

A wide-angle photograph of an offshore wind farm. In the foreground, a large, cylindrical service vessel with a metal cage-like structure is positioned in the water. The vessel has the name 'VATTENFALL' and a logo on its side. In the background, numerous wind turbines are visible, stretching across the horizon. The water is dark, and the sky is overcast. The overall scene is industrial and maritime.

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Energy Storage and Wind Power

Bart Ummels

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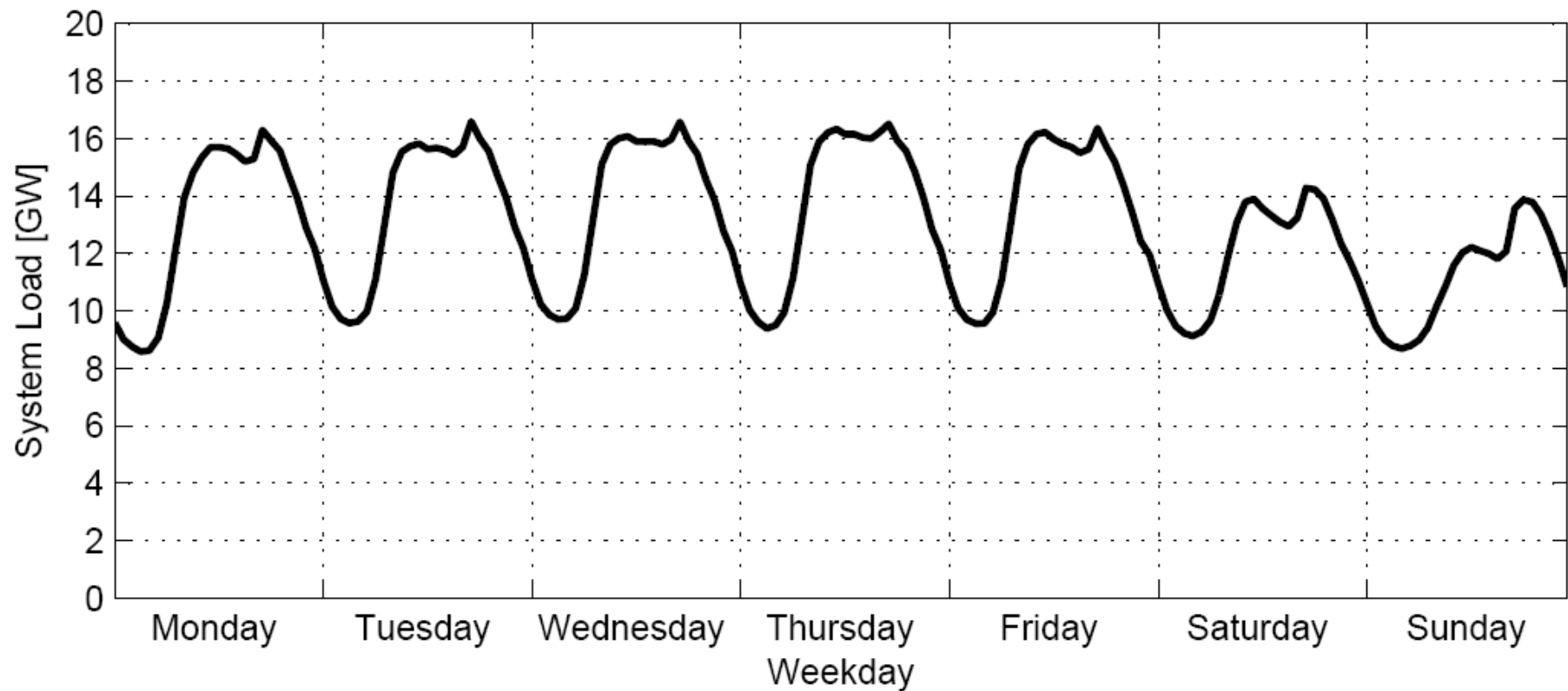
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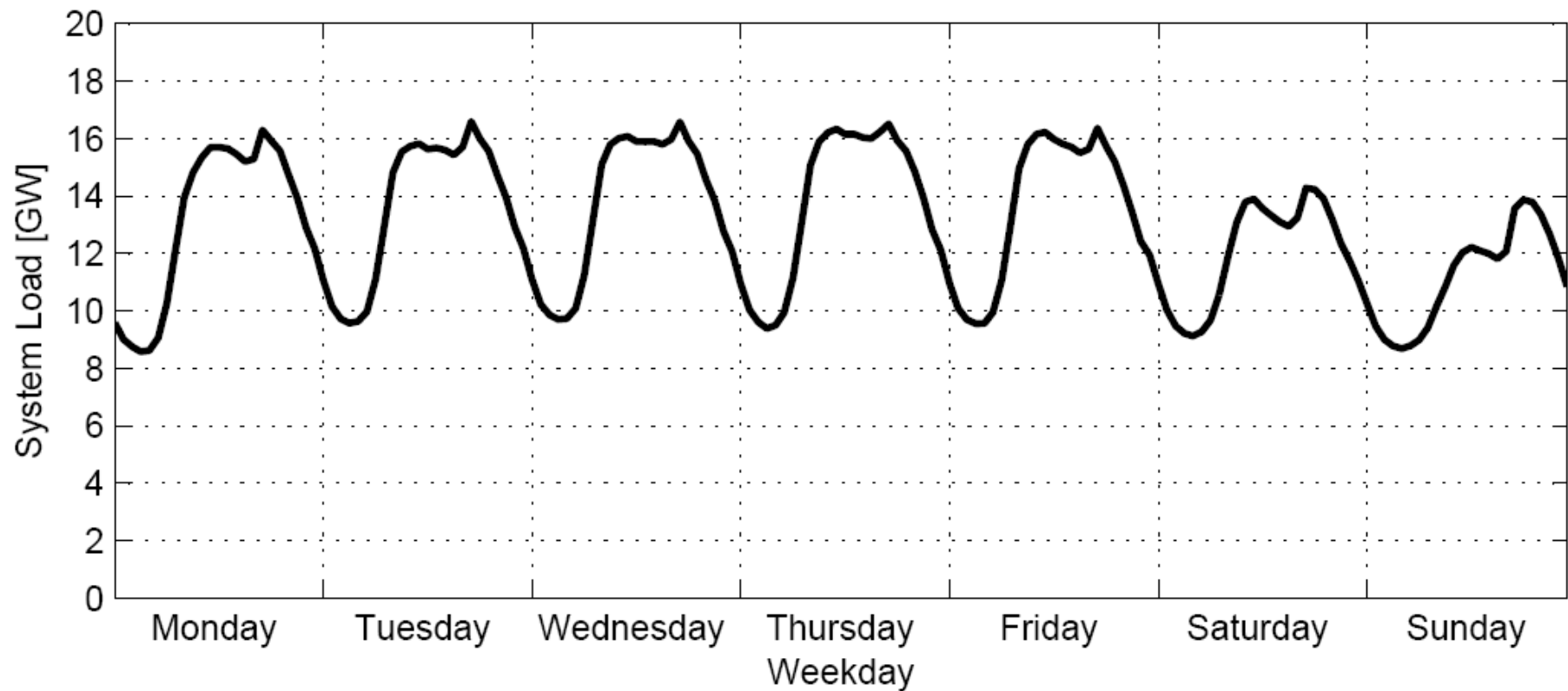
Variability

Power System Operation



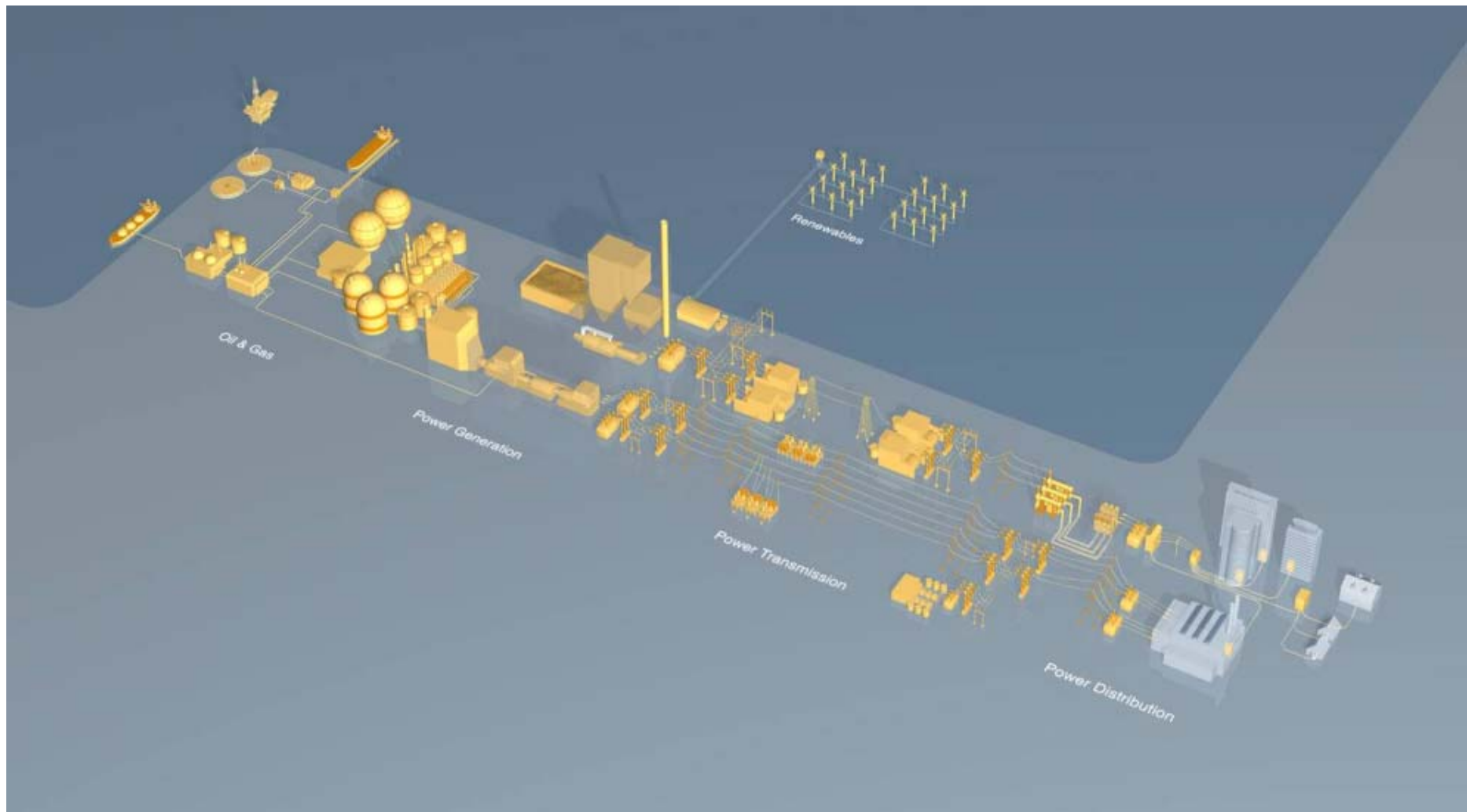
Generation = Load

Power System Operation



Unpredictability

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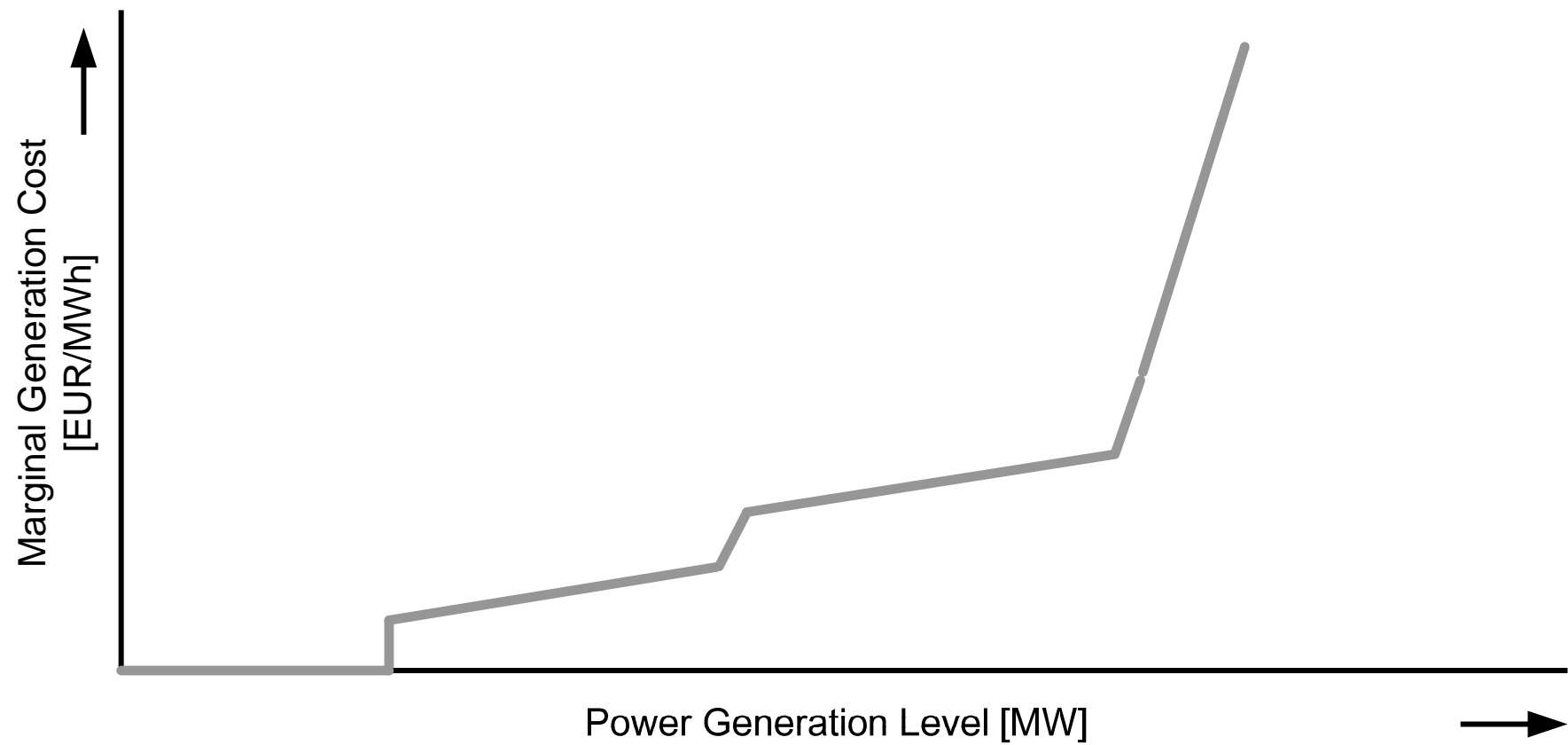


Wind Power

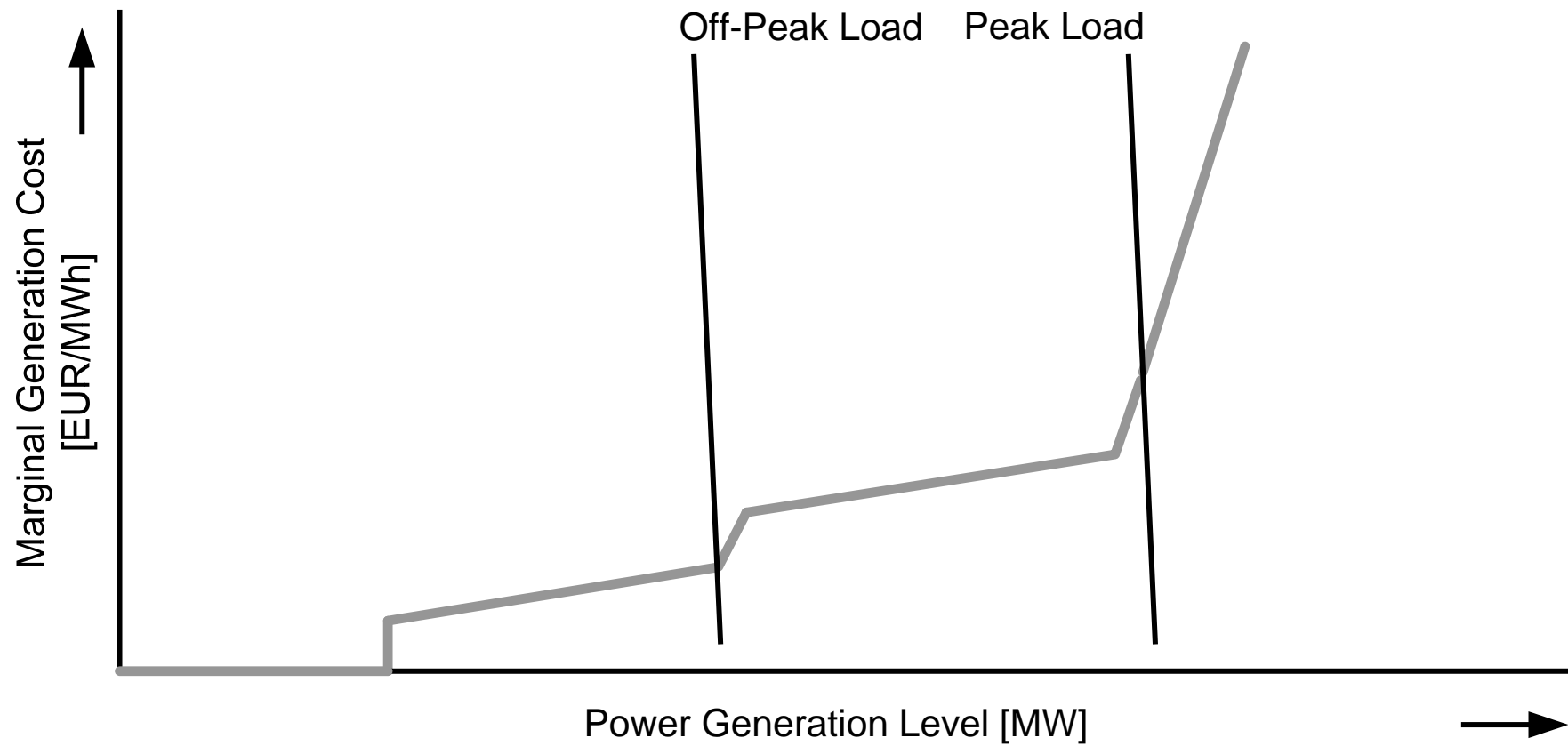


Marginal Cost

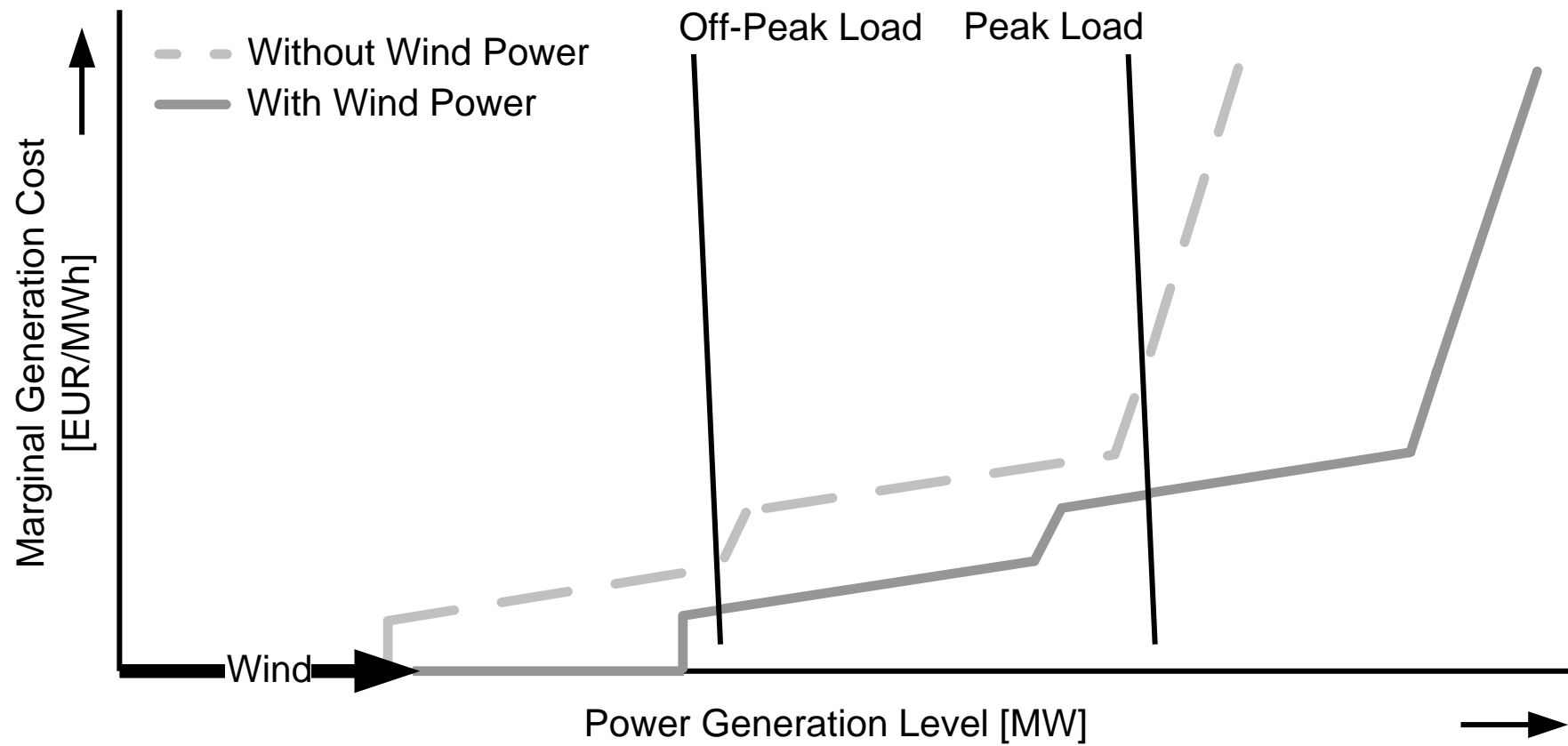
Wind Power



Wind Power

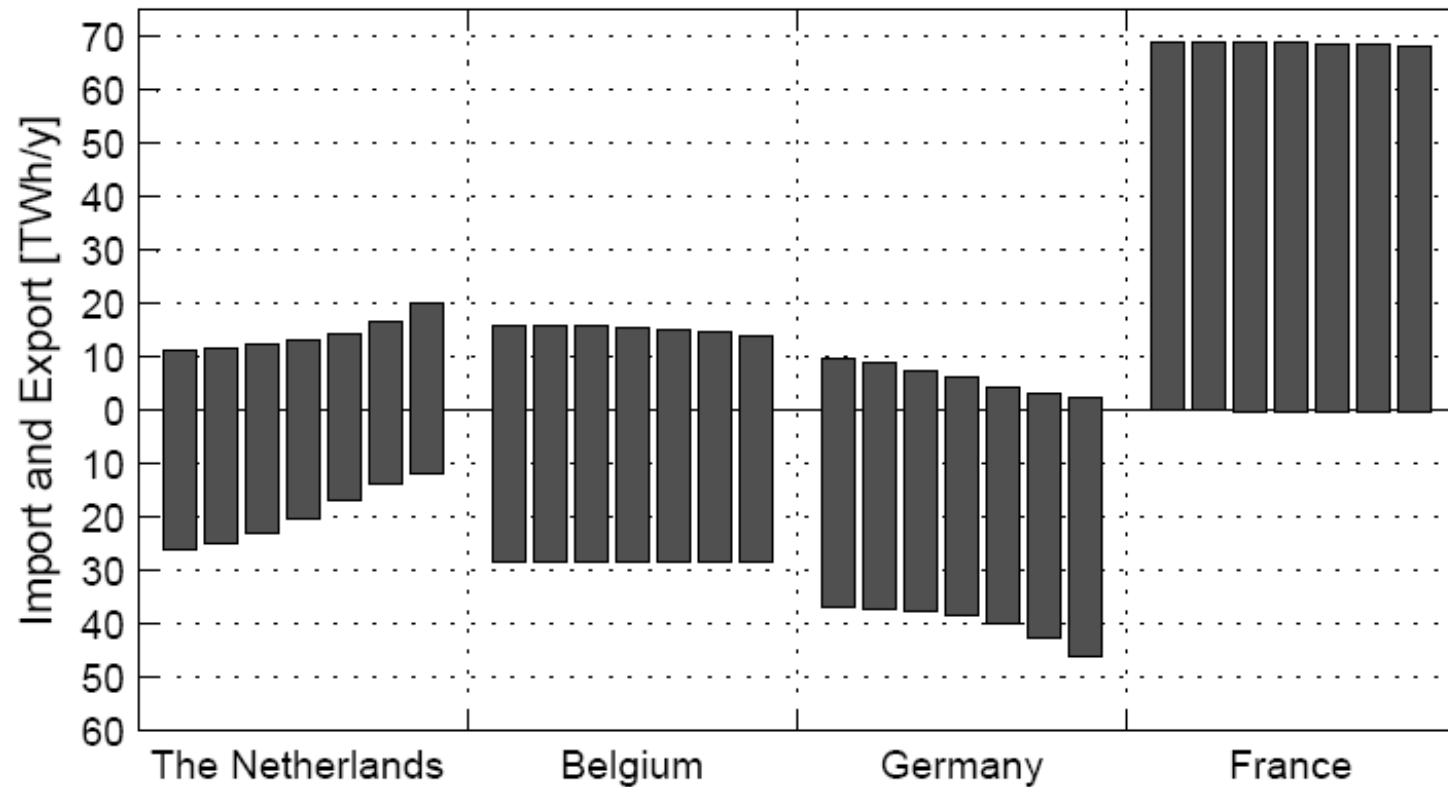


Wind Power



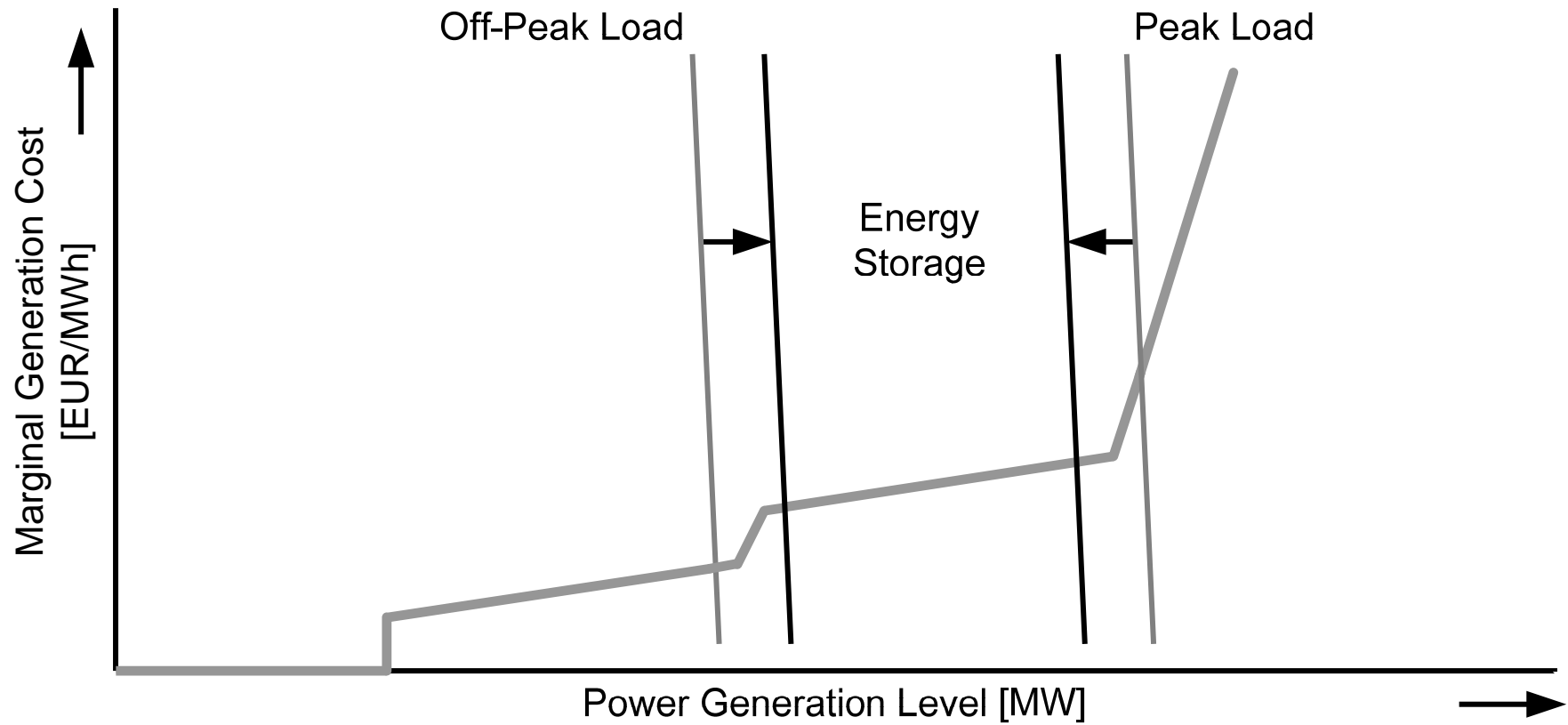
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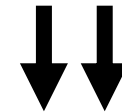
Country, for 0-12 GW Wind Power Capacity in the Netherlands

Energy Storage



Energy Storage

Peak Marginal Cost



Energy Storage

Peak Marginal Cost
Off-peak Marginal Cost



Energy Storage

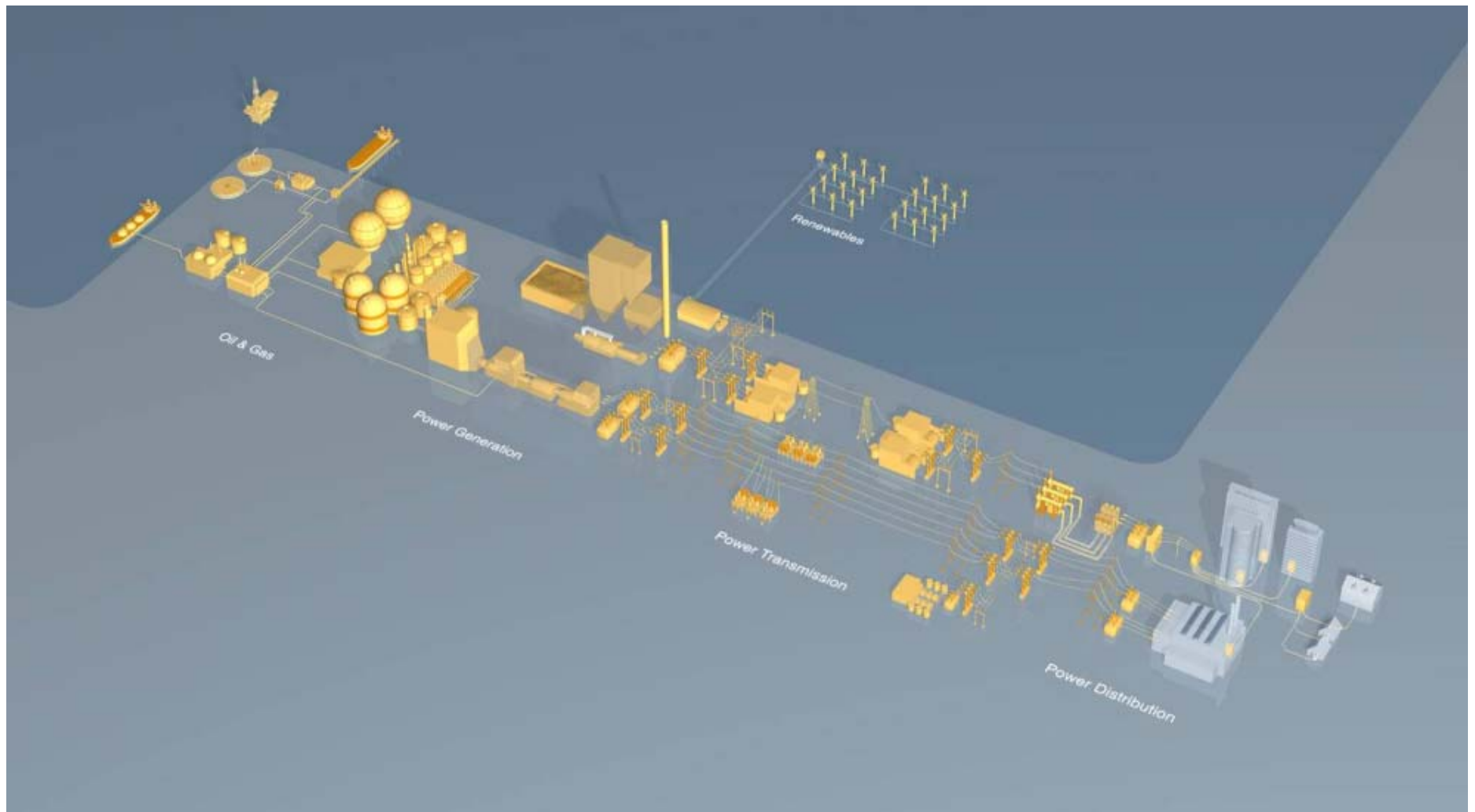
Peak Marginal Cost
Off-peak Marginal Cost
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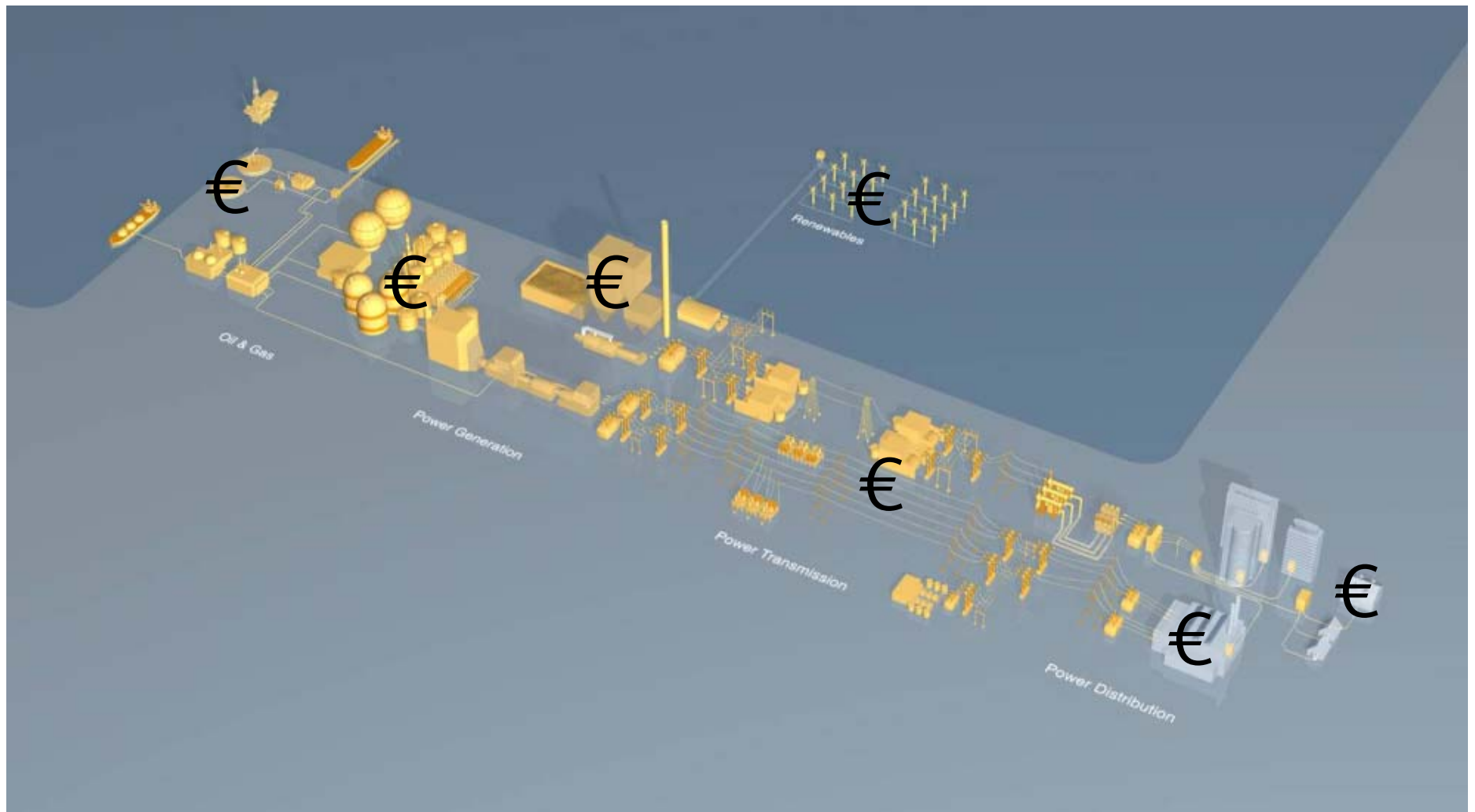
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Business Case

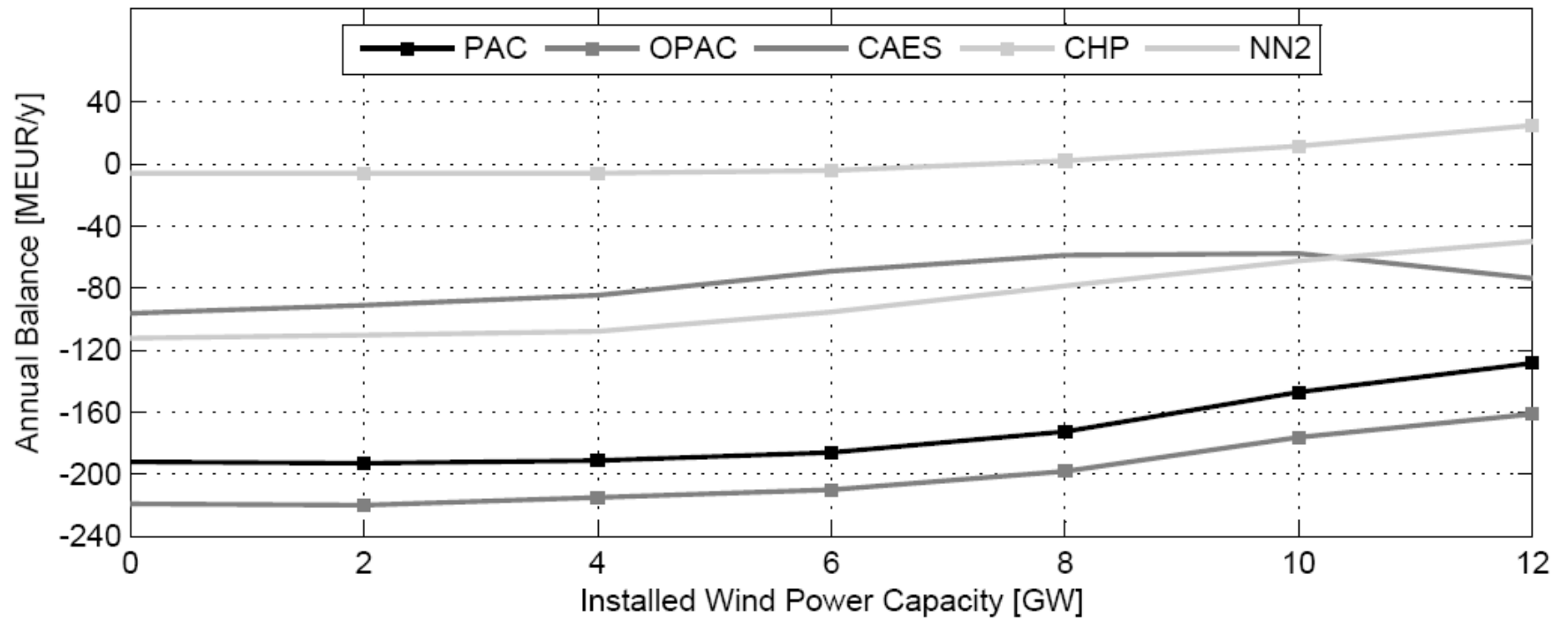
Business Case



Business Case



Business Case



Variability?

Unpredictability?

Energy Storage?



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Thank you for your attention

bart.ummels@siemens.com

Conclusions

- Wind power is not a fundamental challenge
- Wind power complicates power system balancing
- Wind power requires a strong network and flexible market design
- **System provides sufficient buffers for wind power integration**
- Wind power reduces market prices, and increases differences
- Benefits of energy storage depend on price differences
- New energy storage competes with generation units, interconnectors
- **Business case for large-scale storage in the Netherlands is unlikely**