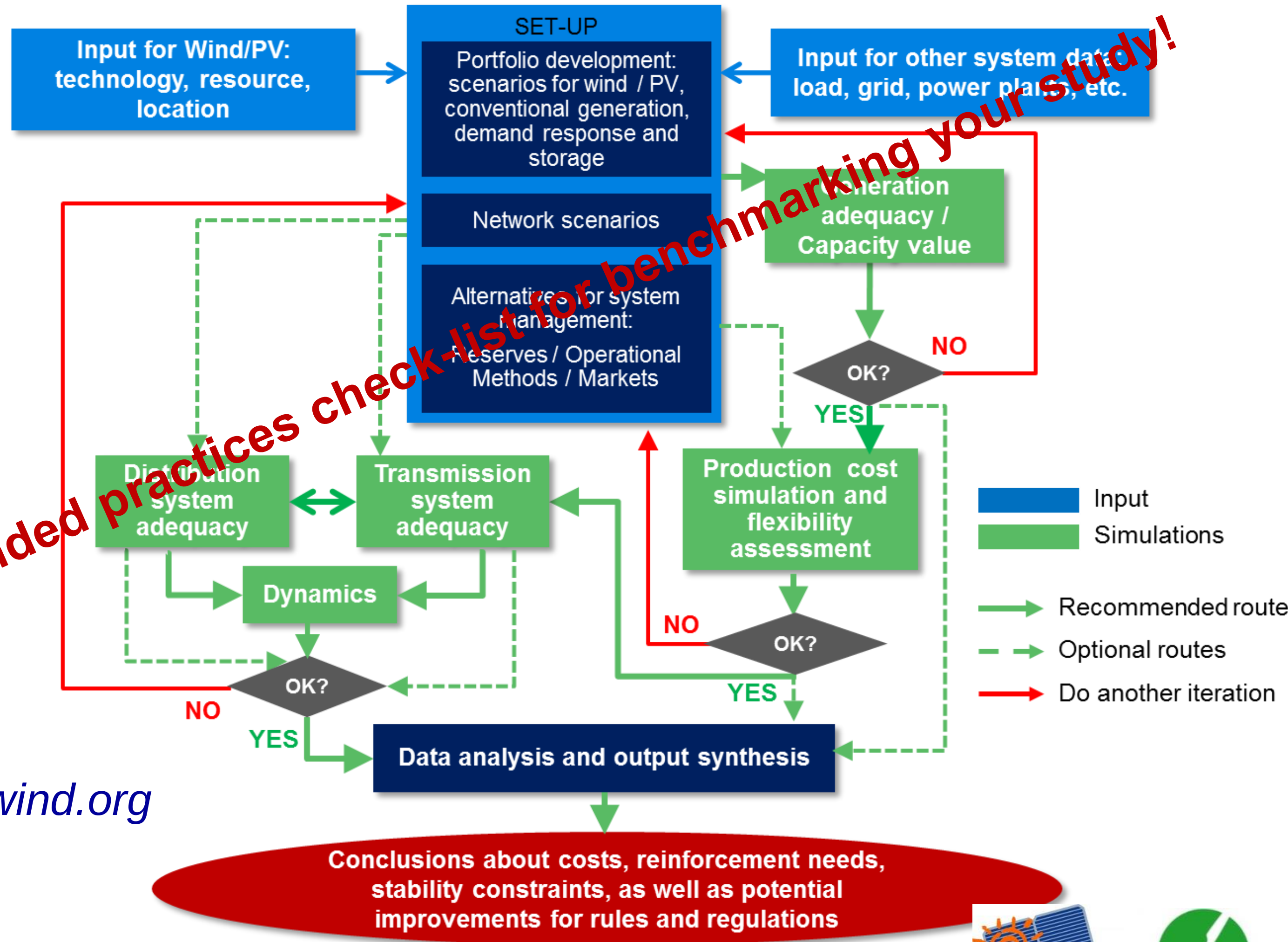
- Issues: outdated (=high) costs for wind and solar and inconsistent system costs, especially for so called profile costs
  - Low cost VRE is a 30% VRE scenario but the profile costs are not same
  - Lowering LCOE cost of VRE will result in negative system costs??

Based on

- WIW18 paper System integration costs -
  a useful concept that is complicated to quantify?
  S Müller (IEA), H Holttinen (VTT), E Taibi (IRENA), D Fraile (WindEurope), J C Smith (ESIG), T K Vrana (Sintef)
- Email discussions of L Söder (KTH), S Müller, L Hirth 2019
- L Söder comments on NEA 2019 report http://kth.diva-portal.org/smash/record.jsf?pid=diva2%3A1316503&dswid=6572
- Recommended Practices for wind/PV integration studies, IEA WIND RP16 Ed.2
  https://community.ieawind.org/publications/rp
- IEA WIND Task 25 summary reports
  https://community.ieawind.org/task25/

Recommended Practices for wind/PV integration studies

- A complete study with links between phases
- Most studies analyse part of the impacts – goals and approaches differ



Use the recommended practices check-list for benchmarking your study!

https://community.ieawind.org

Thank You!!

Hannele Holttinen

Hannele.Holttinen@recognis.fi

+66 61 473 5255

+358 40 5187055