Fexibility Options in the Electricity and Heat Markets

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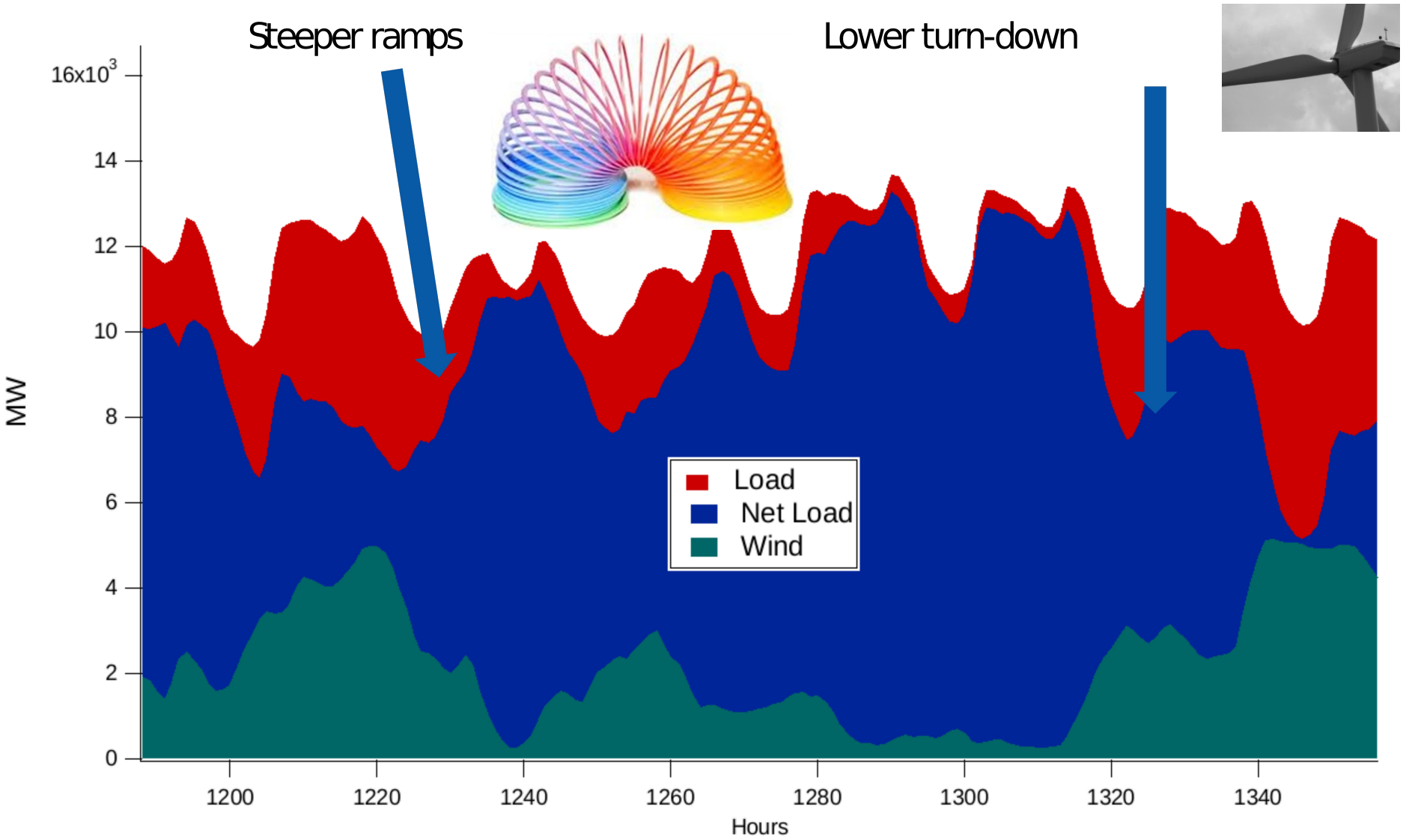
Flexibility

- What is it ?
- How do you measure it ?
- How do you value it ?
- How can you compare sources?
- Is heat coupled with electricity a contender ?

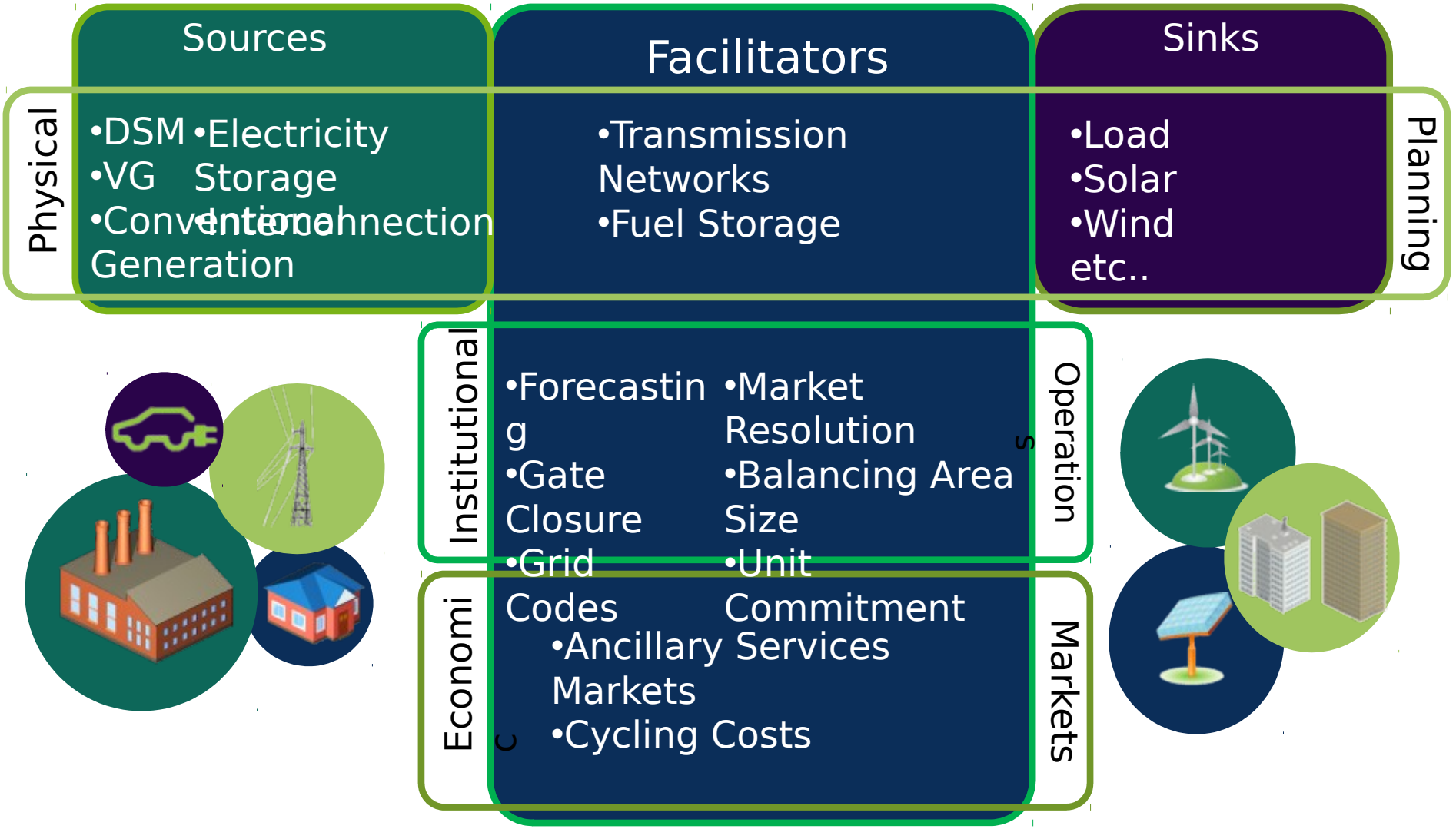
With Variable Renewables More Flexibility is Needed



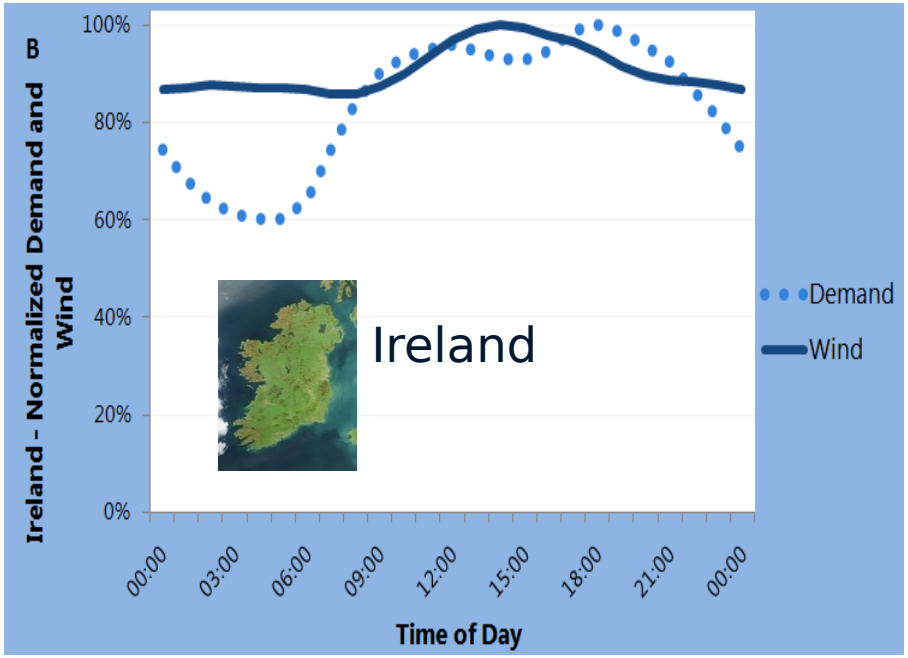
Source: Michael Milligan , NREL

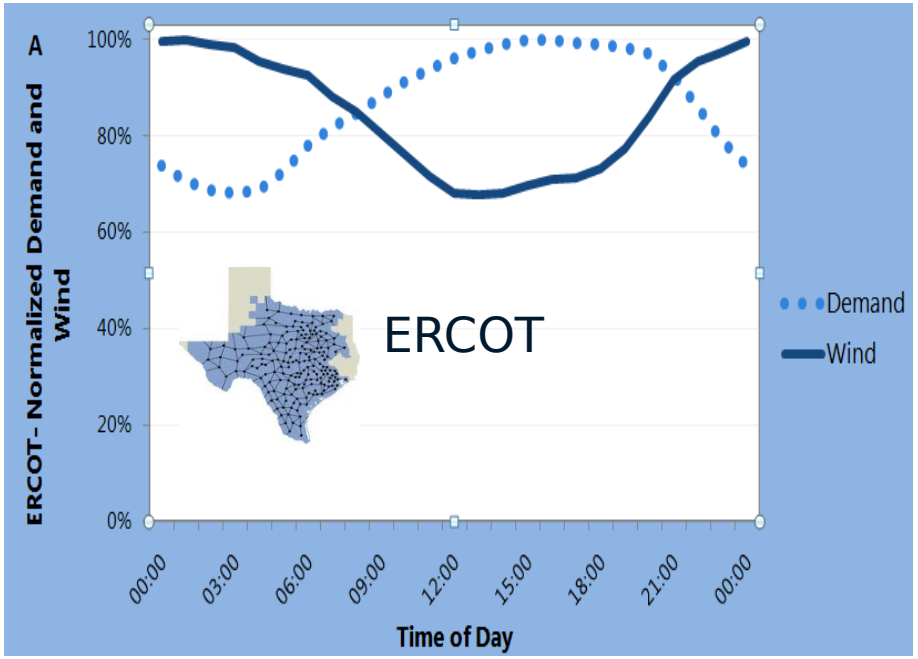

trapytoast

Flexibility Sources, Sinks and Facilitators



Dance partners

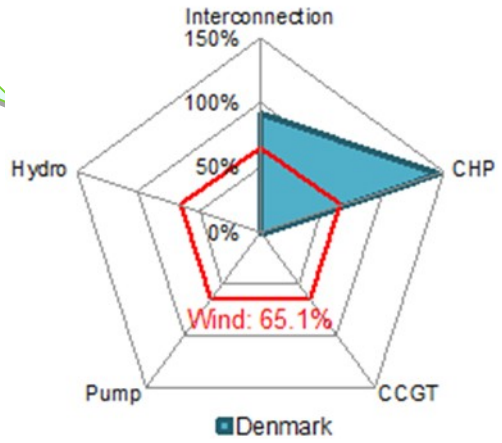




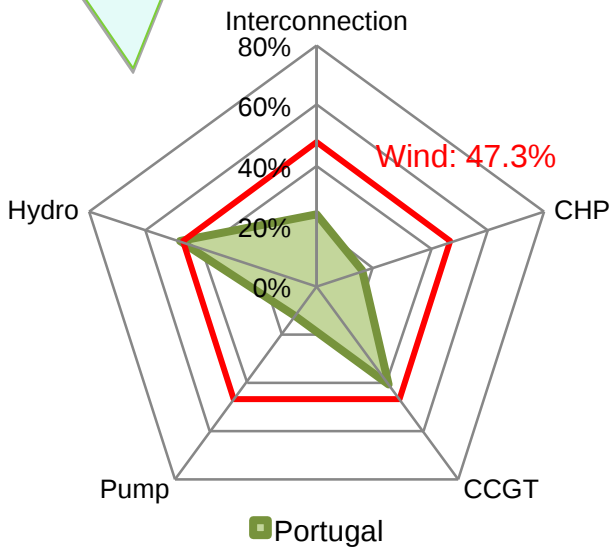
AEMO, Australian Energy Market Operator, “Wind Integration In Electricity Grids: International Practice And Experience” Work Package 1, 2011.
http://www.aemo.com.au/~/media/Files/Other/planning/0400-0049%20pdf.pdf

Flexibility chart

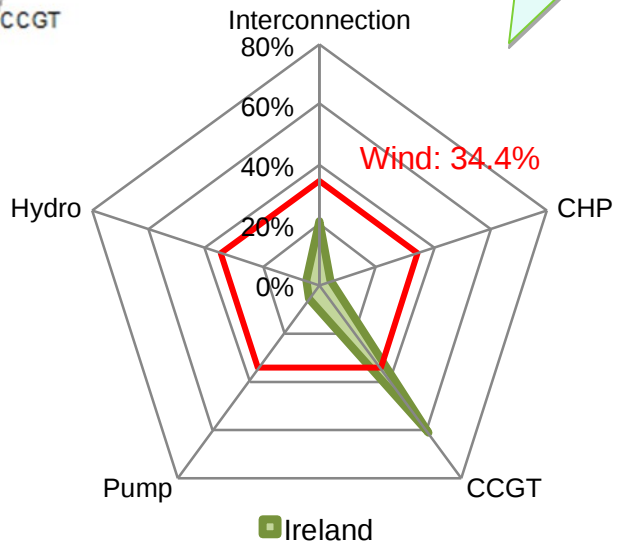
Denmark(Interconnection-oriented)



Portugal (Hydro-oriented)

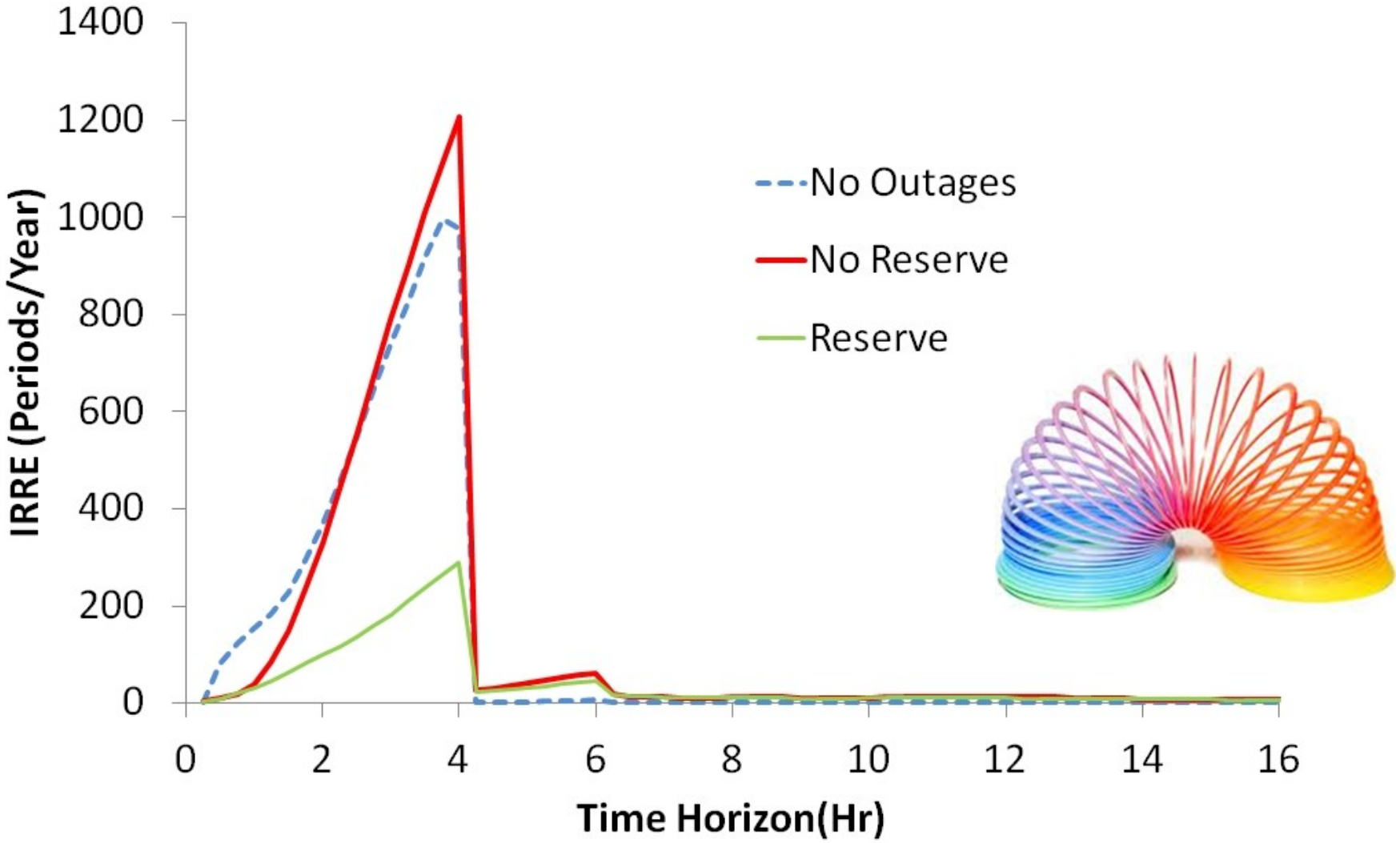


Ireland (CCGT-oriented)



Y. Y asuda et al.: “Flexibility Chart – Evaluation on Diversity of Flexibility in Various Areas”, 13th Wind Integration Workshop, WIW13-1029, (2013, 10, London).

Flexibility Metric



Lannoye, E., Flynn, D. and O'Malley, M.J. "Transmission, variable generation and power system flexibility", *IEEE Transactions on Power Systems*, Vol. 30, pp. 57 – 64, 2014.

Lannoye, E., Flynn, D., O'Malley, M., "Evaluation of Power System Flexibility" *IEEE*

More metrics

Evaluating and Planning Flexibility in Sustainable Power Systems

Juan Ma, *Student Member, IEEE*, Vera Silva, *Member, IEEE*, Régine Belhomme, *Member, IEEE*, Daniel S. Kirschen, *Fellow, IEEE*, and Luis F. Ochoa, *Senior Member, IEEE*

***Abstract*—Power systems have traditionally been designed to provide flexibility in a context where demand is met by bulk generation. The integration of variable and uncertain renewable generation sources, such as wind, increases the flexibility needed to maintain the load-generation balance. This paper aims to provide a systematic approach to evaluate the flexibility level and investigate the role of flexibility in generation planning and market operation. An "offline" index is proposed to estimate the technical ability of both the individual generators and the generation mix to provide the required flexibility. A dedicated unit** are flexibility providers or potential providers that will only deliver this flexibility when this returns an economic profit. The electricity market should, therefore, provide sufficient revenue to make the provision of flexibility profitable in short and long terms.

Previous studies have provided a thorough inventory of the issues related to the requirement of flexibility in wind-power rich system. However, important questions as how to invest in

$$flex(i) = \frac{\frac{1}{2}[P_{\max}(i) - P_{\min}(i)] + \frac{1}{2}[\mathrm{Ramp}(i).\Delta t]}{P_{\max}(i)}, \ \forall i \in A \quad (3)$$

$$\mathrm{FLEX}_A = \sum_{i \in A} \left[\frac{P_{\max}(i)}{\sum_{i \in A} P_{\max}(i)} \times \mathrm{flex}(i) \right], \ \forall i \in A. \quad (4)$$

Ma, J.; Silva, V.; Belhomme, R.; Kirschen, D. S.; Ochoa, L. F.; , "Evaluating and Planning Flexibility in Sustainable Power Systems,"*Sustainable Energy, IEEE Transactions on* , vol.4, no.1, pp.200-209, Jan. 2013

Title:

Assessing Power System Flexibility for Variable Renewable Integration: A Flexibility Metric for Long-Term System Planning

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Keywords:

Flexibility, generation portfolios, variable generation, wind power generation, solar power generation

Abstract:

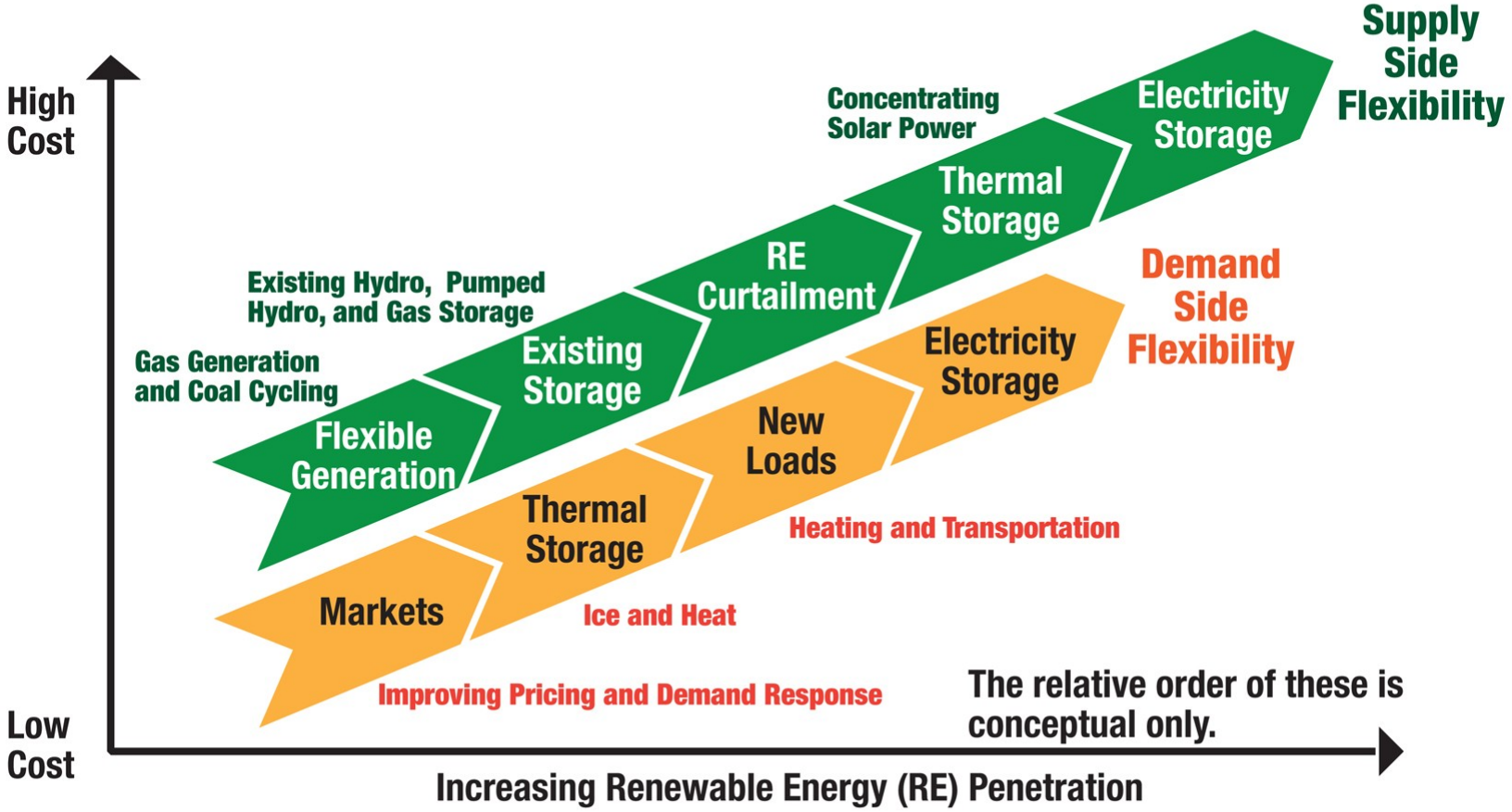
Many countries around the world have instituted policies with the aim of increasing the amount of installed variable generation (VG), such as wind and solar. A consequence of increased penetrations of VG is that changes in their output must be met by the remainder of a system's resources so that the demand-generation balance is maintained. This paper proposes a high-level methodology to assess power system flexibility. In this context, flexibility is the ability of a power system to deploy its resources to meet changes in the system demand and that of variable generation. The inclusion of such analysis at the long-term system planning stage will help to ensure that systems are optimally planned and operated with high levels of VG. Two case studies are presented which illustrate the flexibility assessment methodology and highlight some key issues relating to flexibility in the context of long-term planning.

Periods of Flexibility Deficit (PFD)

- For each time horizon
  - For each time period
    - Calculate the flexibility available from generation
    - Calculate the net load ramp
    - Add the outage of the largest online generator to the net load ramp
    - If there insufficient flexibility to meet the ramp, increase the PFD counter by one.
  - Final PFD is the number of problem periods for that time horizon

Lannoye, E., Tuohy, A., Daly, P., Flynn, D. and O'Malley, M.J., "Assessing Power System Flexibility for Variable Renewable Integration: A Flexibility Metric for Long-Term System Planning", *CIGRE Science and Engineering*, in review, 2015.

Flexibility Supply Curve



How do we choose the optimum mix of flexibility resources?

Can Thermal Power Plant Skip ?

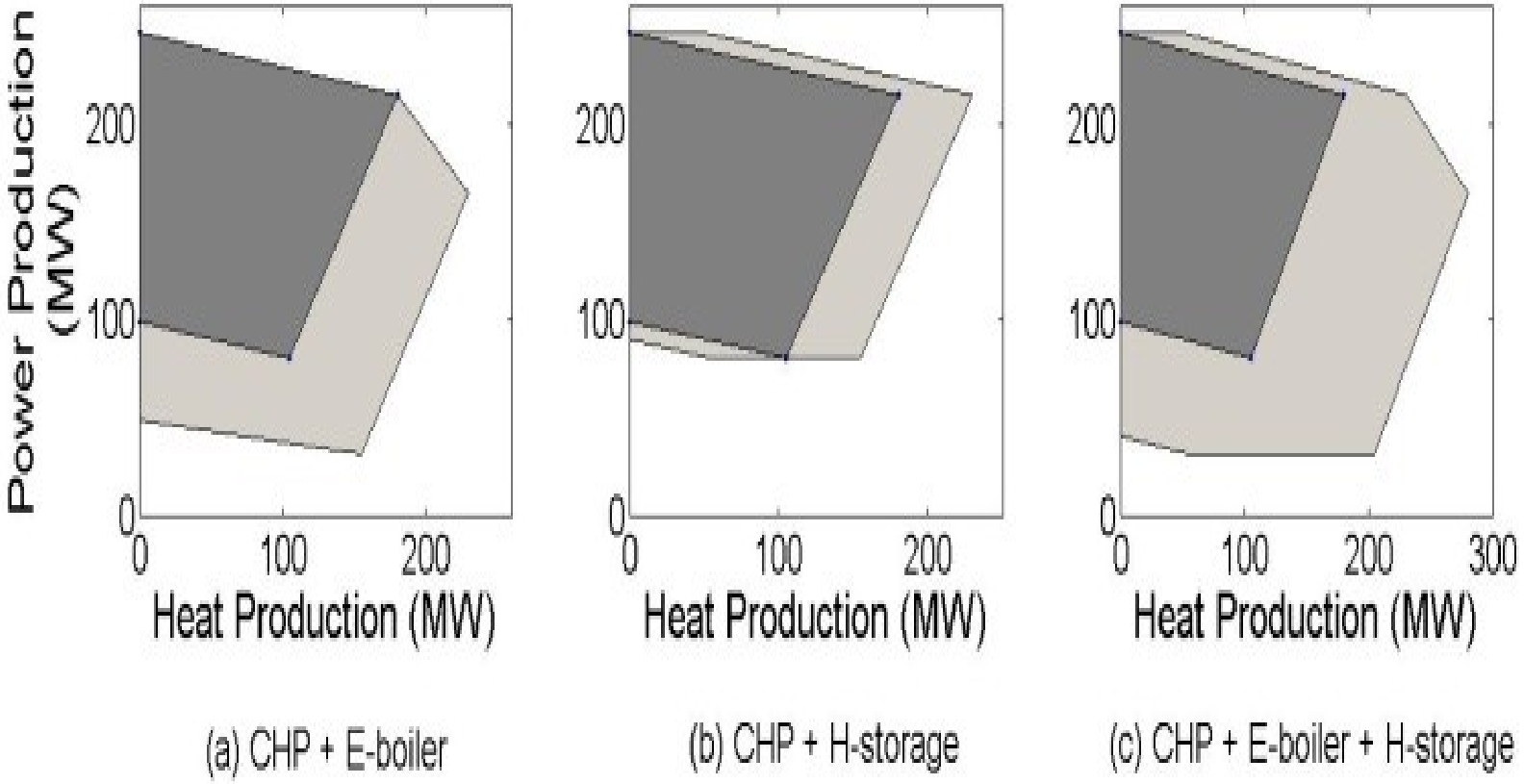
Table 3.2: **The load following ability of dispatchable power plants in comparison**

	Start-up time	Maximal change in 30 sec	Maximum ramp rate (%/min)
Open cycle gas turbine (OCGT)	10-20 min	20-30%	20%/min
Combined cycle gas turbine (CCGT)	30-60 min	10-20%	5-10%/min
Coal plant	1-10 hours	5-10%	1-5%/min
Nuclear power plant	2 hours - 2 days	up to 5%	1-5%/min

Source: EC JRC, 2010 and NEA, 2011a.

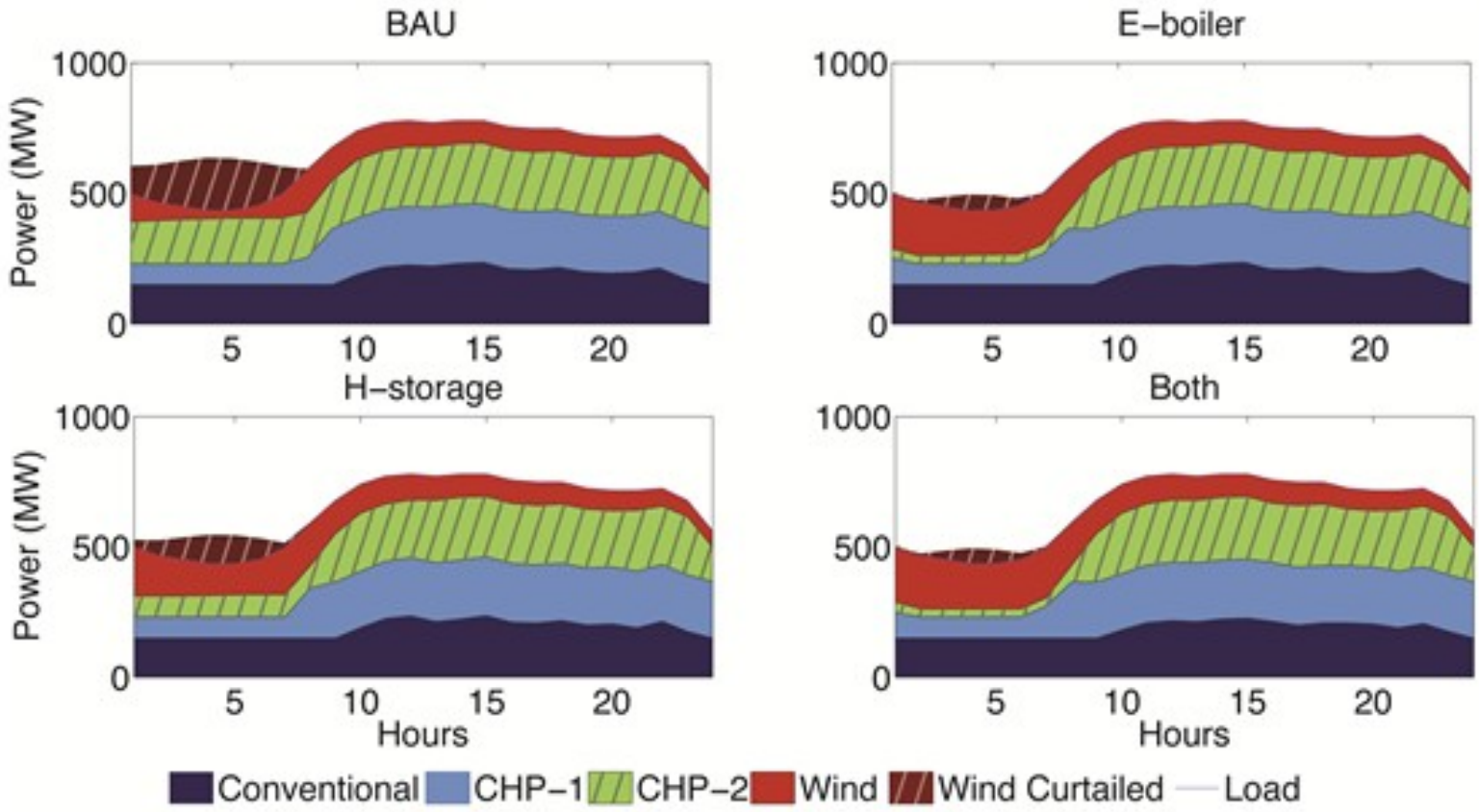
NEA 2012 “Nuclear Energy and Renewables: System Effects in Low-carbon Electricity Systems” Nuclear Energy Agency ISBN 978-92-64-18851-8

Combined heat and power (CHP) can be made flexible



X. Chen, C. Kang, Q. Xia, B. Jianhua, L.Chun, L. Ji, R. Sun, L. Hui and M.J. O'Malley, "Increasing the Flexibility of CHP with Heat Storage and Electrical Boilers for Wind Power Integration in China: Modeling and Implications", *IEEE Transactions on Power Systems*, in press, 2015.

Flexible CHP can reduce wind curtailment



X. Chen, C. Kang, Q. Xia, B. Jianhua, L.Chun, L. Ji, R. Sun, L. Hui and M.J. O'Malley, *"*Increasing the Flexibility of CHP with Heat Storage and Electrical Boilers for Wind Power Integration in China: Modeling and Implications*"*, *IEEE Transactions on Power Systems*, in press, 2015.

Conclusion

- It is very difficult to measure and value
- Multiple sources “very competitive”
- Heat electricity coupling an excellent source
- Getting an accepted methodology for comparison is the challenge

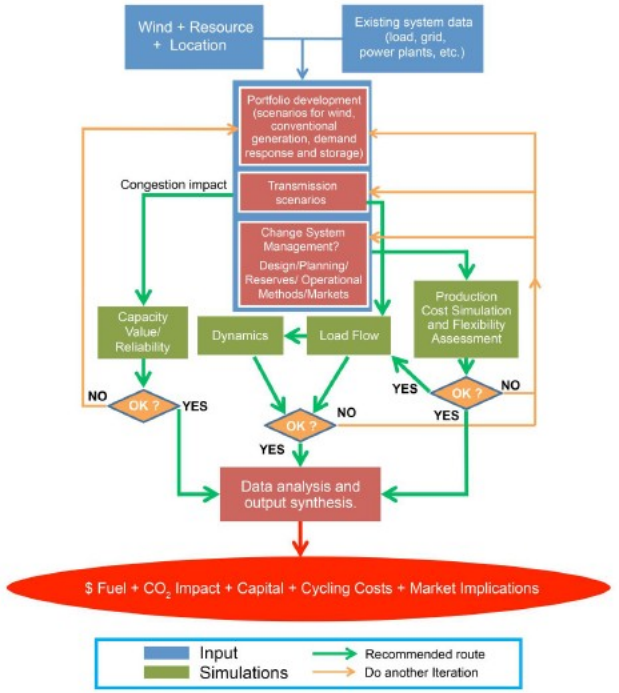


Figure i. Contents of a wind integration study

A full integration study is a complicated process, especially taking into account all possible iteration loops. Not all integration studies need to look at all aspects presented here. Transmission network adequacy and congestions are usually assessed first, in portfolio development, to feed as input to production cost simulations and capacity value (if area needs to be split to sub-areas). Iteration between grid simulations and production cost simulations are often needed. Capacity expansion model runs may be used in portfolio development, to produce generation portfolio scenarios. Or then foreseen changes for future system are made and the adequacy is checked in Capacity value/Reliability simulation.

Enter the “consumer”

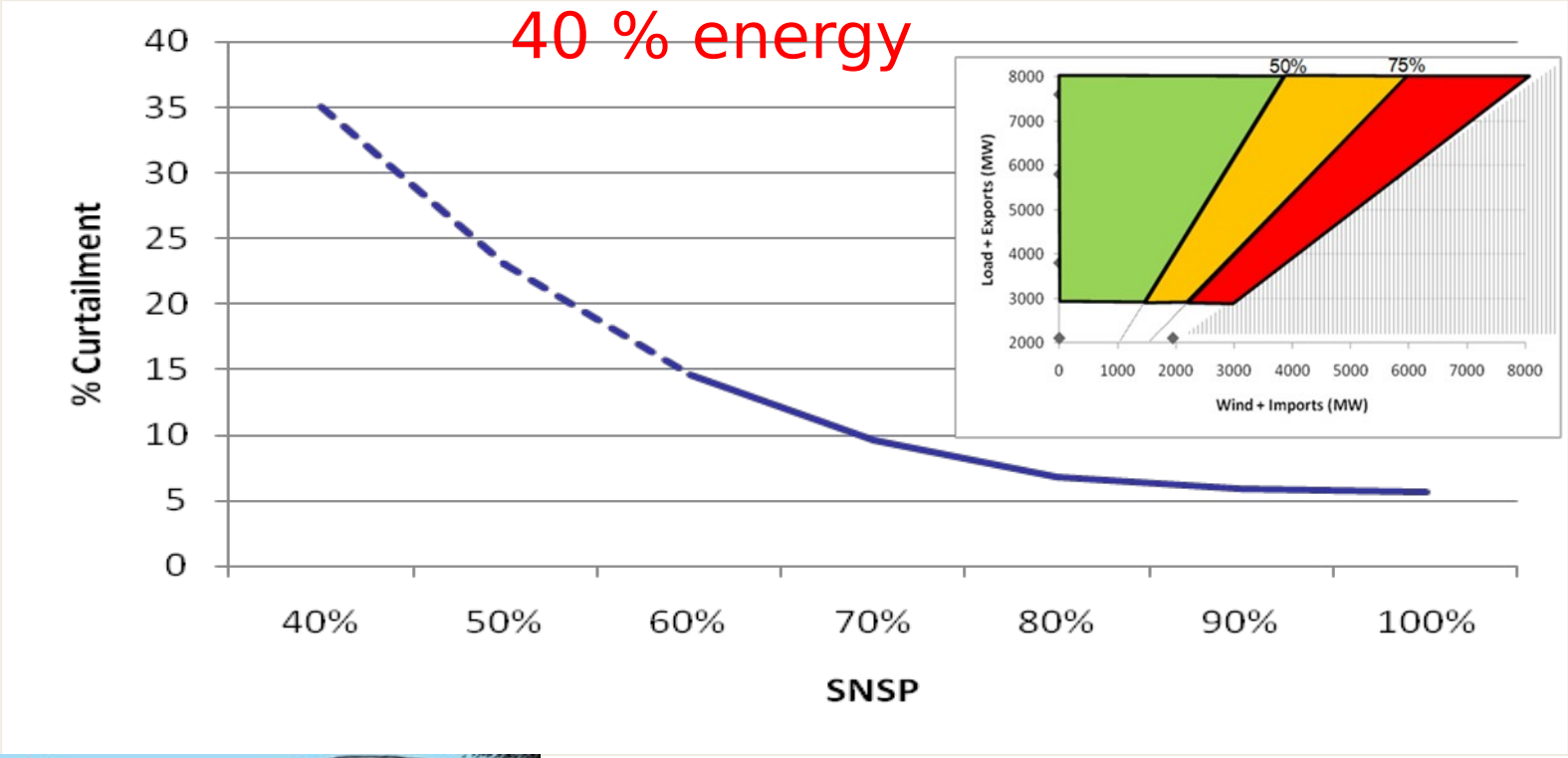

DIETER TELEMANS/PANOS

Masai women from Kenya take a course on solar energy in India.

‘Engineers and economists are ignoring people and miscasting decision making and action’, *Sovacool, B.K. (2014) Nature 511, 529-530*

Energy studies need social science

Impact of SNSP on Wind Curtailment



Curtailment is form of flexibility – can the markets get the balance right ?

In ERCOT they used 3 %