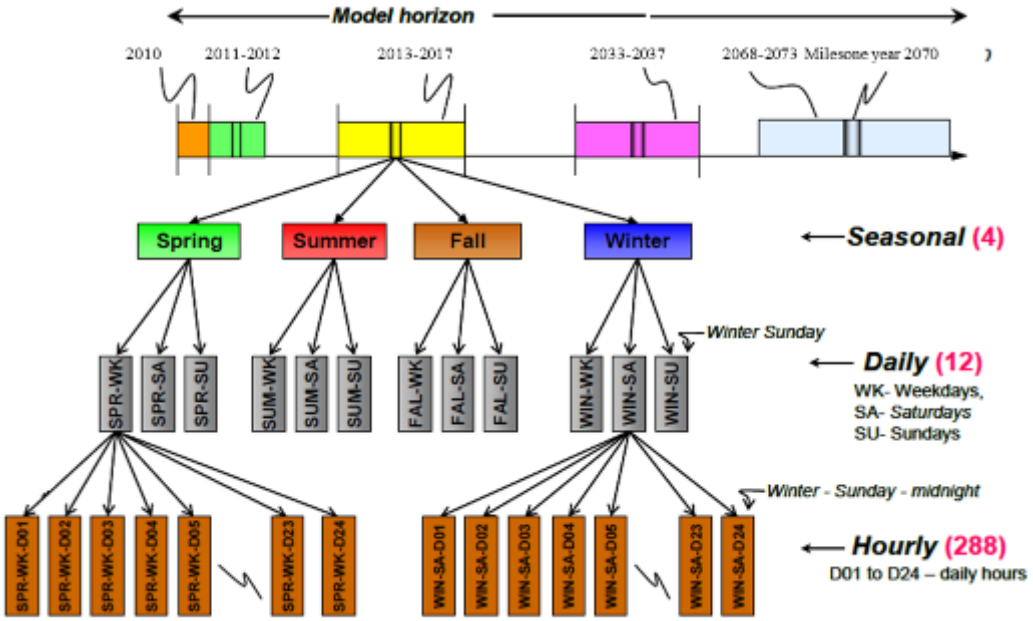
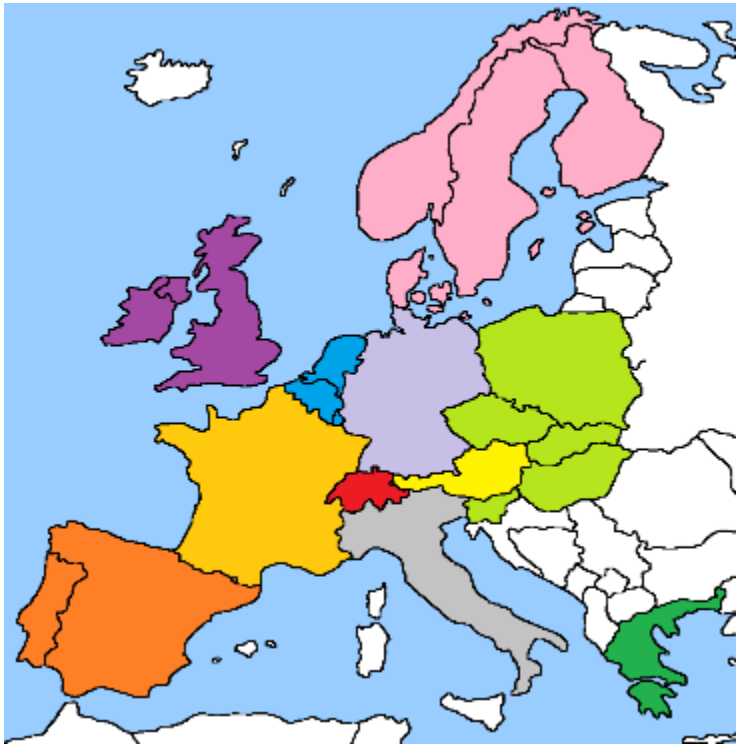
Business models for flexible production and storage
INSIGHT_E Policy Report

Paul Deane (UCC), Bo Normark (KIC InnoEnergy), Aurelie Faure (Ifri)

EUSTEM – European - Swiss TIMES Electricity Model

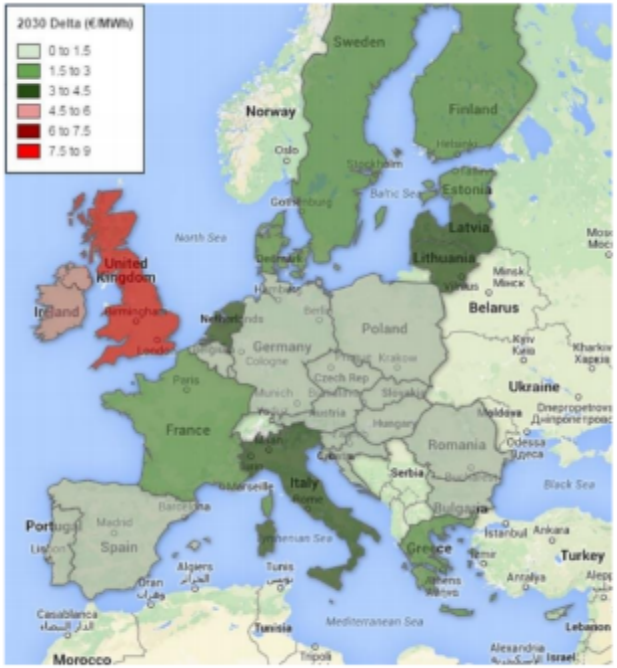
- 11 regions – Switzerland, Germany, France, Italy, Austria (collectively called CROSSTEM), BENELUX (Belgium, Netherlands, Luxemburg), EAST (Czech Republic, Polan, Hungary, Slovenia, Slovakia), SPAPO (Spain, Portugal), UKIRE (UK, Ireland), NORDIC (Norway, Sweden, Finland, Denmark) and GRE (Greece).
  - Long time horizon (2050+)
  - An hourly representation (288 timeslices)
  - Full electricity system (resource supply, renewable potentials and demands)
  - Calibrated for electricity demand & supply (2000-2010)





Future Market Modelling 2030 and 2050

PSI TIMES Electricity Model (EUSTEM)



UCC Integrated Gas and Electricity Model

Germany case study - Scenarios

•2 Scenarios selected for Analysis

- **Reference *(Ref)*** – No specific constraints on technology choice, nor any emission targets. Nuclear phase-out in Switzerland, Germany, Belgium, Sweden. Free market for electricity trade. CO_2 ETS price of 44 € / t CO_2
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- **Low Carbon *(LC)*** – Same as *Ref*, with a cap on the total CO_2 emission from electricity generation is applied across all regions. Level of decarbonisation to reach 60% of 1990 levels by 2030, 95% by 2050[2].

•1. EU Roadmap 2050 - http://ec.europa.eu/energy/energy2020/roadmap/doc/com_2011_8852_en.pdf

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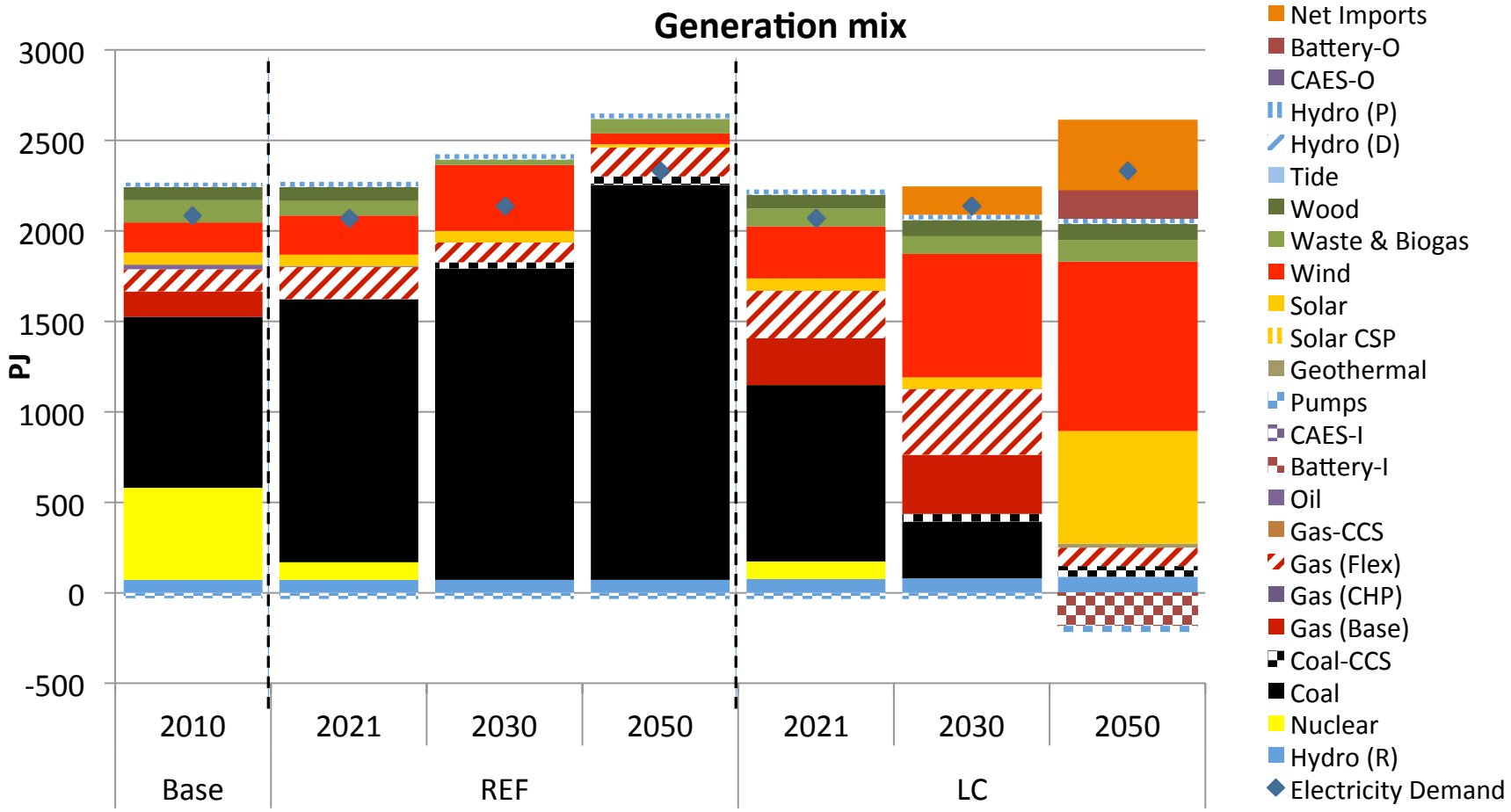
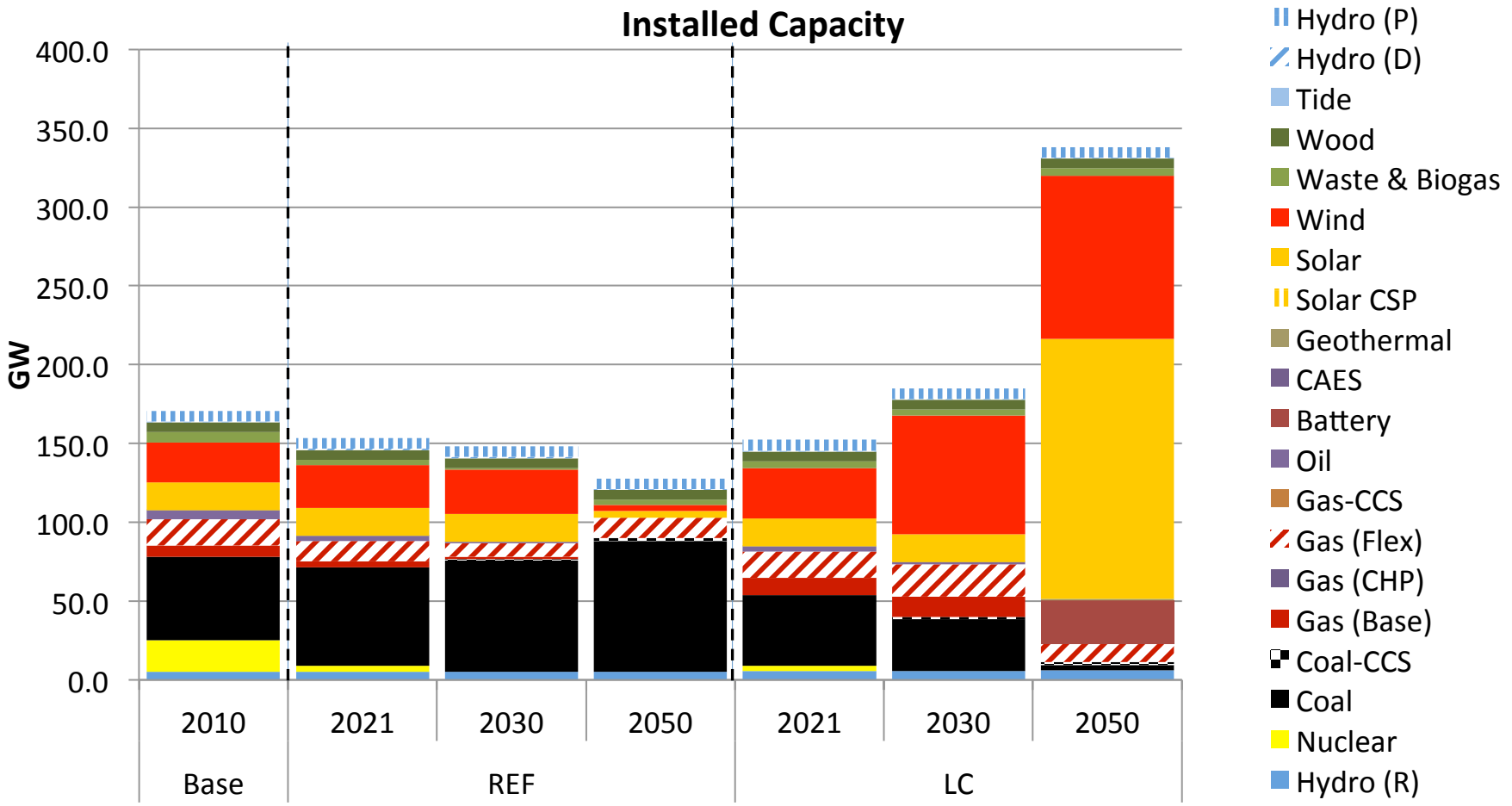
Germany case study – Results



- In a low carbon scenario, share of renewables is 78% of total generation mix by 2050.
- 6% of the total generation or 10% of generation from solar + wind generation is stored in batteries (2050).
- ~ 17% of the demand is met with imported-electricity from NORDIC (increased renewables, flexible generation) and BENELUX (high CCS potential, baseload generation) regions
- Besides batteries, around 4% of additional flexible generation is provided by dispatchable gas power plants.

Germany case study – Results



- In a reference case, coal would be the most cost-effective option, with renewables (solar PV and wind) the most expensive
- In a low carbon scenario, share of renewables is 83% of total installed capacity by 2050.
- Battery capacity of around 8% of total installed capacity and 10% of wind + solar capacities in 2050.

Results from the Market simulation model (UCC)

		Pumped Storage	Pumped Storage	Pumped Storage	Pumped Storage	Batteries	Batteries
		Germany	Germany	Germany	Germany	Germany	Germany
Property	**Units**	**2030 Reference**	**2030 CO2 Scenario**	**2050 Reference**	**2050 CO2 Scenario**	**2050 Reference**	**2050 CO2 Scenario**
Market Price	$/MWh	84.24	86.04	96.99	103.46	96.99	103.46
Annual Generation	GWh	5064	9482	5209	9112	0	47917
Number of Starts	-	5665	7303	6256	10794	0	727
Dispatchable Energy	GWh	5064	9482	5209	9112	0	129373
Undispatched Energy	GWh	0	0	0	0	0	81456
Hours of Operation	hrs	1348	1845	1201	1609	0	3113
Capacity Factor	%	9	16	9	16	0	14
Ramp Up	MW	1716600	2212719	1895551	3270688	0	13580318
Minutes of Ramp Up	minutes	47280	44940	40140	42060	0	101460
Ramp Down	MW	1716600	2212719	1895551	3270688	0	13580318
Minutes of Ramp Down	minutes	45720	46980	41880	43680	0	126480
Hours of Pump Operation	hrs	1556	2128	1575	1739	0	2521
Cost of Purchased Energy	$000	456354	815946	547302	308558	0	2720530
Average Price Received for Energy Sold	$/MWh	93	99	108	99	0	109
Gross Revenue	**$000**	468783	936646	562701	906672	0	5215923
Net Revenue	**$000**	12429	120700	15398	598114	0	2495384
Max Capacity	MW	303	303	303	303	0	39600
Installed Capacity	MW	6666	6666	6666	6666	0	39600

Key Contributions

- Model results reflect on importance of storage technologies (batteries). Around 10% of storage capacity required to cope with a generation mix consisting of a high share of intermittent renewables.

- Besides storage, other flexible generation technologies such as gas and hydro plants (~4% of total demand) and electricity imports (~17% of total demand) are required to balance the supply and demand.

- A capital outlay of ~ € 40 billion is estimated for investments in batteries during the period 2046 – 2055

- The net revenue from battery sources estimated from the market model is around € 2.5 billion for the year 2050, falling short of the required investment amount.

Conclusions

The modelling study report verifies findings from other studies that multiple benefits are required to justify battery storage.

- There is a clear correlation between the degree of RES penetration and the value of storage. This is illustrated by the difference in feasibility of storage between the reference scenario and the CO_2 scenario.
- Under current estimations of battery prices, there is no business case for battery storage up to 2030. Storage becomes attractive in selected markets in 2050.
- There are large variations between the countries which were investigated: Austria, France, Germany and Italy. The main reason is the significant difference in production mix and infrastructure.