Renewable Energy Sources in Context: Market Fundamentals for Demand and Supply

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Outline

PART I: Fundamentals of electricity demand/supply

- Overview / Modelling scenarios (example: VSE Vorschau)
- Demand
- Supply, in particular renewables (forced introduction)
- System equilibrium

PART II: Renewables intermittency impact

- Residual load
- Demand for flexibility
- Supply of flexibility

PART I:

Fundamentals of electricity demand/supply

Fundamentals of Electricity Market: Only some of them are influenceable

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VSE AES

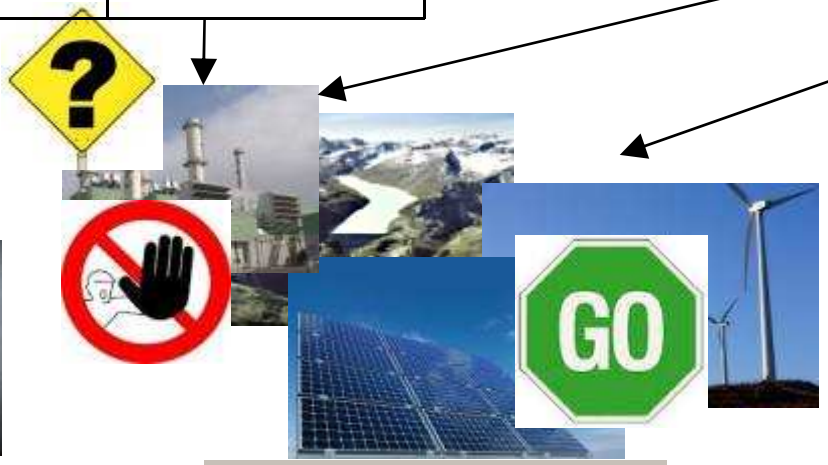
Demography

Politics

Macroeconomy

Energy markets

Weather fluctuations



Demand

Supply (production mix)

Availability of interconnections

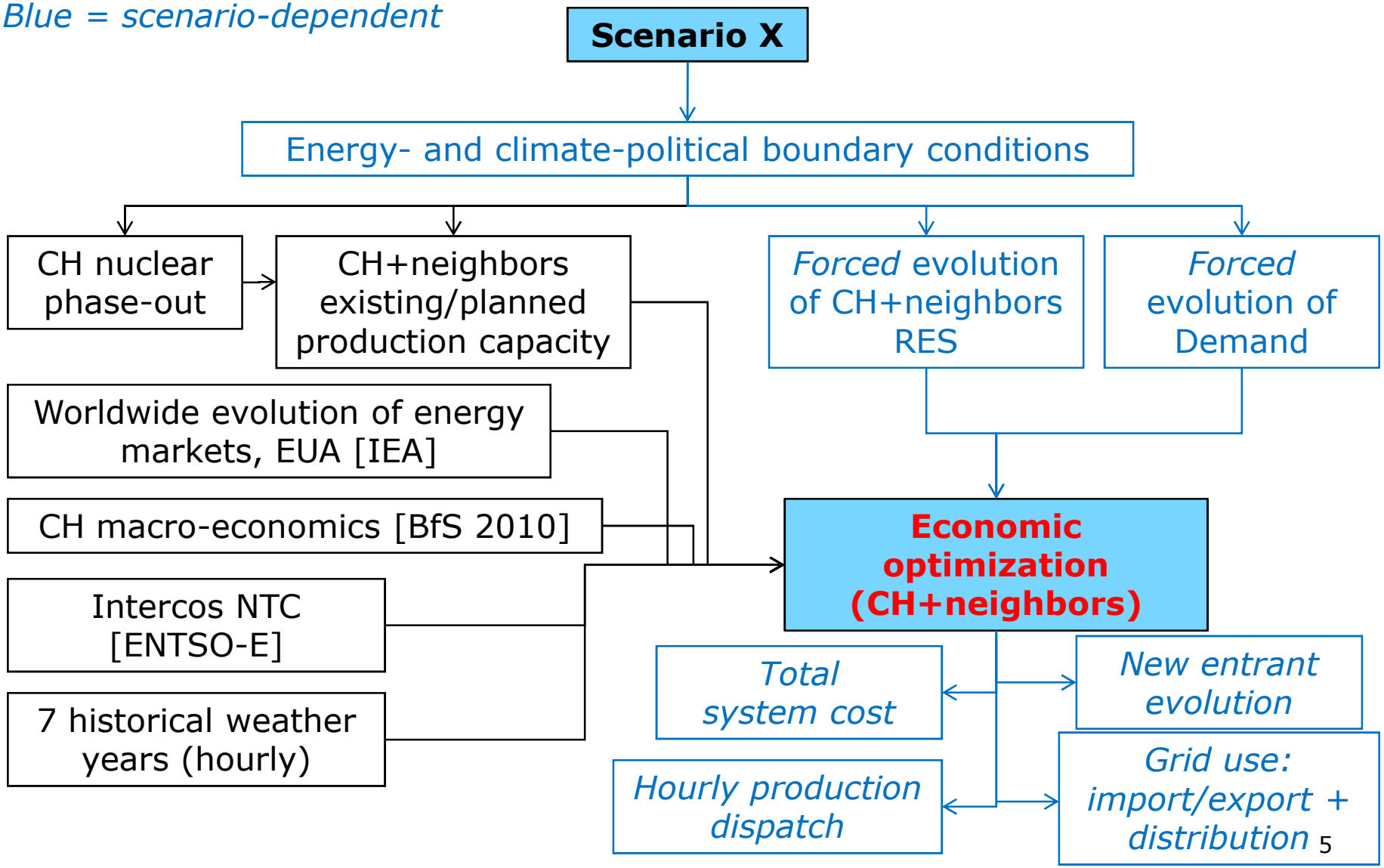
Permanent balancing

Production and electricity **Price**
(price = time-varying shortfall signal)

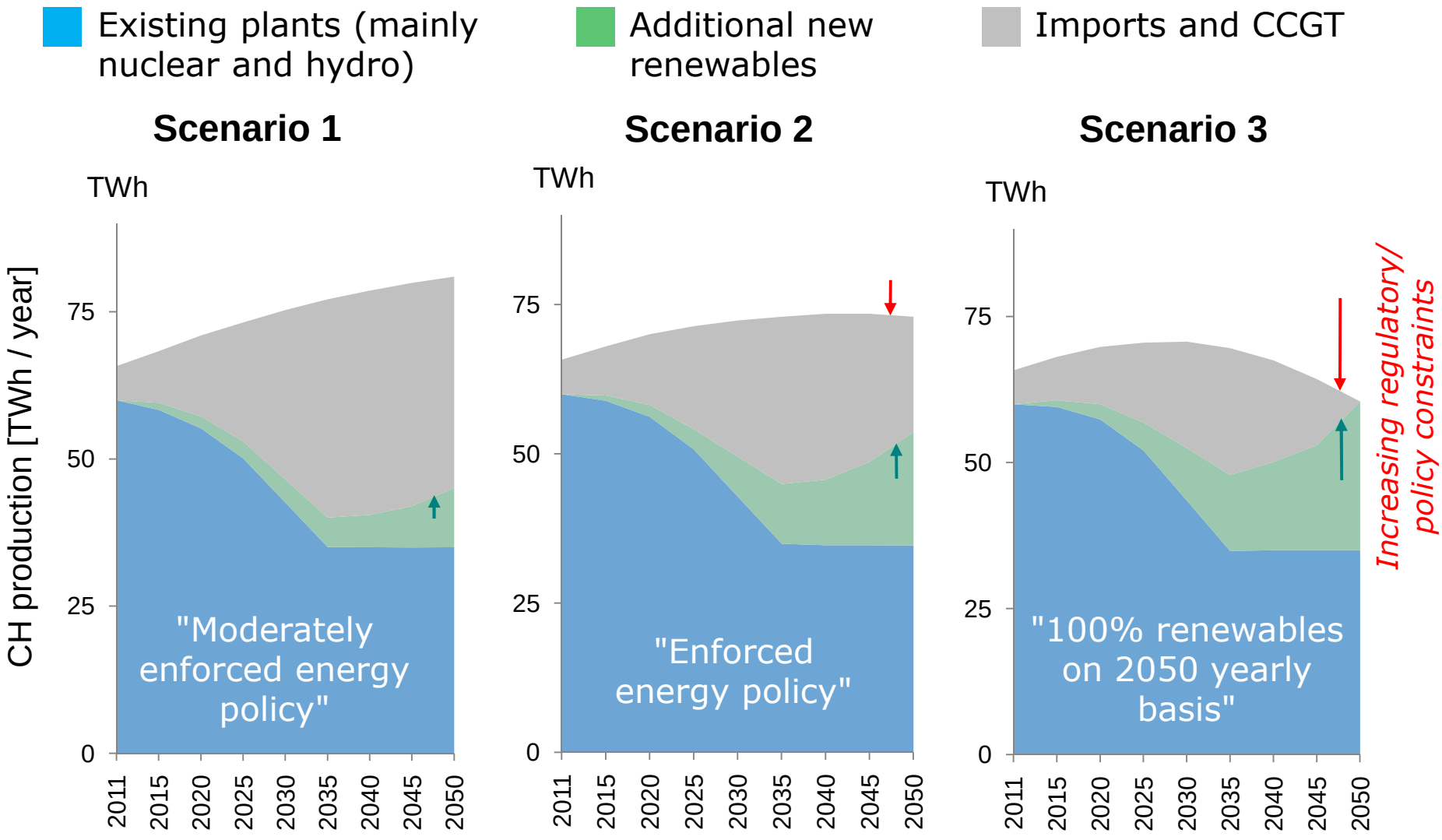
Economic and **ecological impact**

Modelling different hypothetical evolutions in CH: Methodology (example: latest VSE Vorschau 2012)

Blue = scenario-dependent

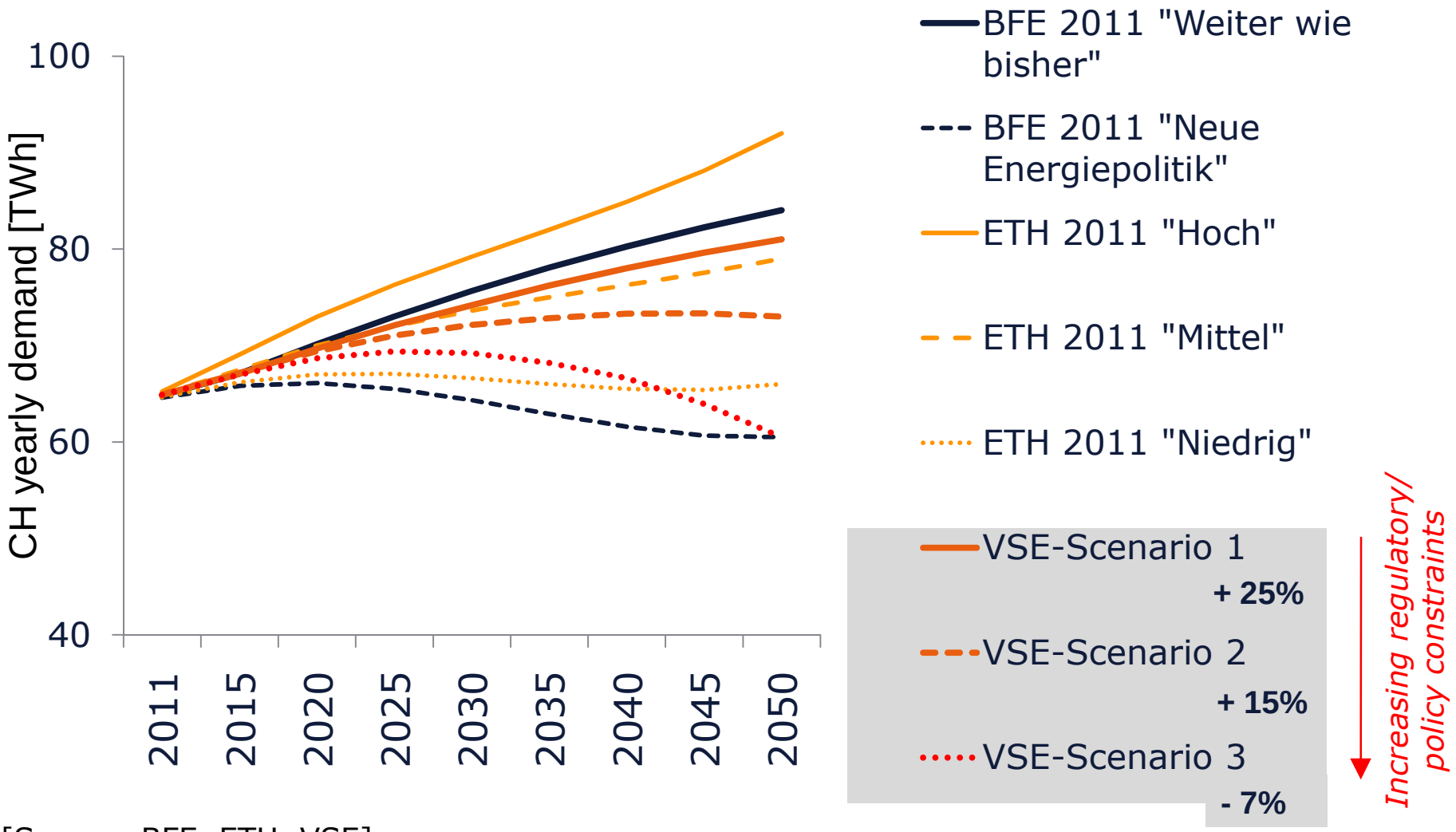


Overview: 3 scenarios show possible solutions … and their consequences



[Source: VSE, 2012]

Evolution of CH demand: Comparison of assumptions

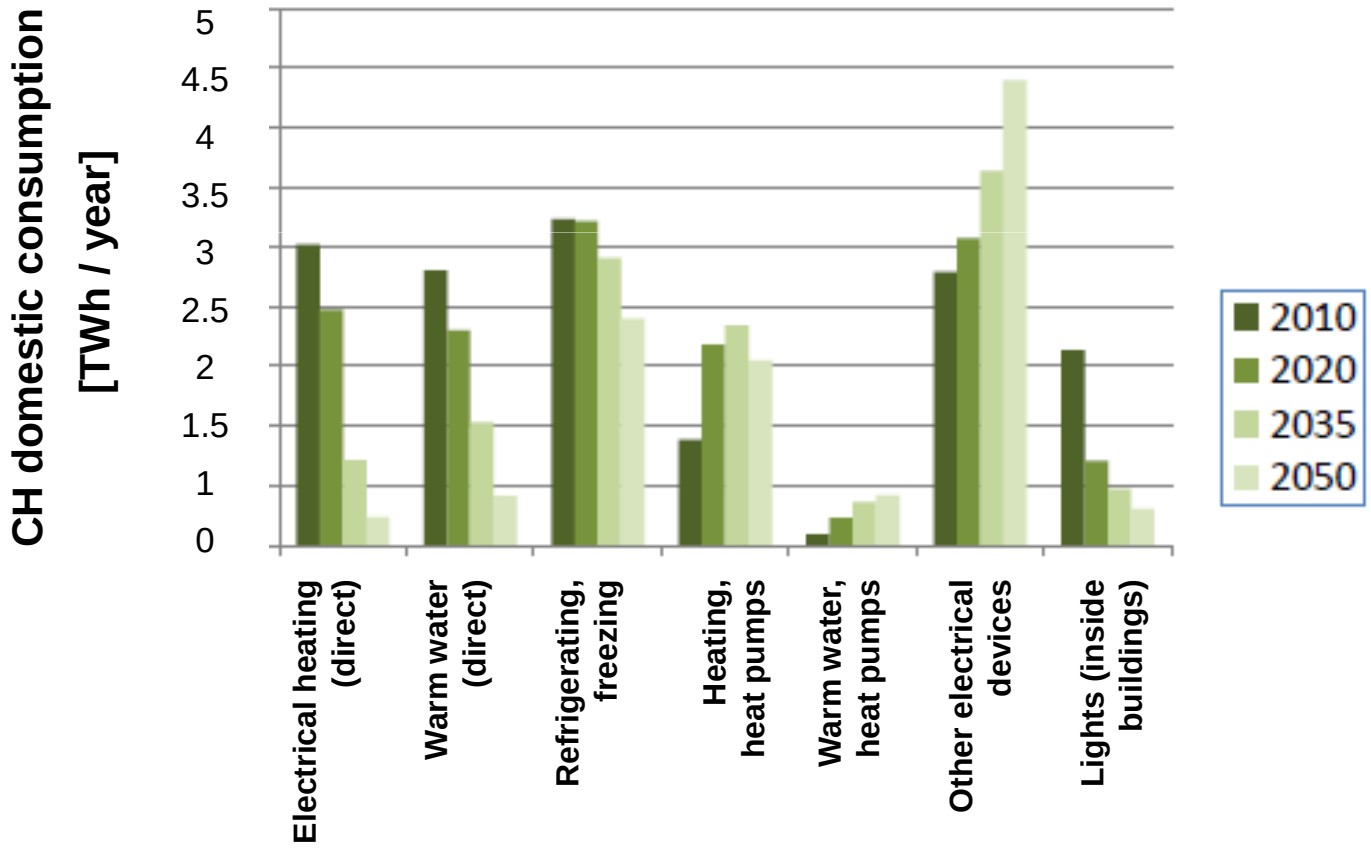


[Source: BFE, ETH, VSE]

Demand: electrification vs. efficiency improvement (bottom-up analysis) / limited flexibilization potential

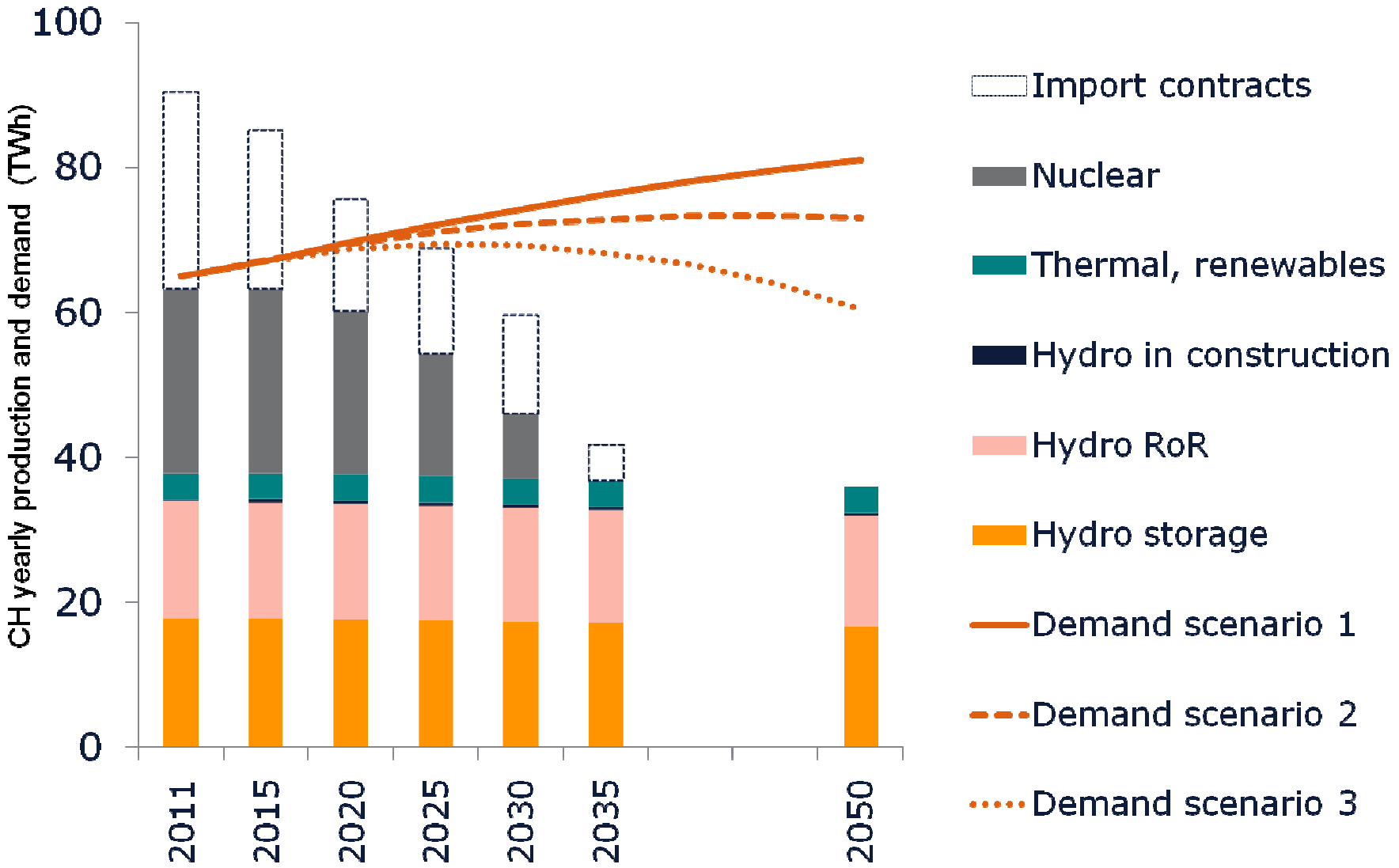
Reduction: electrical heating, refrigeration, lights, efficiency

Growth: heat pumps, electronics, new devices, number of households



[Source: Ernst Basler & Partner, 2012]

Existing and already-planned production: How to guarantee security of supply (fill the gap to demand)?



Wind/solar potential vs. possible future deployment

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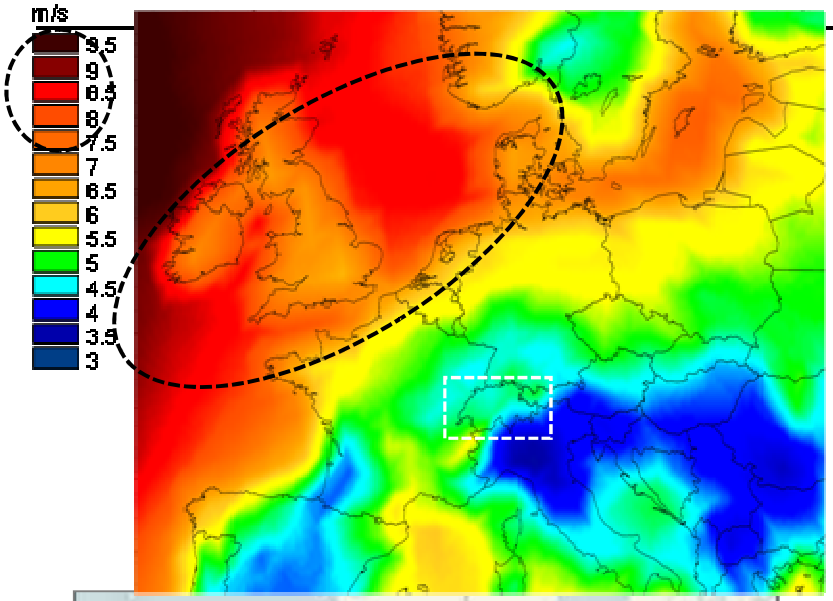
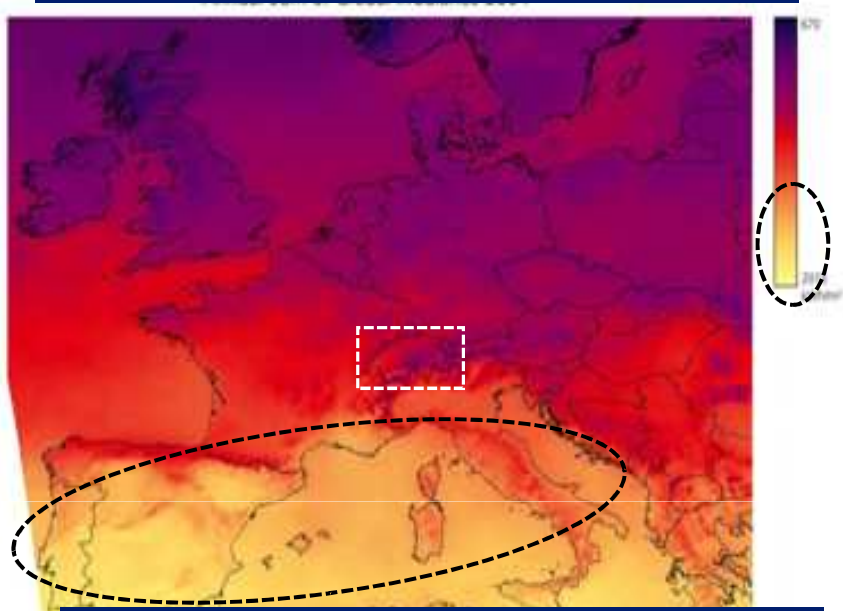
VSE

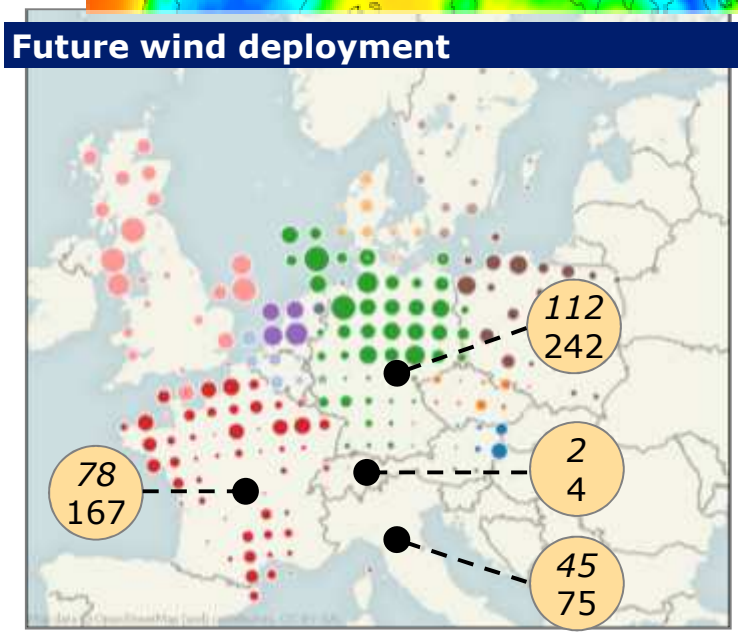
Anemos wind atlas



Transvalor solar data



Future wind deployment

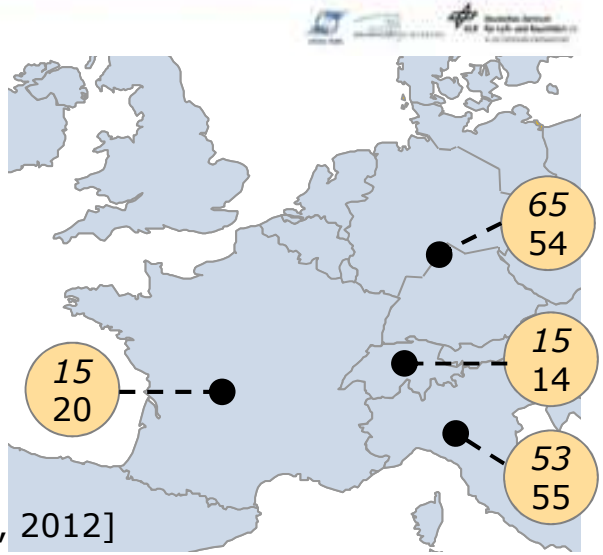


Future solar deployment

Installed capacity

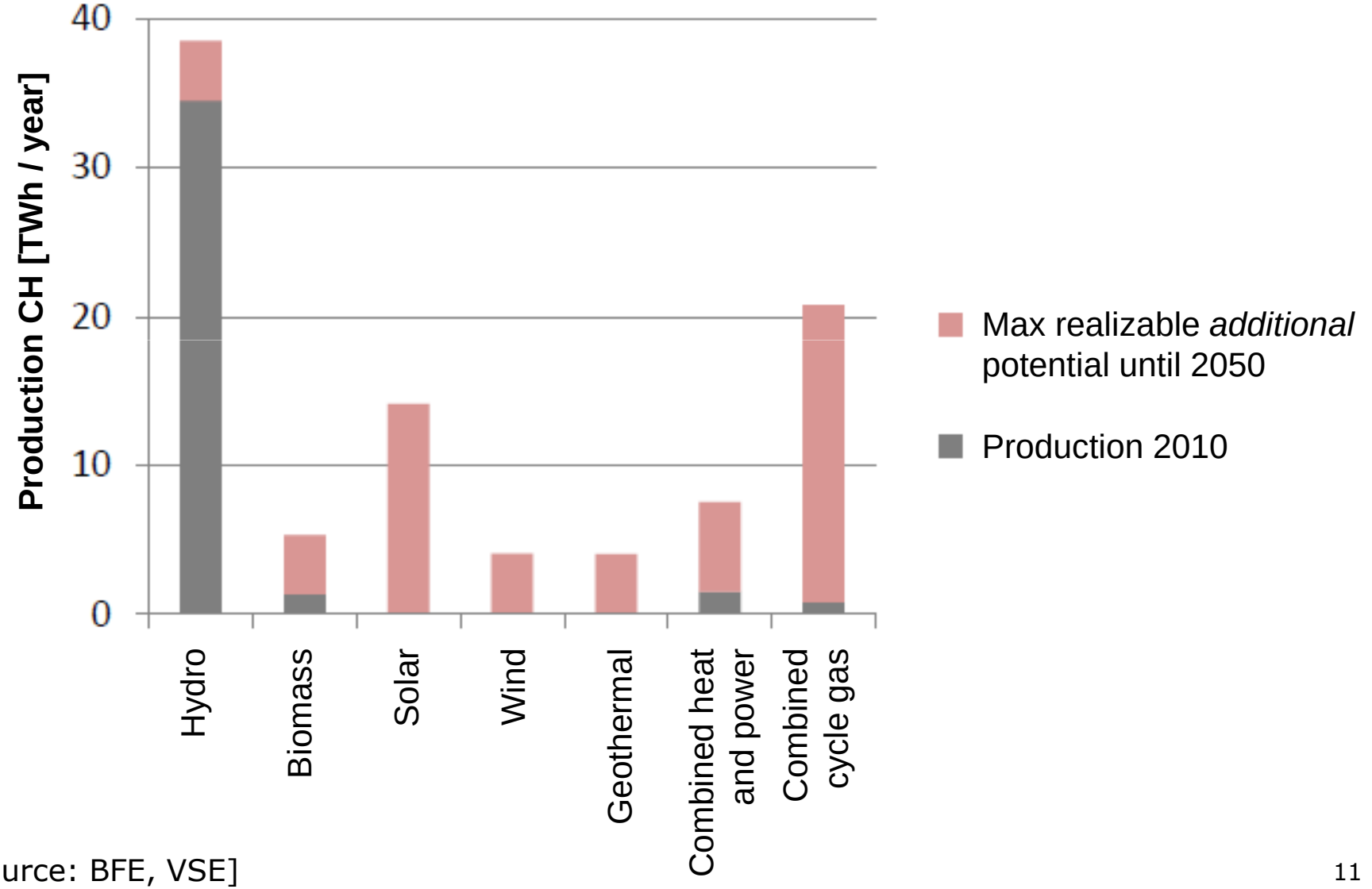
GW
TWh

Yearly production



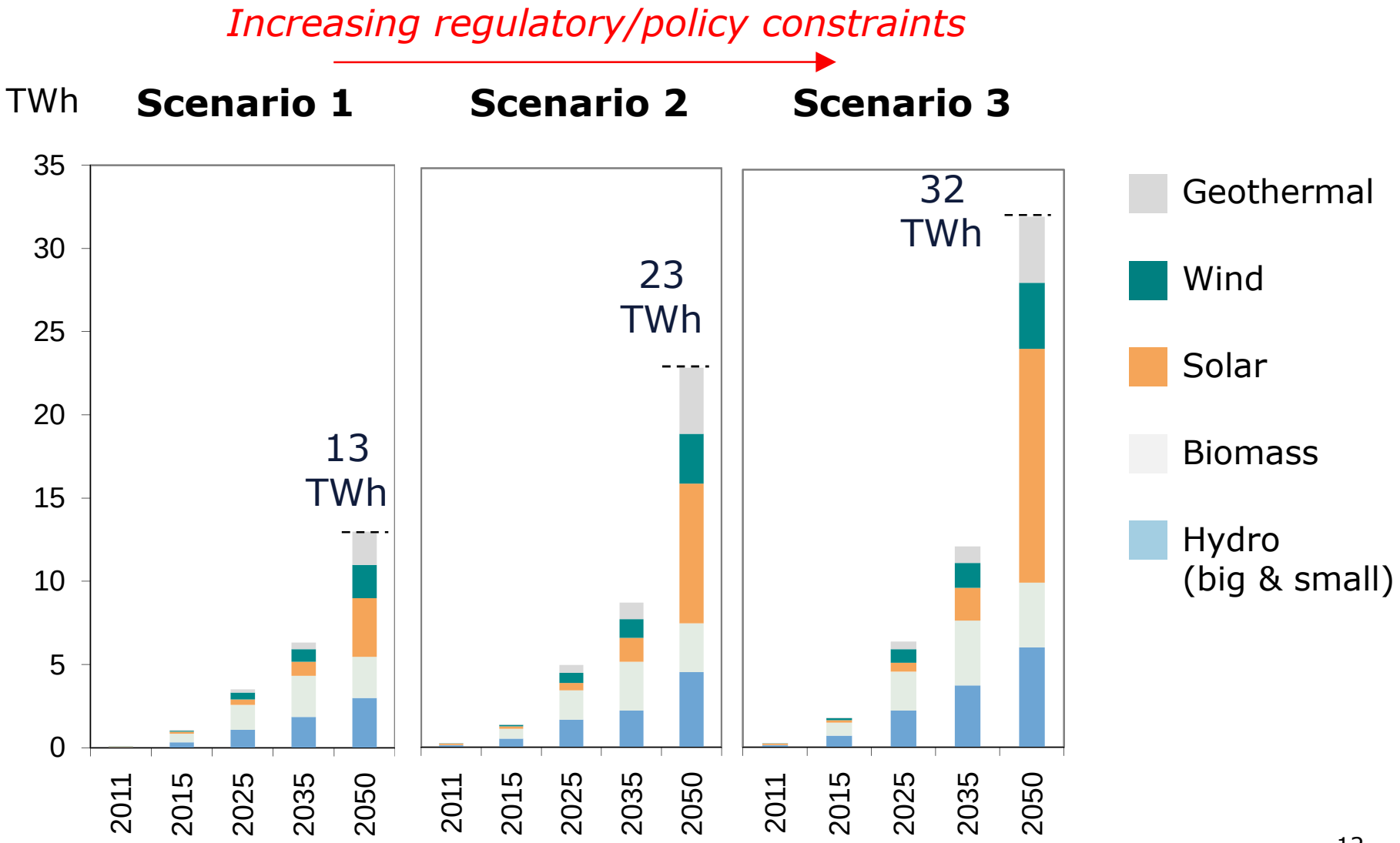
[Source: Pöyry, 2012]

Production in Switzerland: Realizable potential (results from bottom-up analysis)

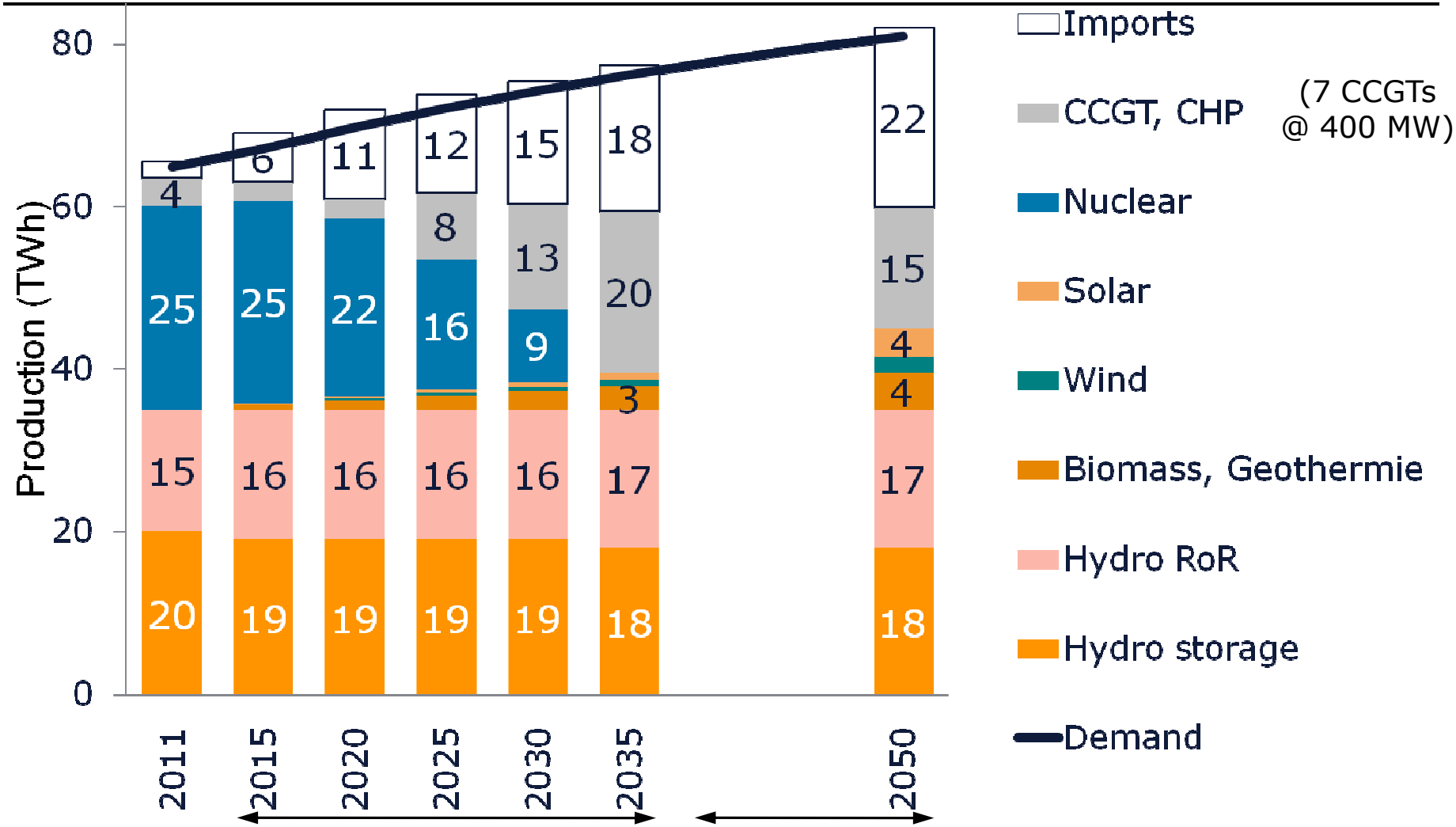


[Source: BFE, VSE]

Hypothetical development of renewables (exogeneous = *forced*)



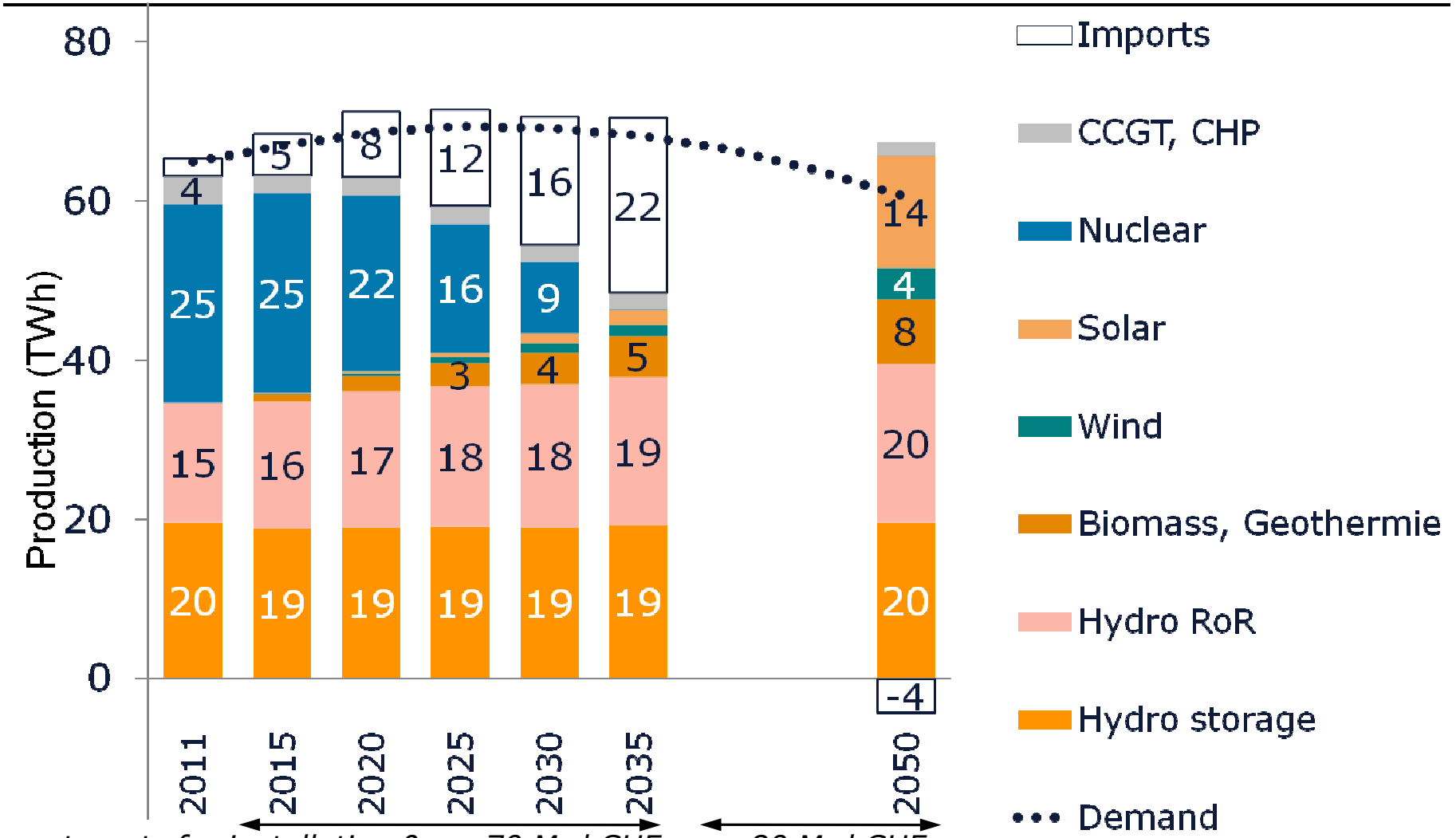
Economic-optimum results **Scenario 1**: Imports and CCGTs compensate suppressed nuclear capacity



Investments for installation & maintenance (excl. inflation):	*~70 Mrd CHF*	*~48 Mrd CHF*
Grid reinforcement:	*~5'000 km*	*~15'000 km*

[Source: Pöyry, Consentec, 2012]

Economic-optimum results **Scenario 3**: Compressed demand, grid expansion and imports finally allow a yearly overall of 100% renewables in 2050



Investments for installation & maintenance (excl. inflation):	*~70 Mrd CHF*	*~80 Mrd CHF*
Grid reinforcement:	*~7'000 km*	*~50'000 km*

[Source: Pöyry, Consentec, 2012]

The environmental *no-free-lunch* principle: *Either* CO2 emissions are caused, *or* landscape areas are impacted

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	Scenario 1		Scenario 3	
	2035	**2050**	**2035**	**2050**
Climate	Fossile imports >40%	Fossile imports >40% (CCGTs)	Import of renewable energy (buying certificates)	100% renewables
Climate	For Switzerland:			
Climate	7.8 mio. t CO_2/a	6.1 mio. t CO_2/a	1.7 mio. t CO_2/a	1.4 mio. t CO_2/a
Landscape	200 turbines	600 turbines	450 turbines	1'250 turbines
Landscape	1x Göschenen (160 MW)	1.5x Göschenen	2x Göschenen	3x Göschenen
Landscape	700x Stade de Suisse (12'000 m²)	3'000x Stade de Suisse	1'600x Stade de Suisse	11'500x Stade de Suisse

[Source: VSE, 2012]

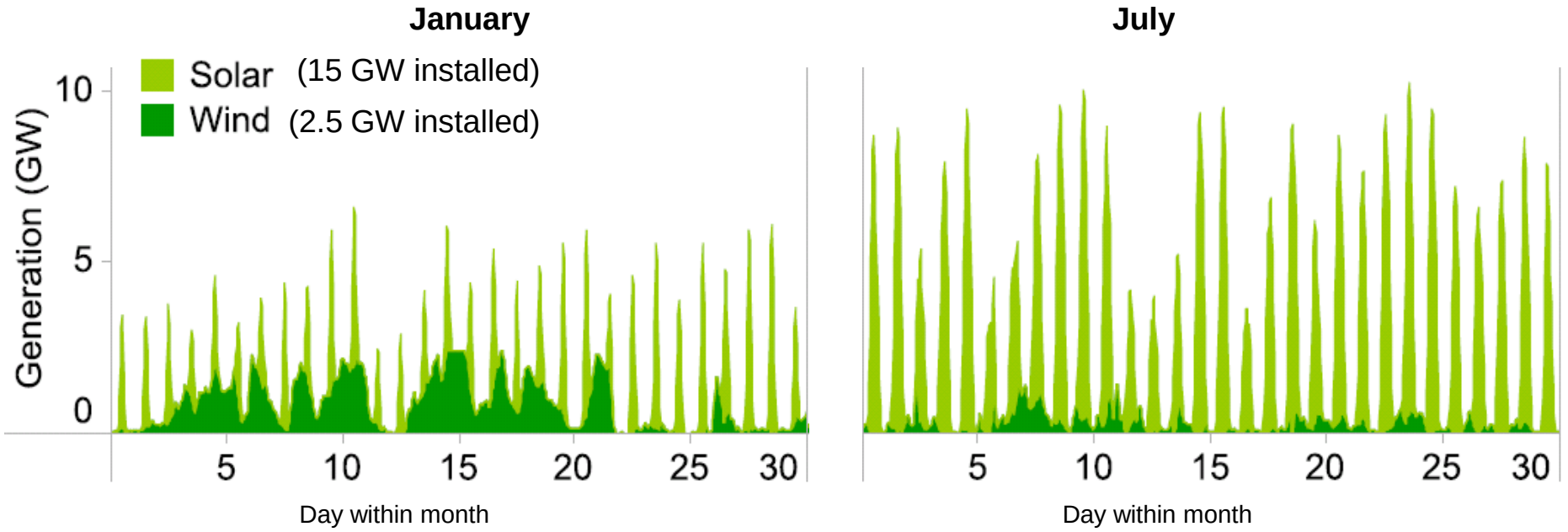
PART II:

Renewables intermittency impact

Intermittent production of new renewables increases demand for flexible generation

Seasonal and daily variations in *solar* and *wind* productions (magnitude and duration)

Example of a **summer** and of a **winter** month (weather of 2008):

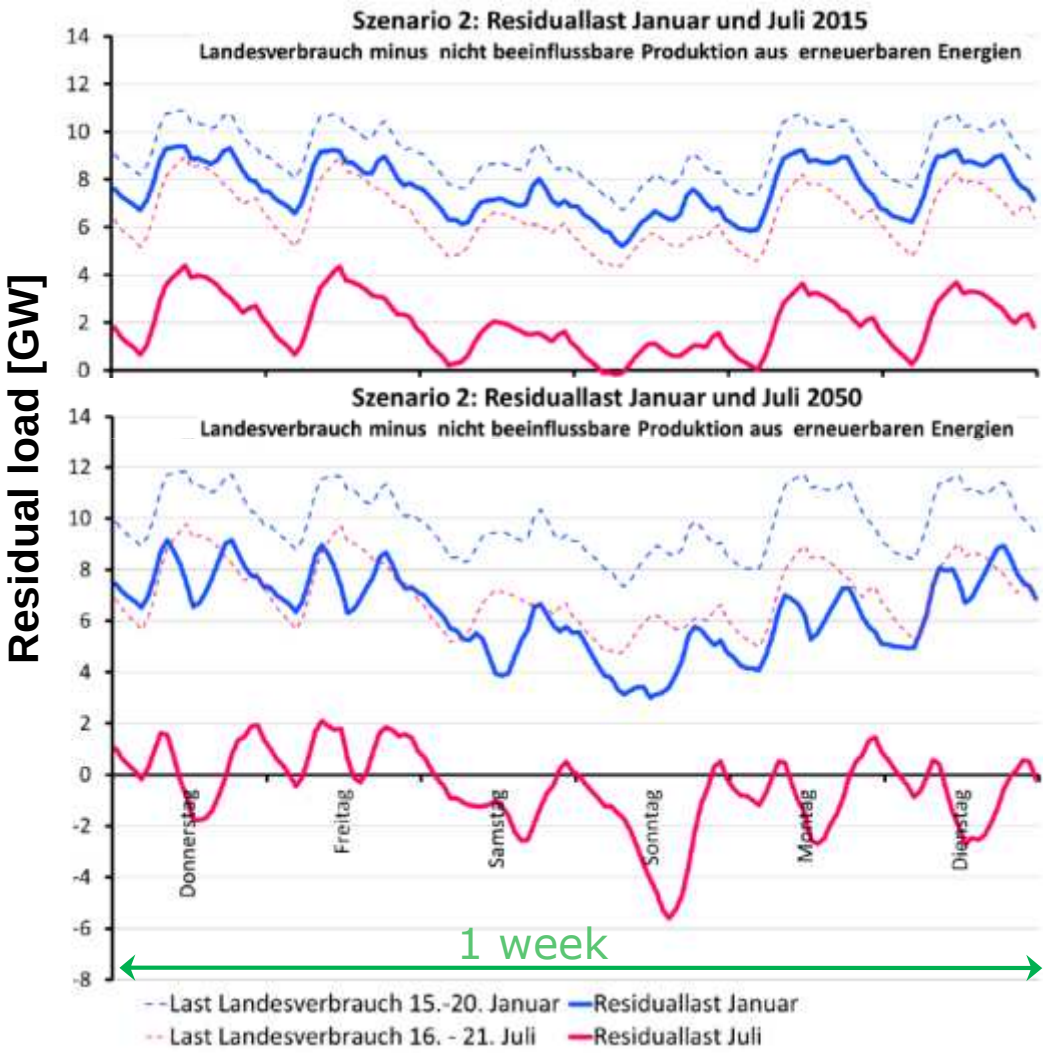


Fluctuation of *residual* load (= load – uncontrollable production)

Installed capacities [GW]:

hydro
inflexible: 4
solar: 0.1
wind: 0.1

hydro
inflexible: 5
solar: 8.9
wind: 1.9



1 week in January

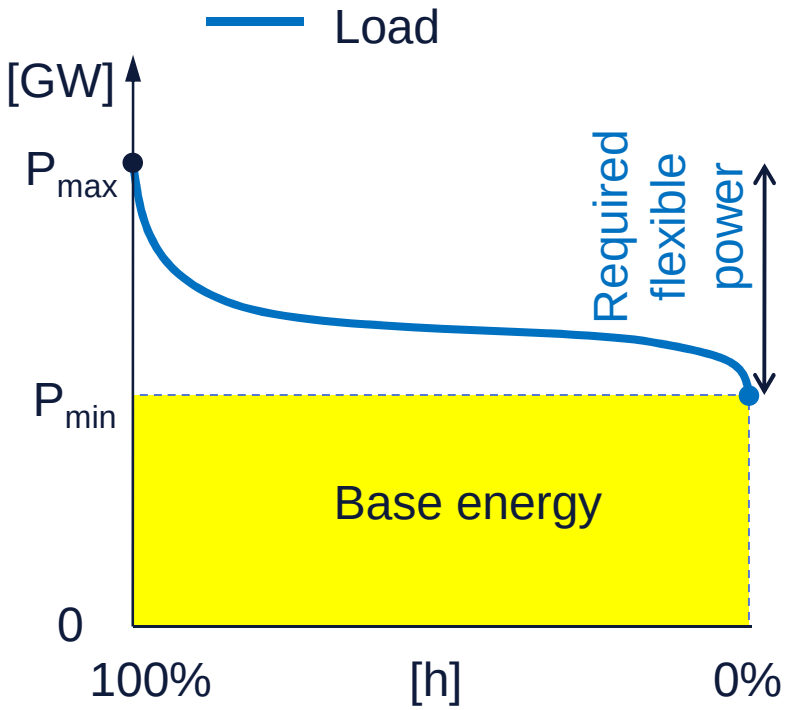
1 week in July

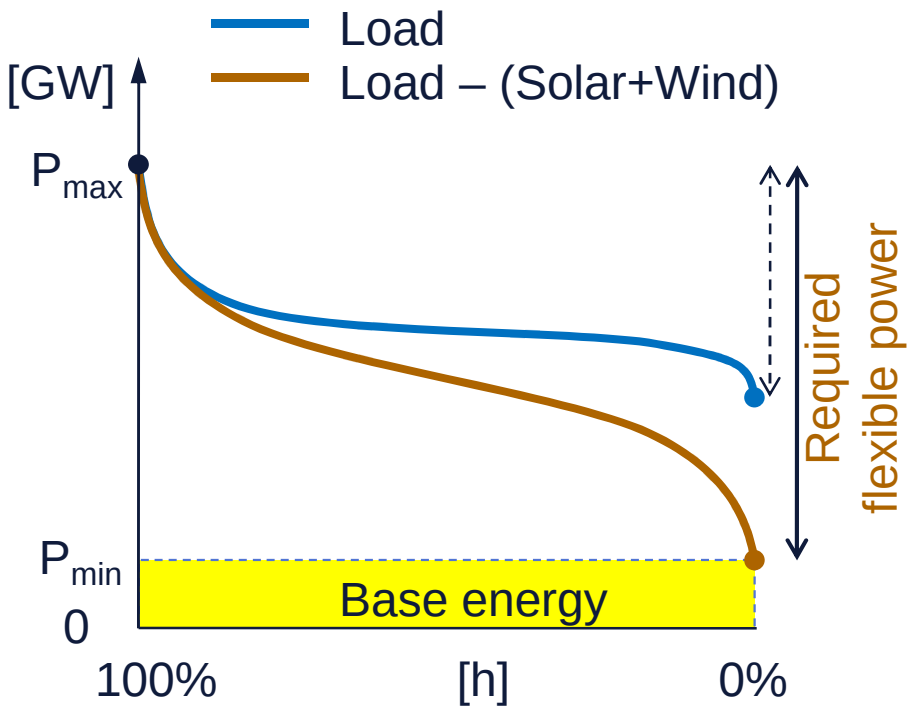
---- load

____ residual load

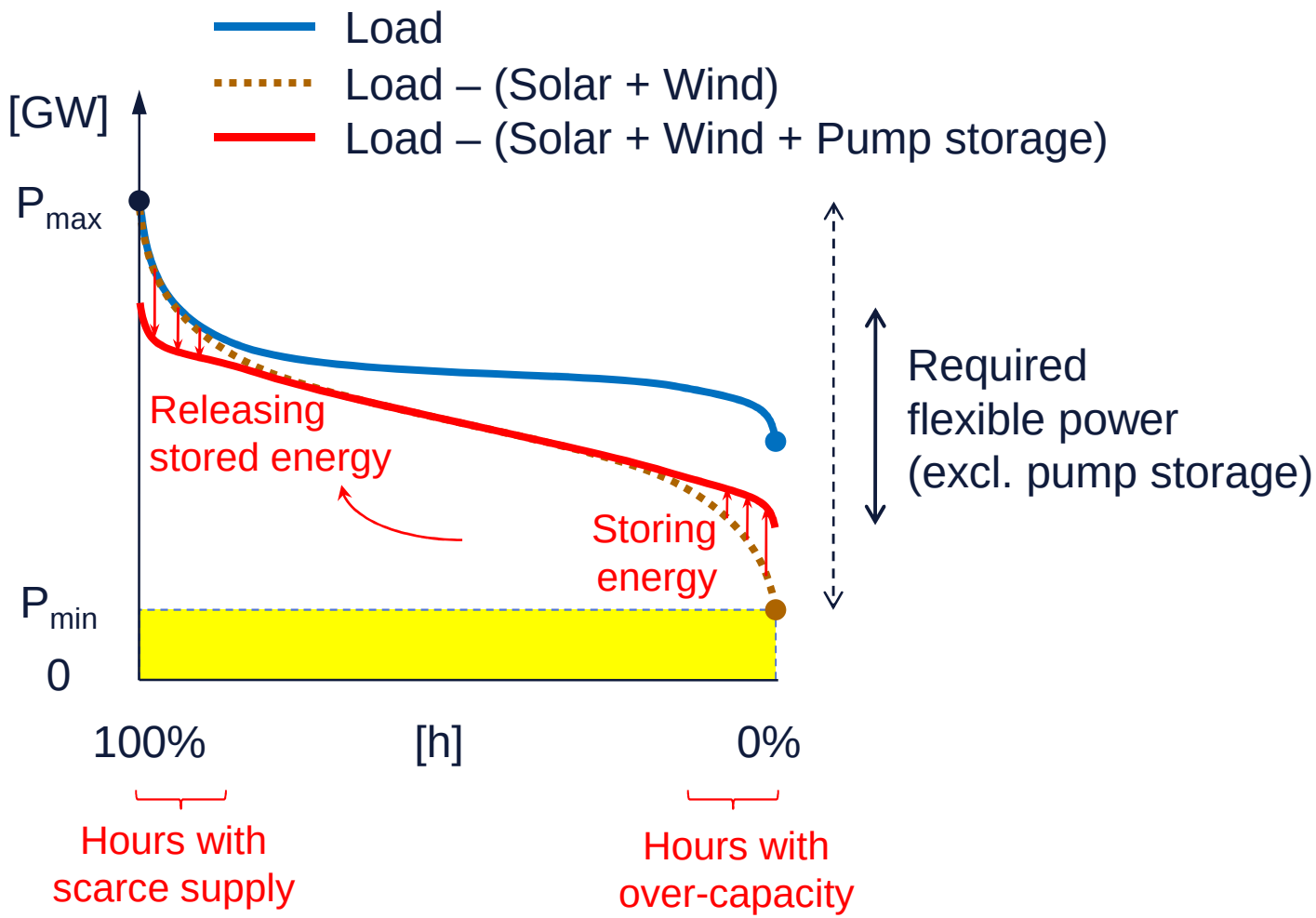
approx. 2 x Grande-Dixence!

Duration curve: New renewables decrease the need for base *energy*… but increase the need for flexible *power*

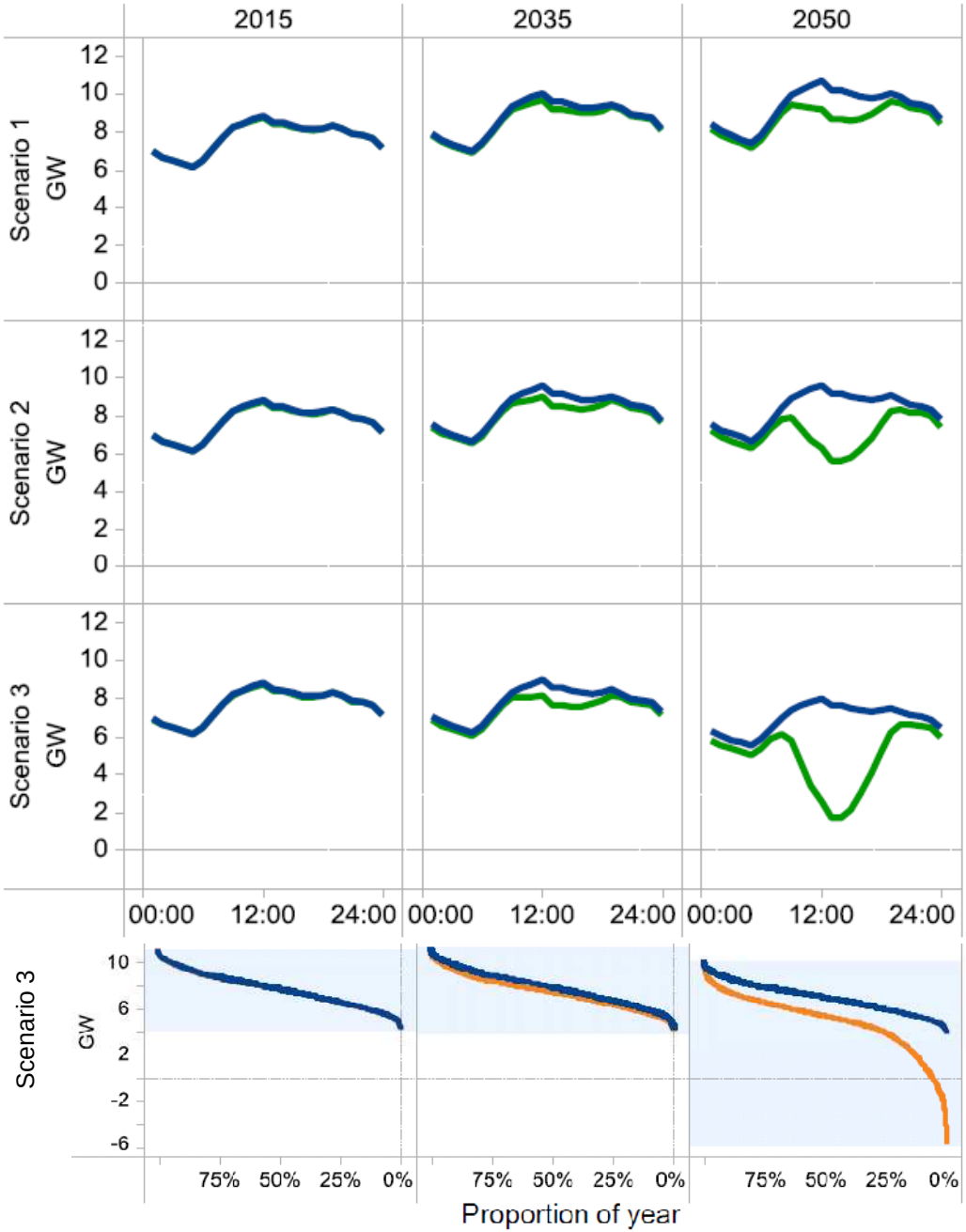




Moving energy over time:
Pump storage contributes to flexibility



Residual Load: intra-day & year changes

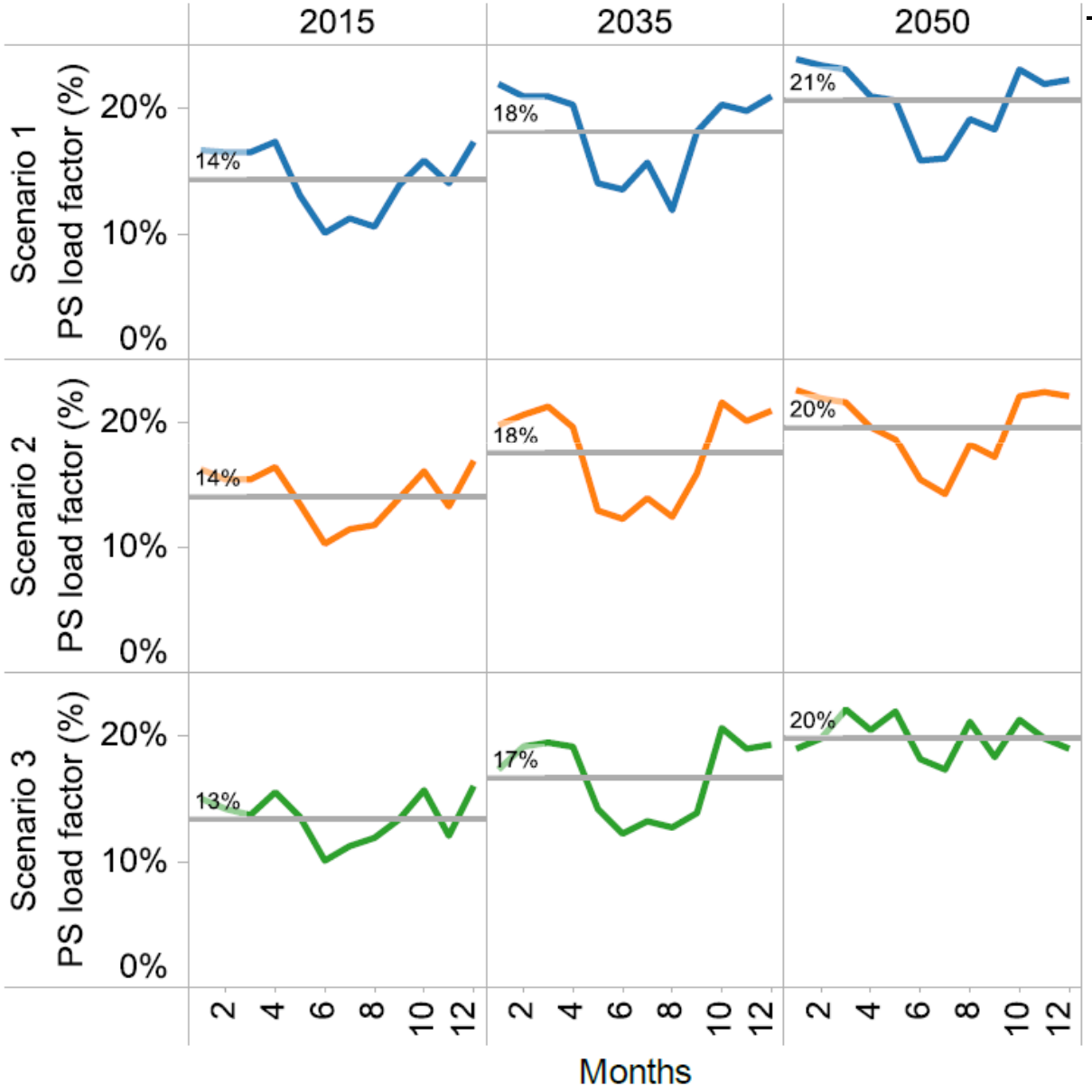


Demand

Demand net wind and solar

[Source: Pöyry, 2012]

Pump storage: Its load factor will increase, its seasonality will dampen



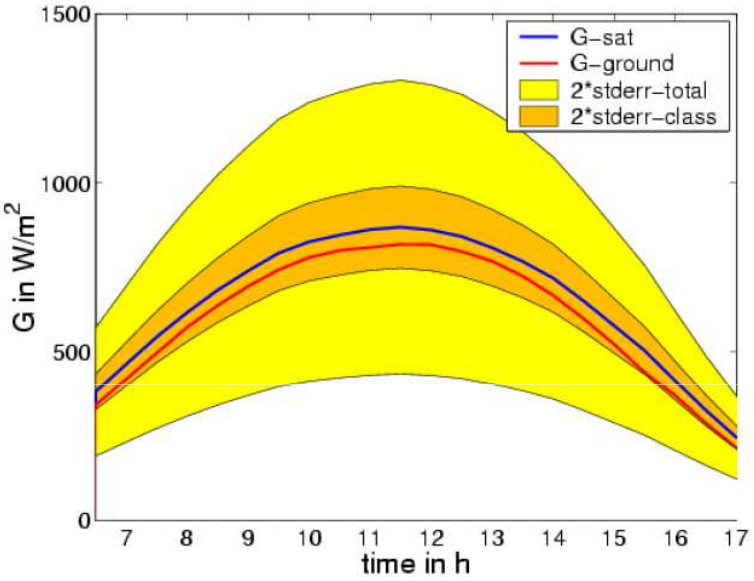
Demand for short-term balancing will increase due to growing *absolute* error of solar/wind production forecast (despite improvement of forecasts *relative* error)

Example:

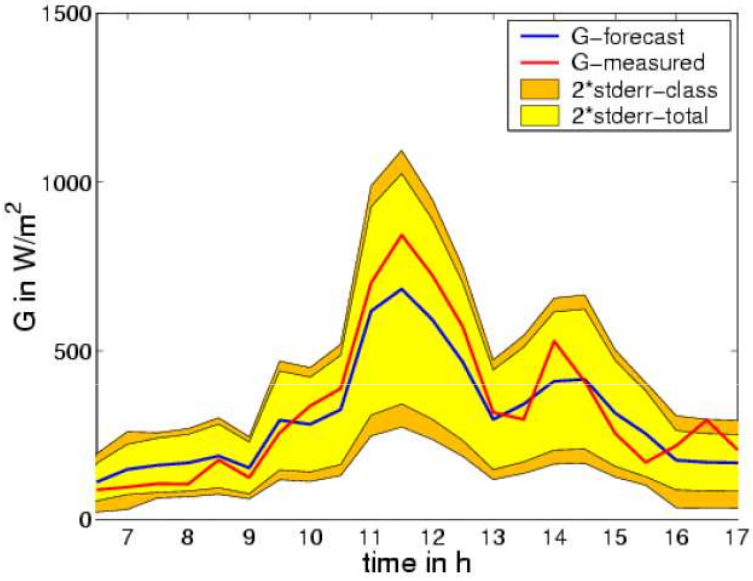
Solar short-term forecasting

(through satellite imaging, cloud motion vector)

Sunny day



Partly cloudy day



To compensate **intraday**-forecast error, the following (increasing) **additional balancing capacity** will be required:

- solar: ~ 8% of solar installed capacity, only 12 hours/day on avg
  5% activation rate (tertiary control)
- wind : ~ 10% of wind installed capacity
  5% activation rate (tertiary control)

[Source: Uni Oldenburg, Deutsche Bundesnetzagentur, Fraunhofer, Pöyry]

Finally –
Food for thought: Some key issues

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- Popular acceptation of future policy constraints?
  (grid, production sites, subventions, taxes, demand cut)

- Risk-taking readiness of investors?
  (regulatory and acceptation uncertainties)

- Fundamental capacity limit of high-voltage transmission networks?
  (support long-distance import of renewable energy)

- Fundamental stability limit of low-voltage distribution networks?
  (support injection of distributed renewable energy)