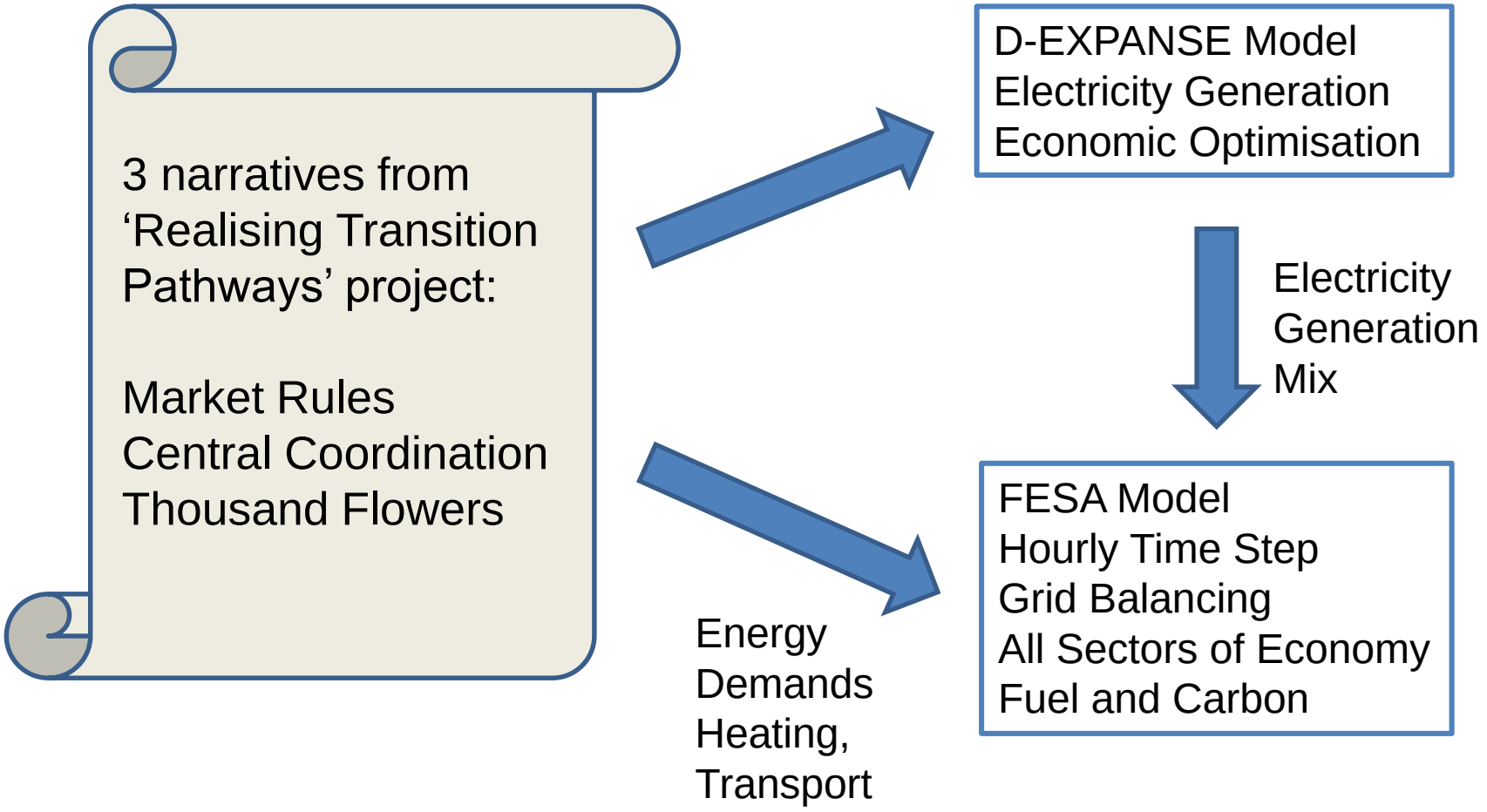
Synthesis of Qualitative Narratives and Quantitative Models into Consistent Descriptions of Low Carbon Energy Transitions

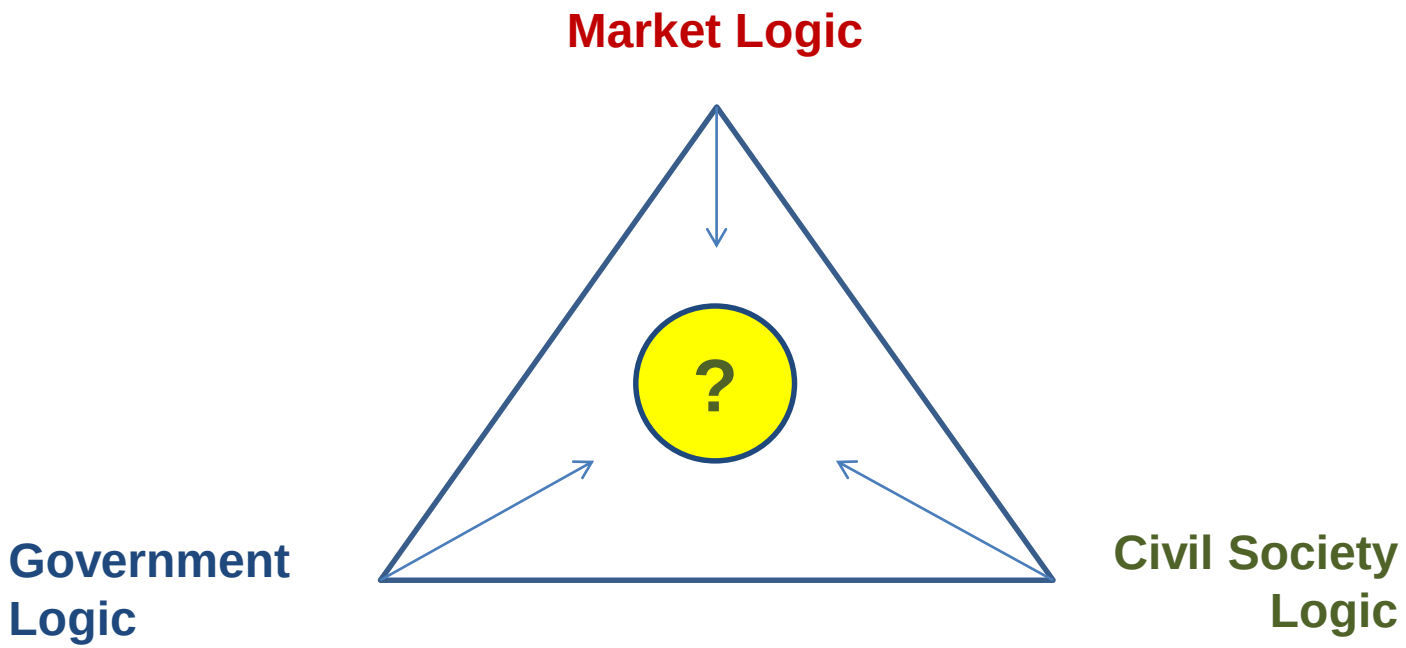
John Barton
CREST
Loughborough University
j.p.barton@lboro.ac.uk

Narratives and Models



The Transition Pathway Narratives

Based on the Realising Transition Pathways project, collaboration of 9 universities and E.On: http://www.lowcarbonpathways.org.uk/ and http://www.realisingtransitionpathways.org.uk/

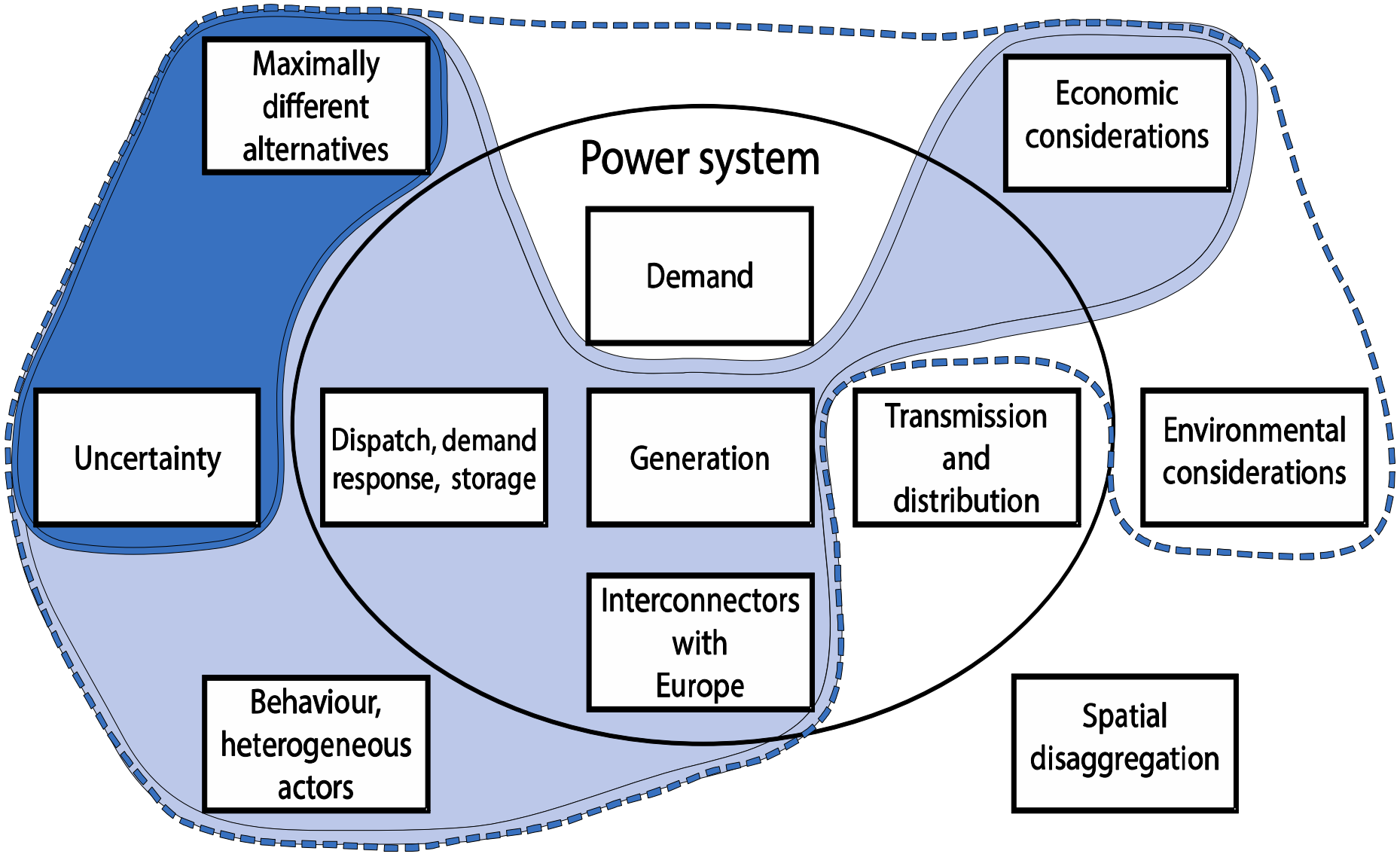


Source: Jacquie Burgess & Tom Hargreaves – Transition Pathways Project

Governance narratives

- **“Market Rules”** storyline envisions that market-led logic will deliver low-carbon transition with the focus on large-scale low-carbon generation;
- **“Central Co-ordination”** storyline envisions increased role of the government in shaping this transition through contracts for large-scale low-carbon generation;
- **“Thousand Flowers”** storyline envisions the wider civic society, including households, communities, local governments and non-governmental organizations, playing a leading role through bottom-up initiatives and focus on smaller-scale generation.

D-EXPANSE



Picture: Evelina Trutnevyte – Transition Pathways Project

EXPANSE model (Trutnevyte, 2013; Trutnevyte and Strachan, 2013)

EXploration of **PA**tterns in **N**ear-optimal energy **S**c**E**narios

- Bottom-up, technology rich, cost-optimisation model
- Includes exploration of near-optimal pathways, e.g. that have up to 20% higher total system costs
- Selects a smaller set of maximally-different pathways

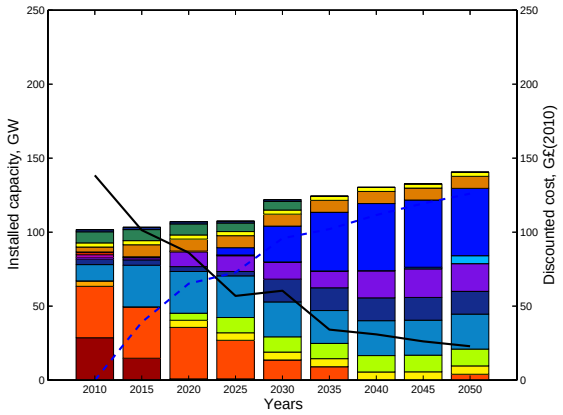
Trutnevyte E., 2013. Applied Energy 111; 593-601.
Trutnevyte E., Strachan N., 2013. Paper for the International Energy workshop, 19-21 June 2013, Paris, France

‘Translation’ of narratives into modeling inputs for D-EXPANSE

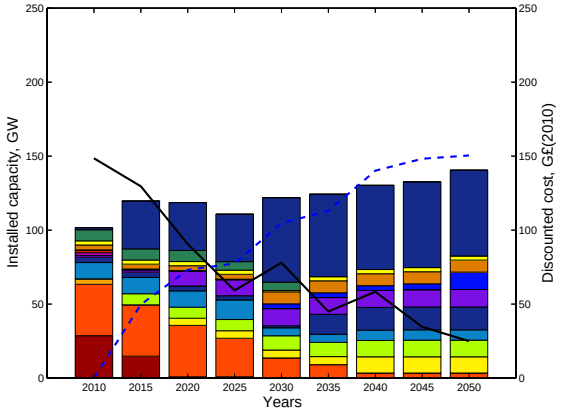
	Market Rules			Central Co-ordination			Thousand Flowers		
	2020	**2030**	**2050**	**2020**	**2030**	**2050**	**2020**	**2030**	**2050**
Minimum installed capacity, GW	106	130	174	103	122	141	107	134	149
Annual electricity generation and import, TWh/year	404	469	560	380	425	448	334	341	328
Share of coal CCS, %	≥10%			≥10%			-		
Share of gas CCS, %	≥10%			≥10%			-		
Share of nuclear, %	≥10%			≥10%			-		
Share of offshore wind, %	≥10%			≥10%			≥10%		
Share of onshore wind, %	-			-			≥10%		
Share of solar PV, %	-			-			≥5%		
Share of renewable-based CHPs %	-			-			≥10%		
Maximum greenhouse gas emissions, gCO_2/kWh	300	70	20	300	70	20	300	70	20

Central Co-ordination Installed Capacities, GW

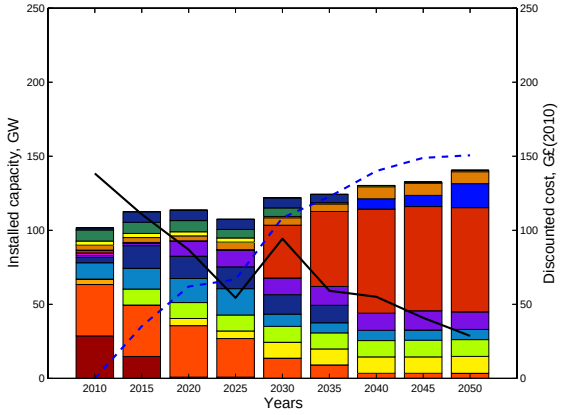
Cost-optimal



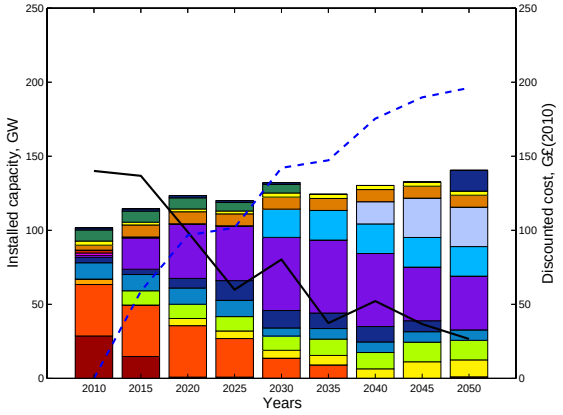
Maximally different 1

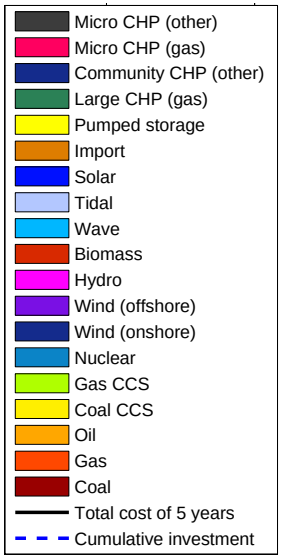


Maximally different 2



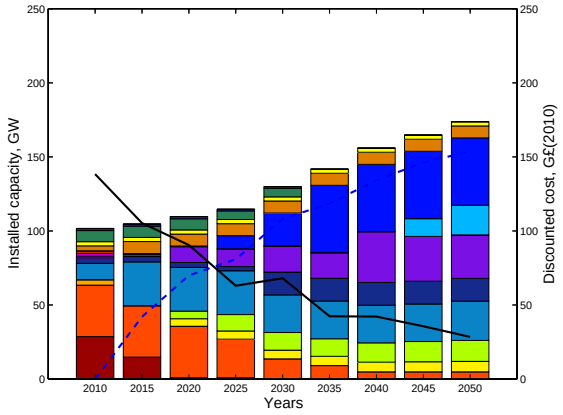
Maximally different 3



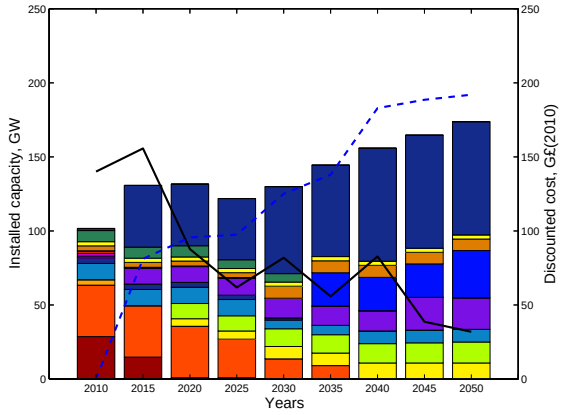


Market Rules

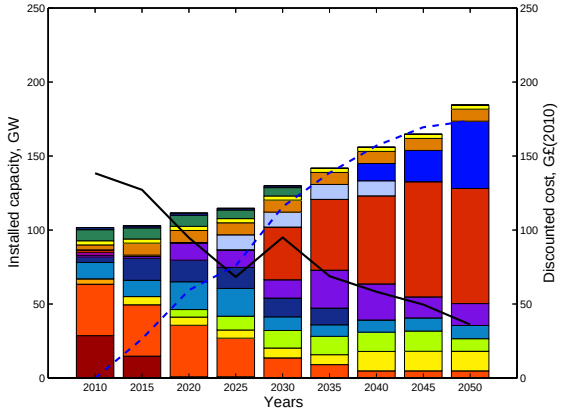
Cost-optimal



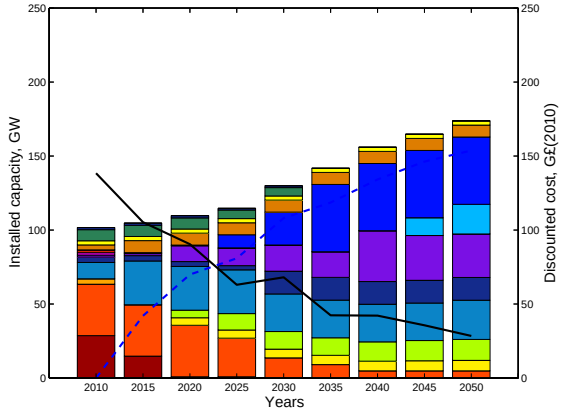
Maximally different 1

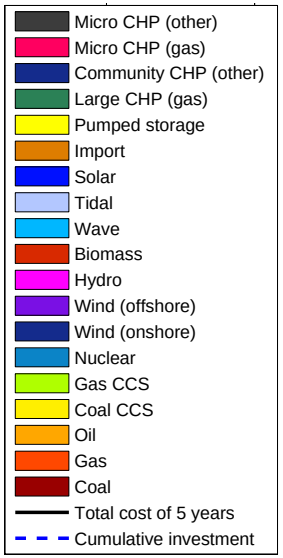


Maximally different 2



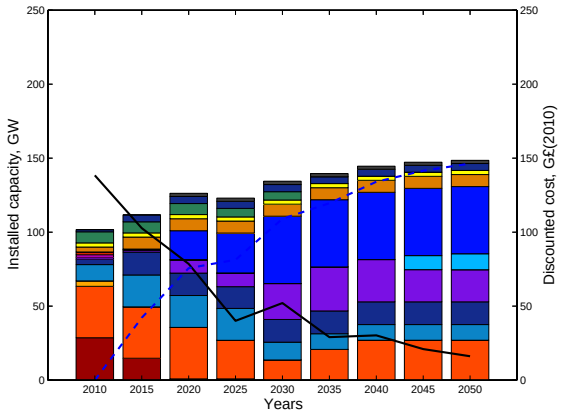
Maximally different 3



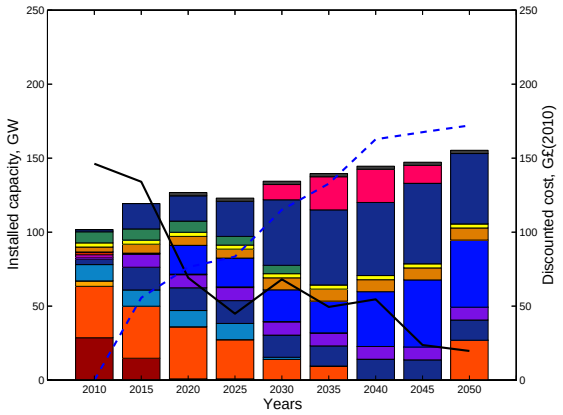


Thousand Flowers

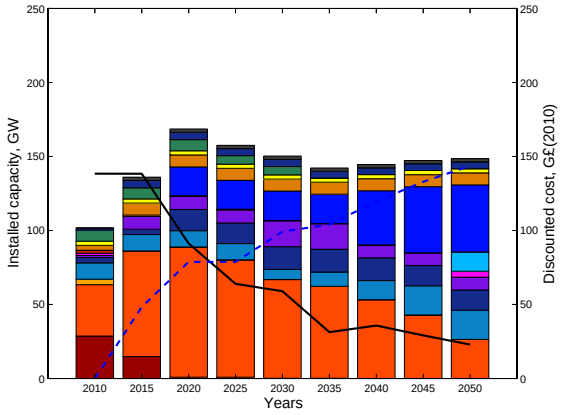
Cost-optimal



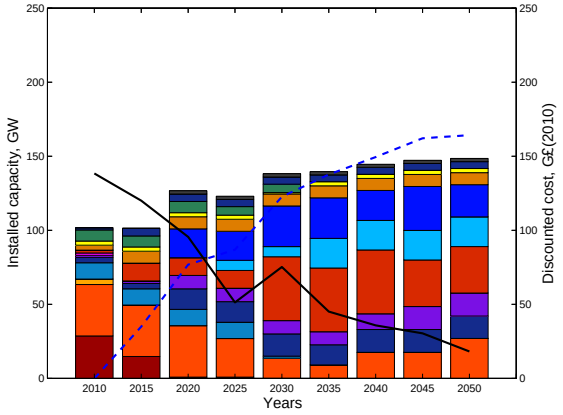
Maximally different 1

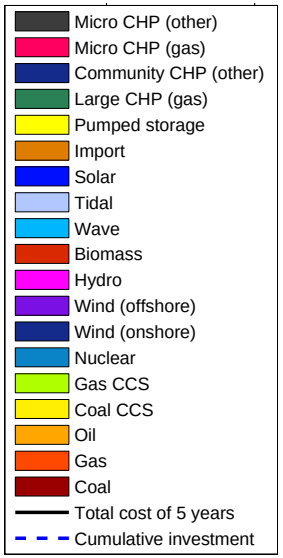


Maximally different 2

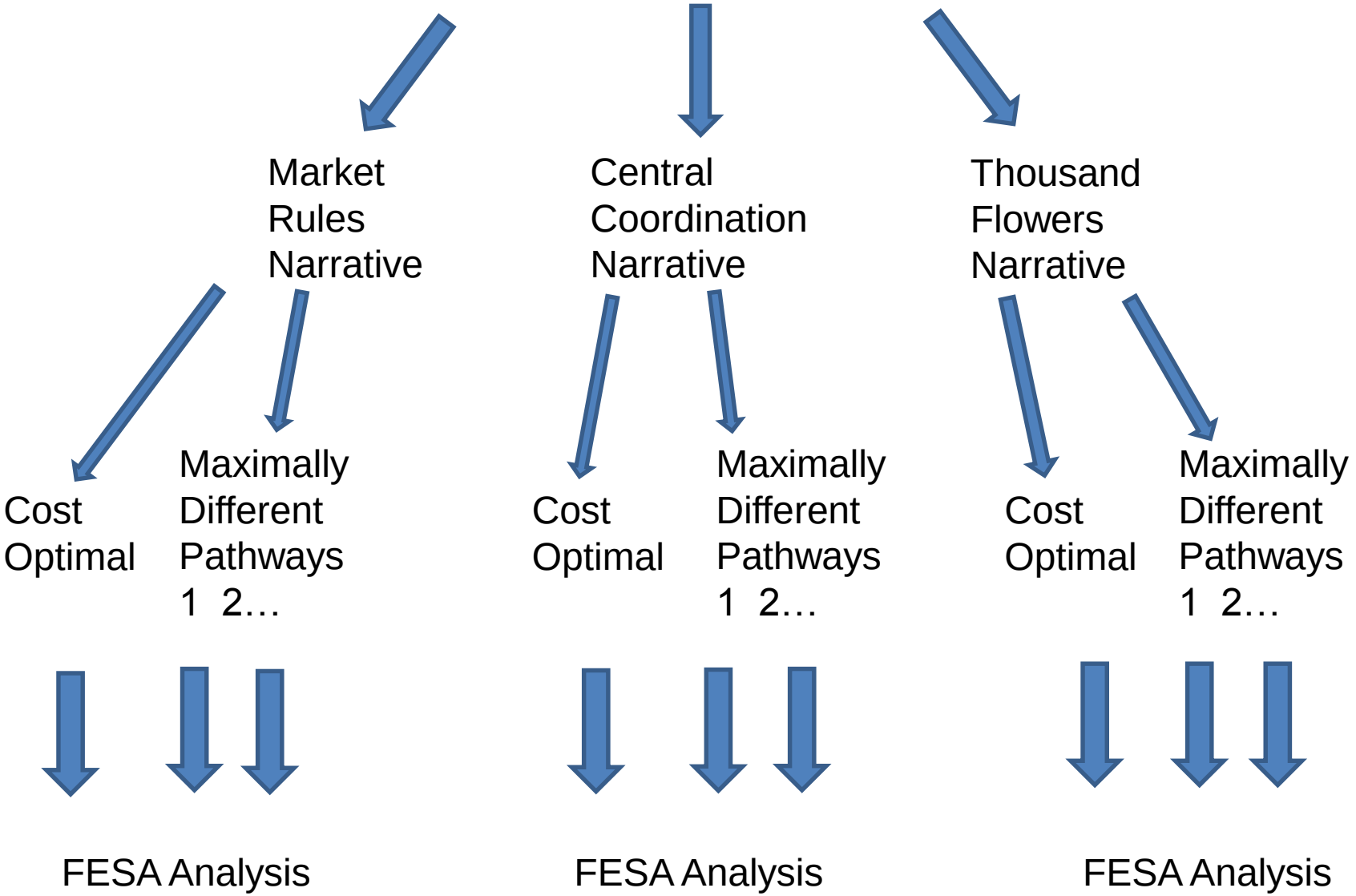


Maximally different 3

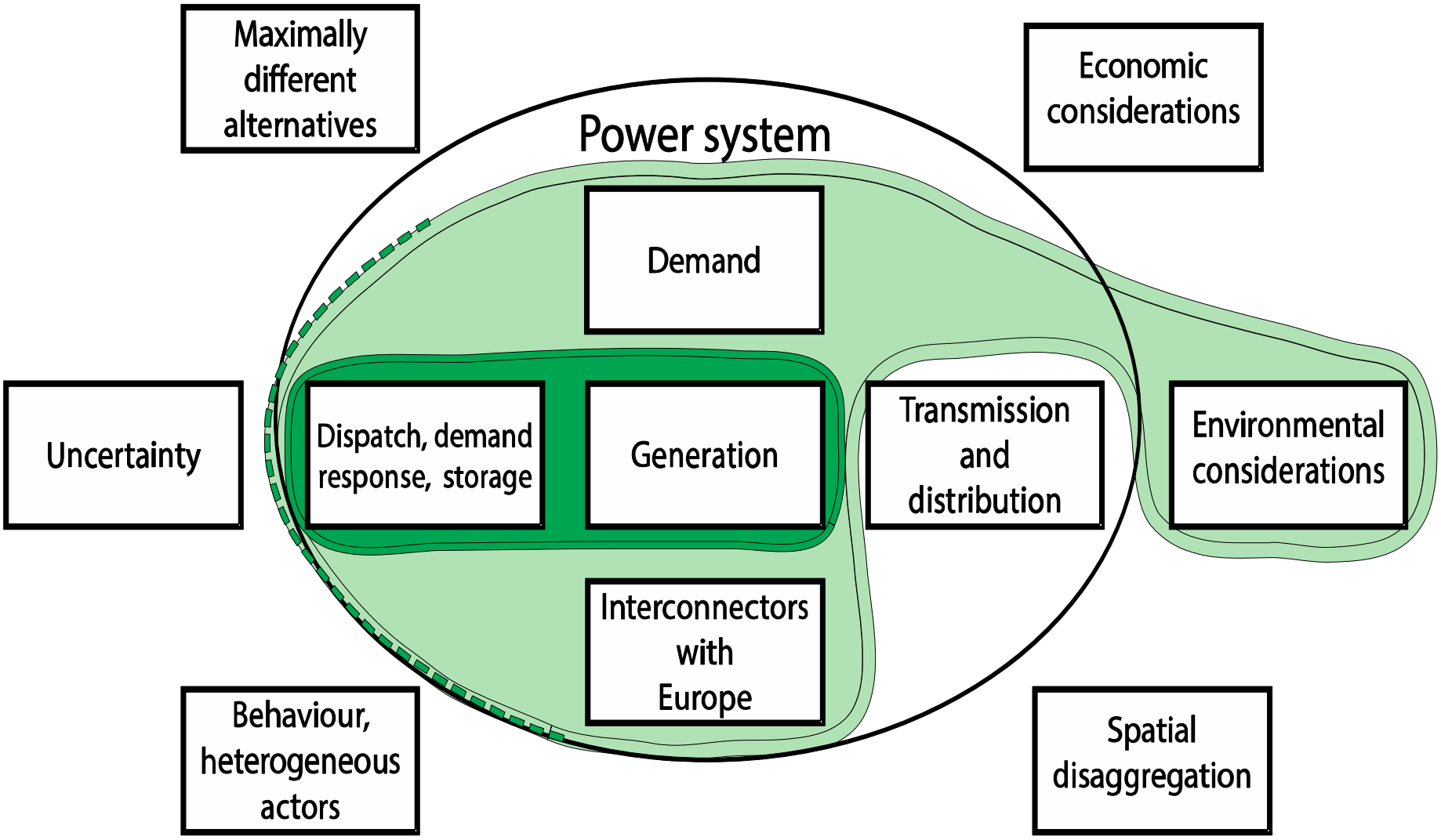




9 Alternative Pathways, 2010 to 2050



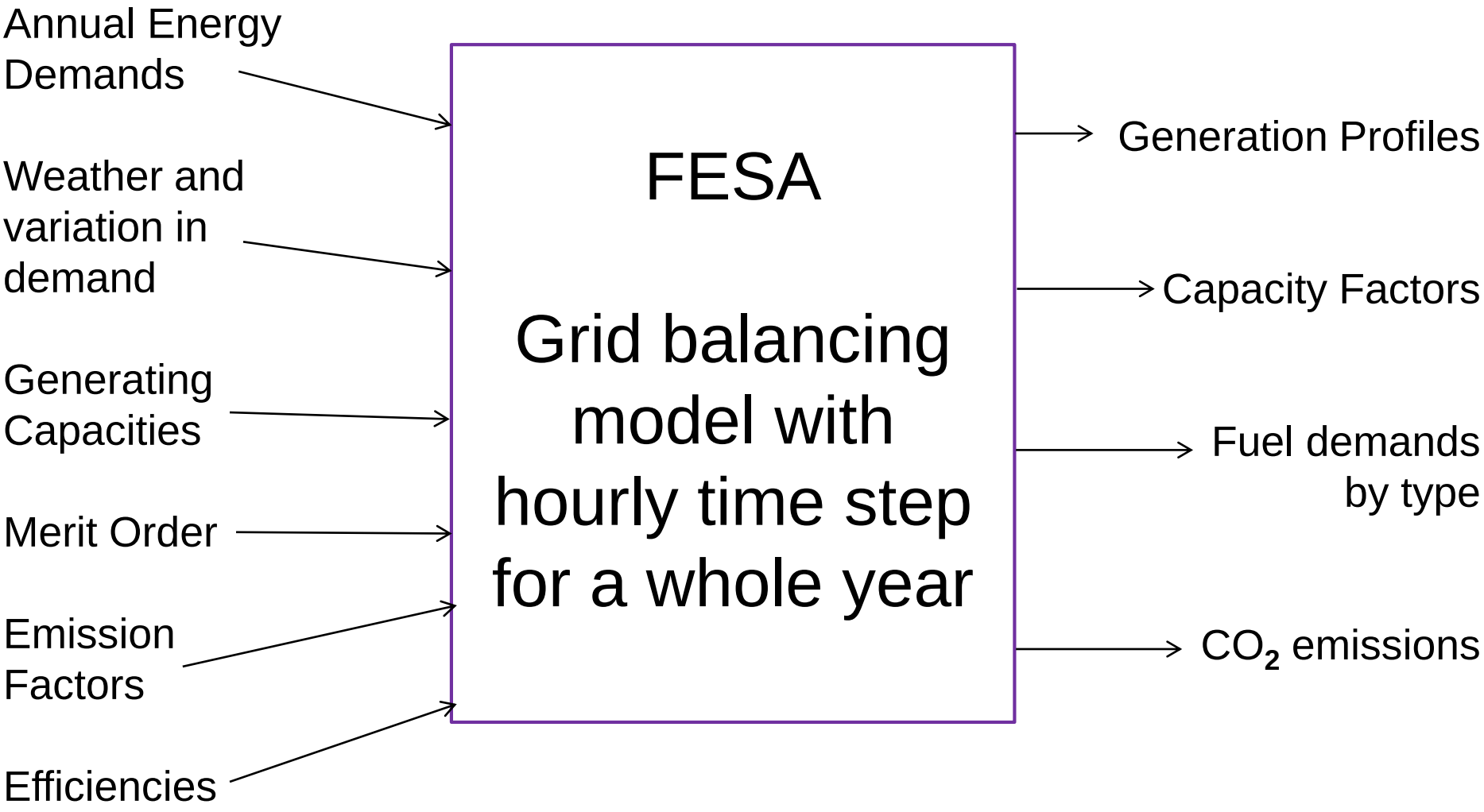
FESA



Picture: Evelina Trutnevyte – Transition Pathways Project

‘FESA’ = Future Energy Scenario Assessment

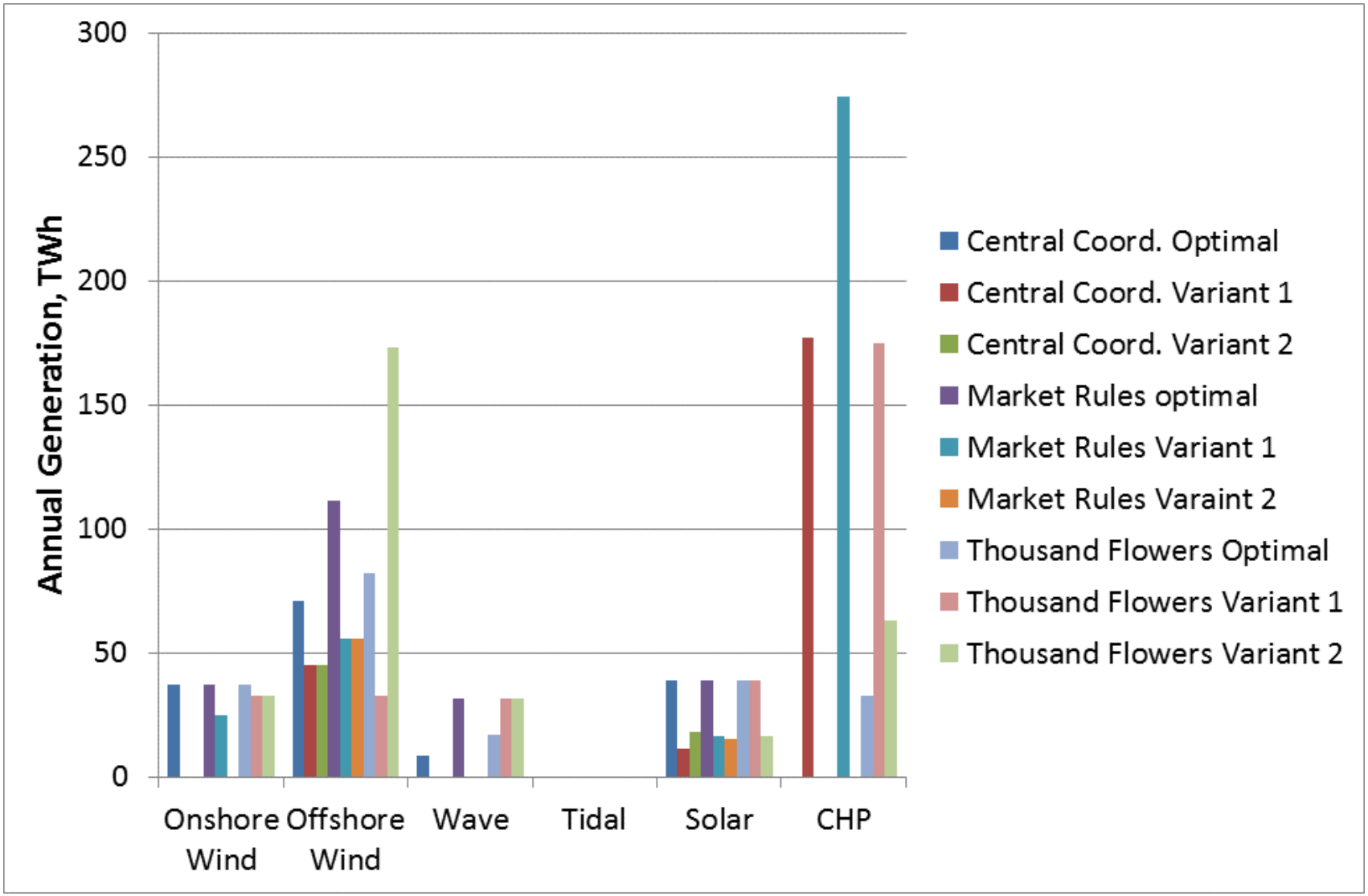
(Barnacle et al., 2013; Barton et al., 2013)



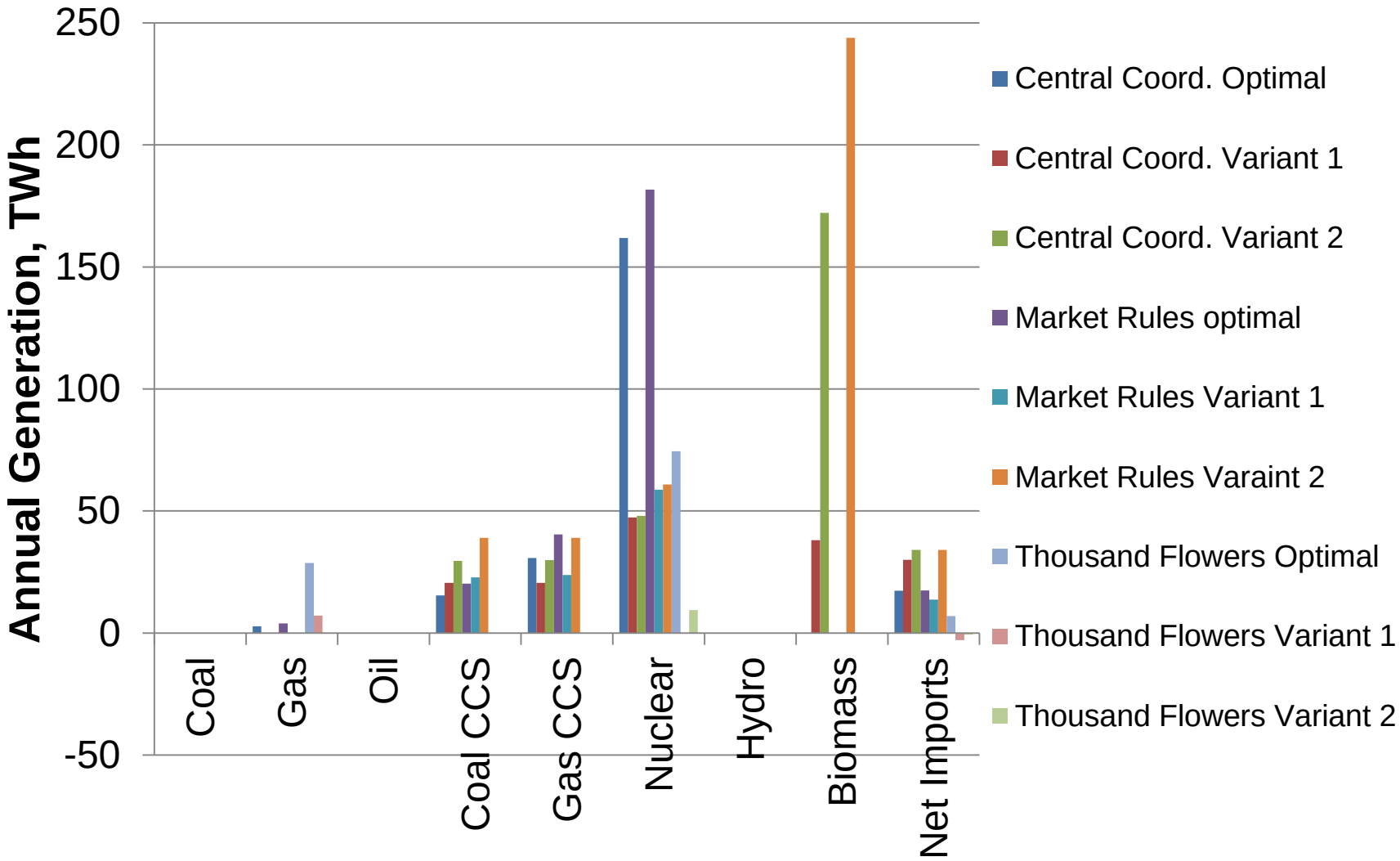
Linking with FESA

- Take generation capacities from D-EXPANSE
- Take technology efficiencies, availabilities and turn-down ratios from D-EXPANSE
- Take total electricity demand from D-EXPANSE
- Use previous FESA values for non-electric energy use, separately translated from the narratives.

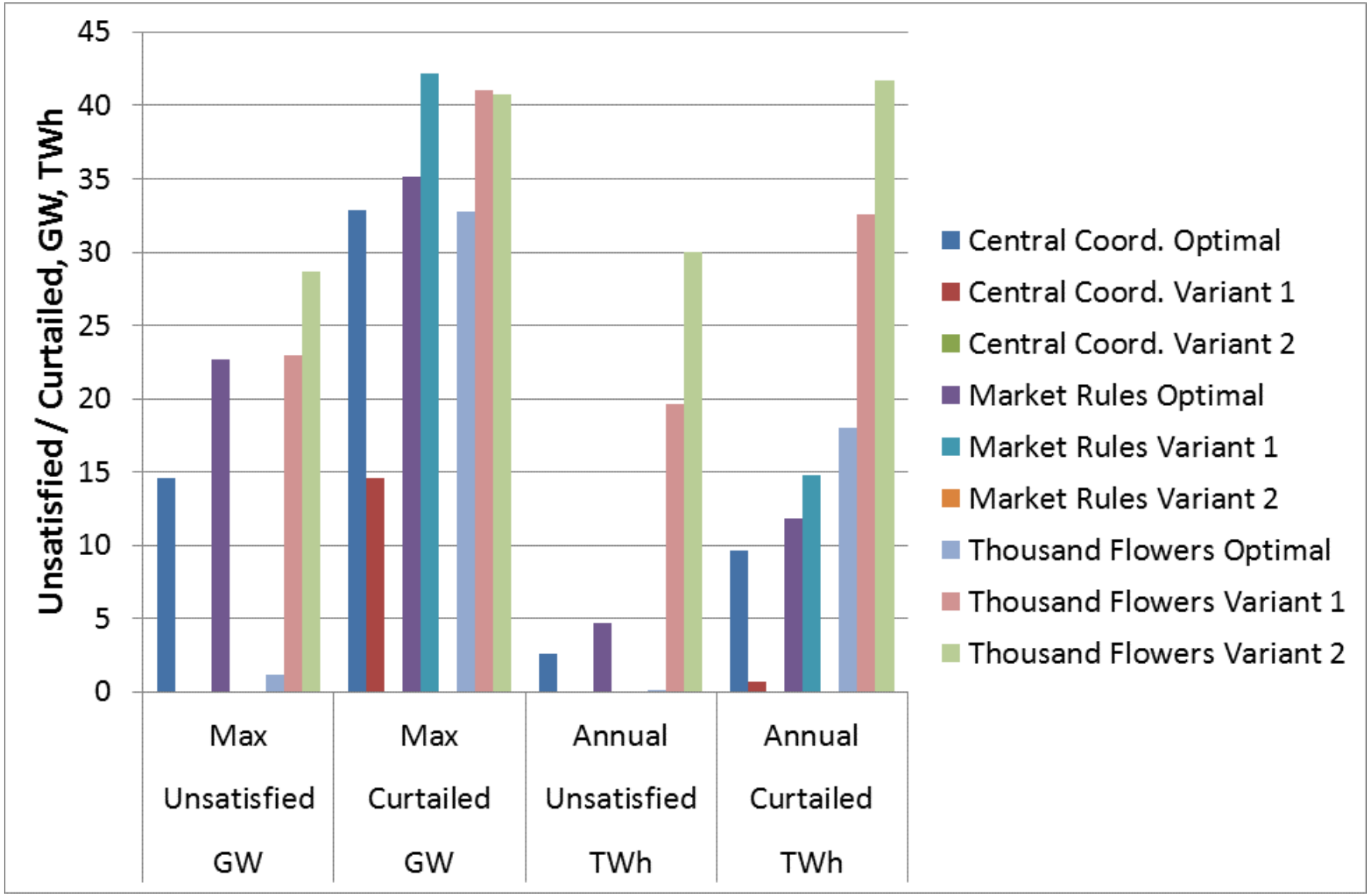
Inflexible and Uncontrolled Generation Components in 2050



Flexible, Despatchable Generation Components in 2050

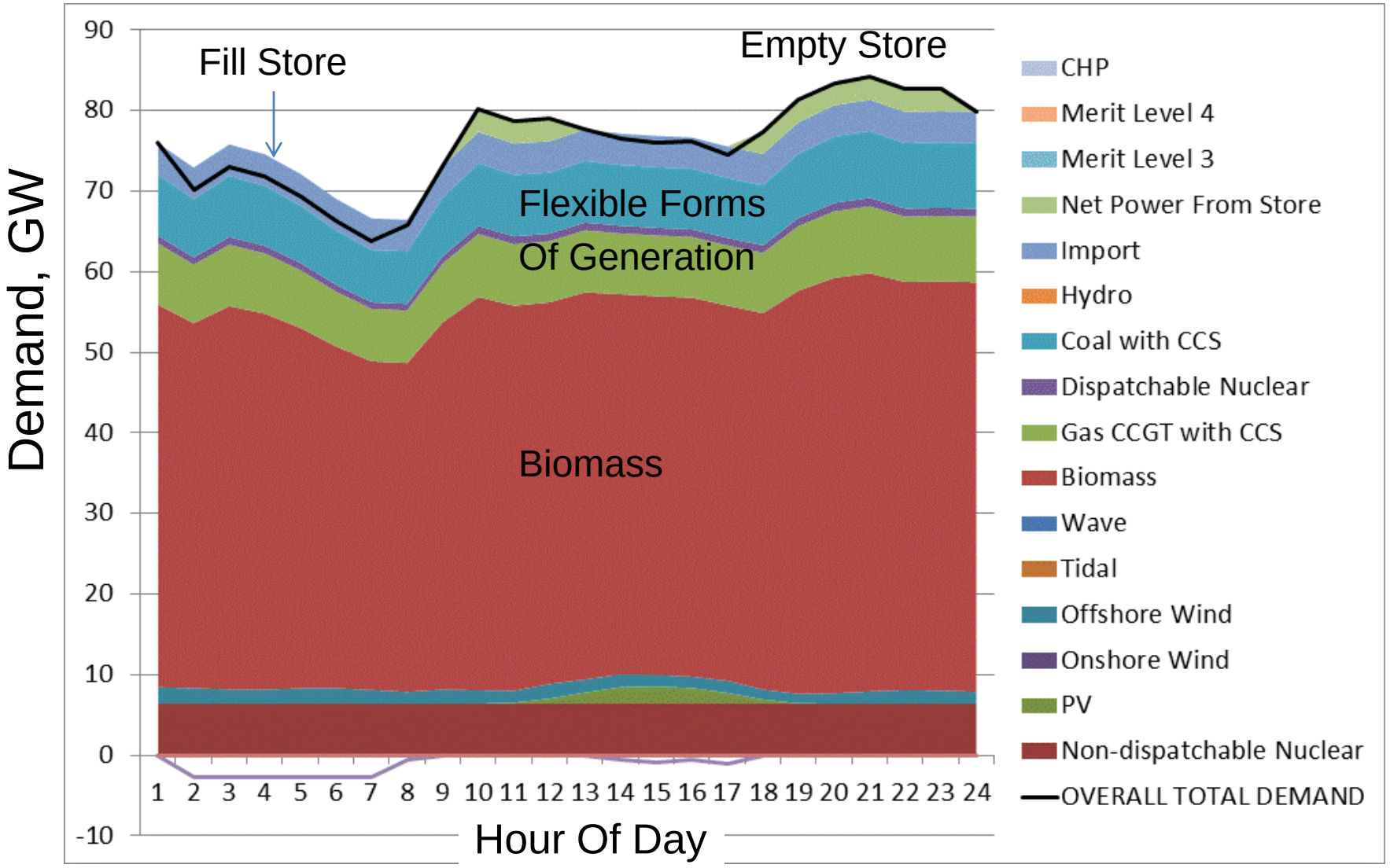


Remaining Imbalances After Energy Storage in Year 2050



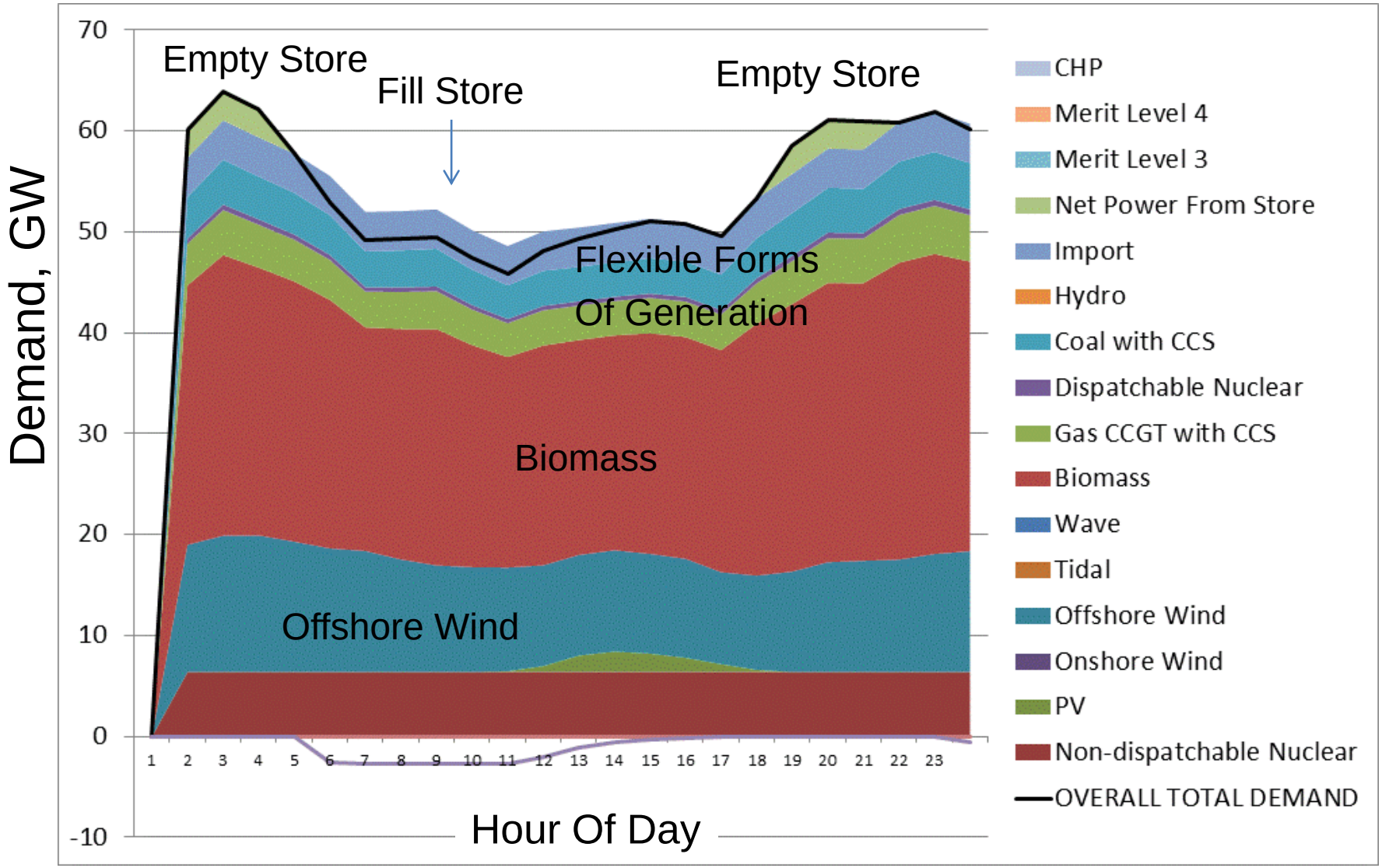
Market Rules Variant 2 on 18th January

(Day of Highest Net Demand, 2050)

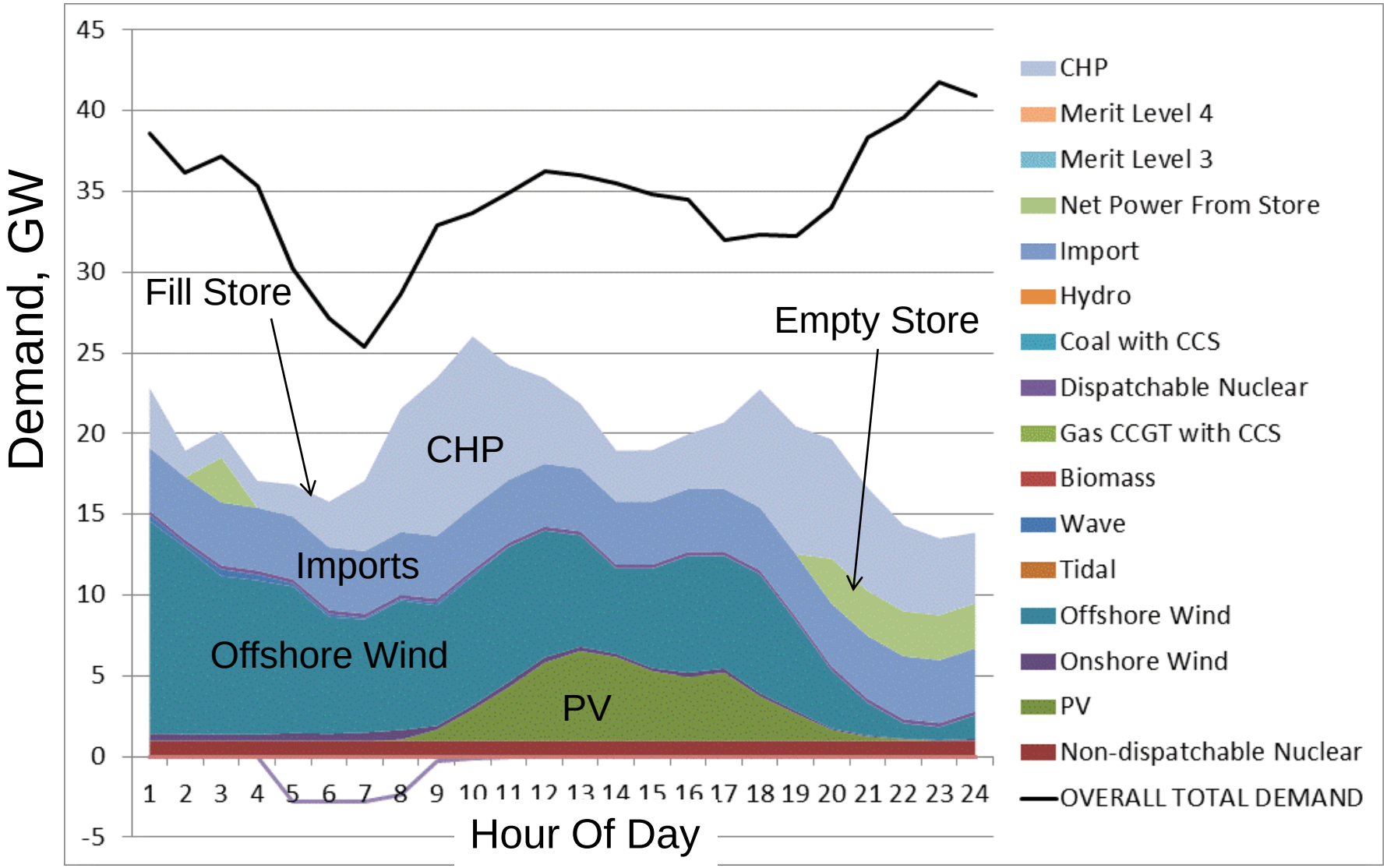


Market Rules Variant 2 on 1st January

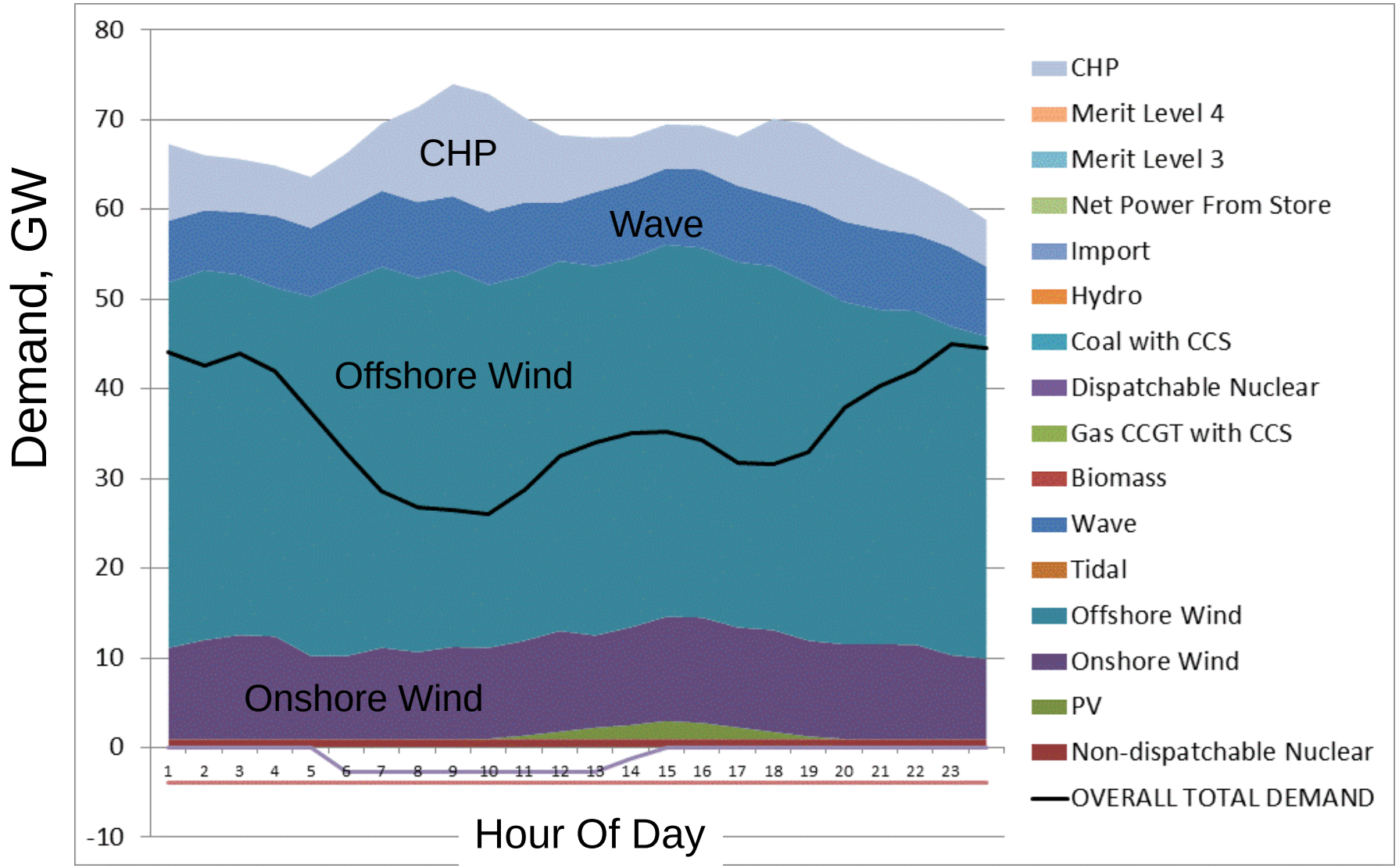
(Day of Lowest Net Demand, 2050)



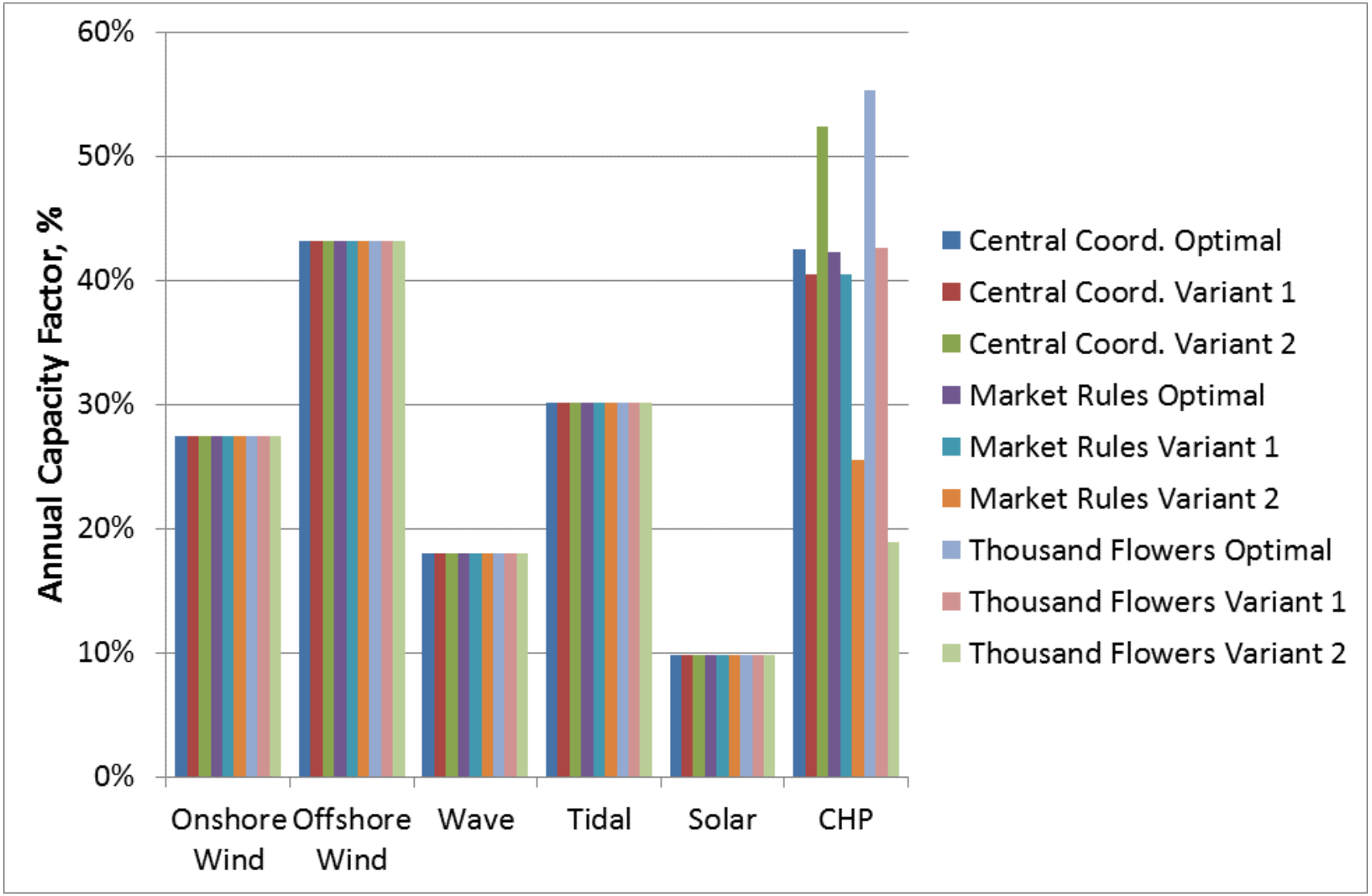
Thousand Flowers Variant 2 on 21st September
(Day of Highest Net Demand, 2050)



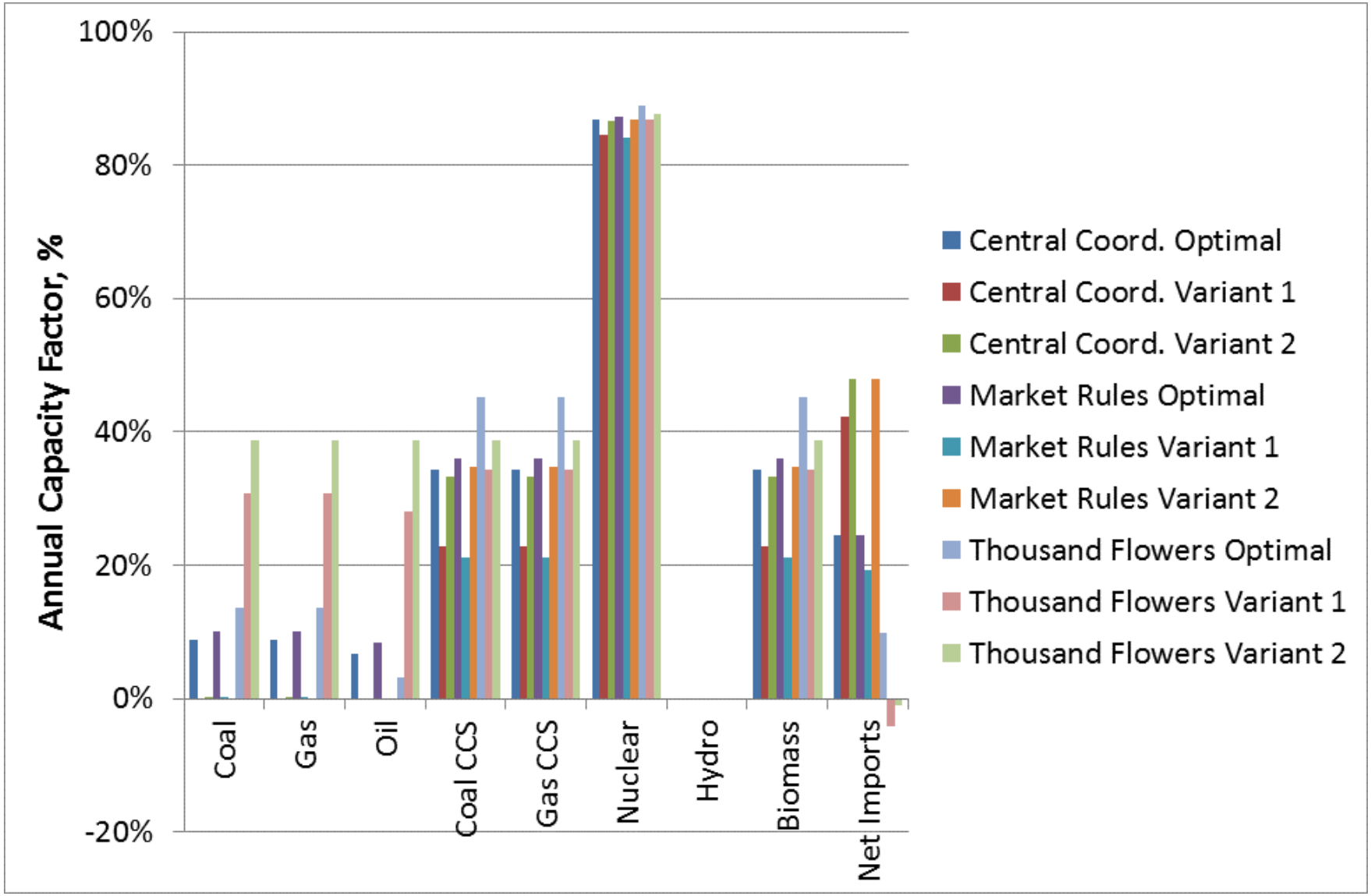
Thousand Flowers Variant 2 on 11th February
(Day of Lowest Net Demand, 2050)



Capacity Factors of Inflexible Generation (Mostly unchanged across pathways)



Capacity Factors of Flexible Generation



Conclusions

- Market Rules and Central Coordination by their technology priorities and pathways are relatively similar
- Thousand Flowers is the most different pathway
- Detailed analysis in FESA shows that variations perform very differently (system imbalance)

Future research needs

- Explore how to ‘translate’ narratives into modeling parameters even more systematically
- Extend translation to transport, heat and industrial uses of energy
- Use FESA to select only the viable maximally different pathways.
- Feedback to the narratives in order to improve their consistency