

A roadmap for electrification of chemical industry

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Acknowledgements

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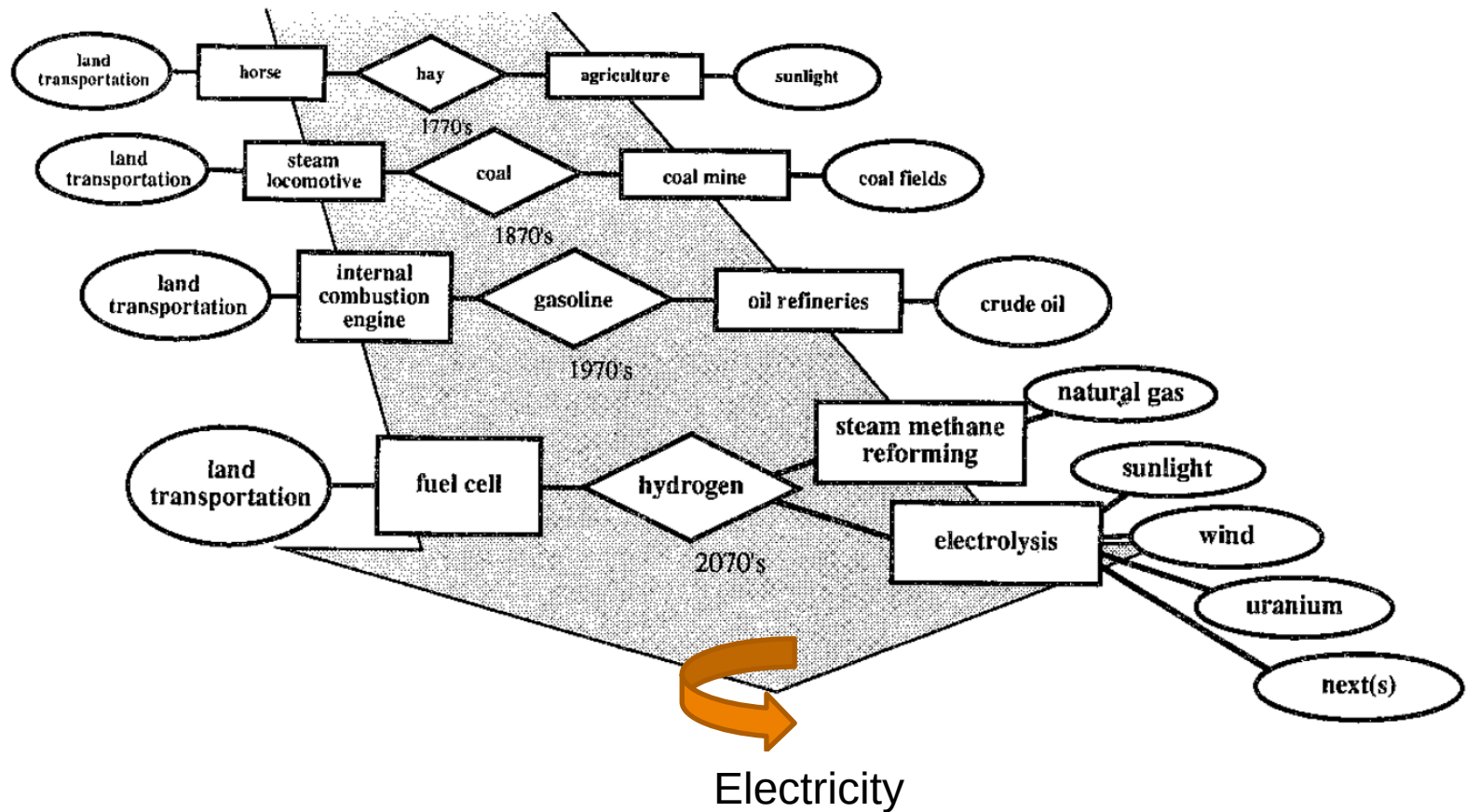
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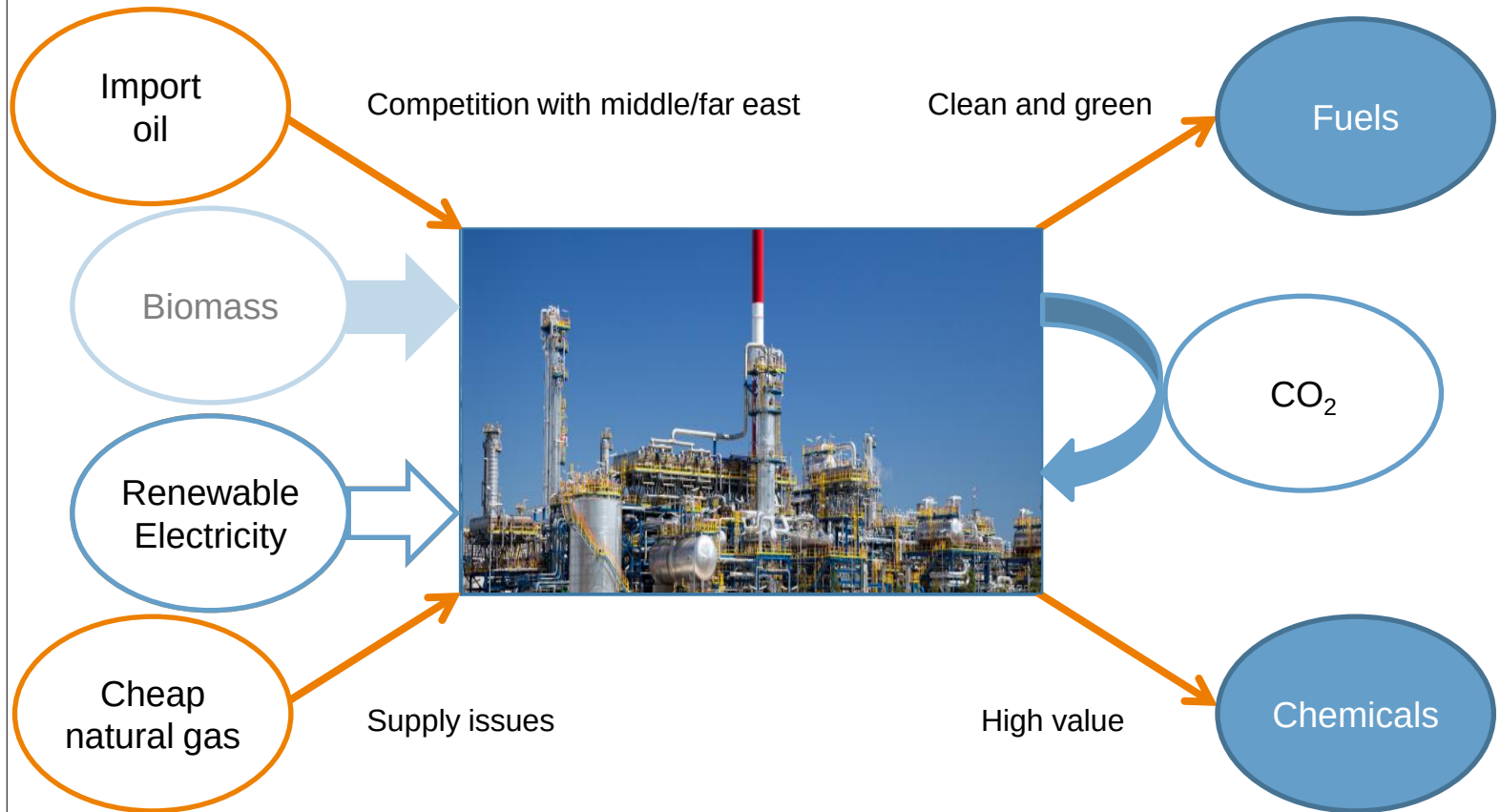
MORTON STREET, CORNER OF BEDFORD, LOOKING TOWARD BLEECKER
MARCH 17, 1893.



New energy sources cause big changes

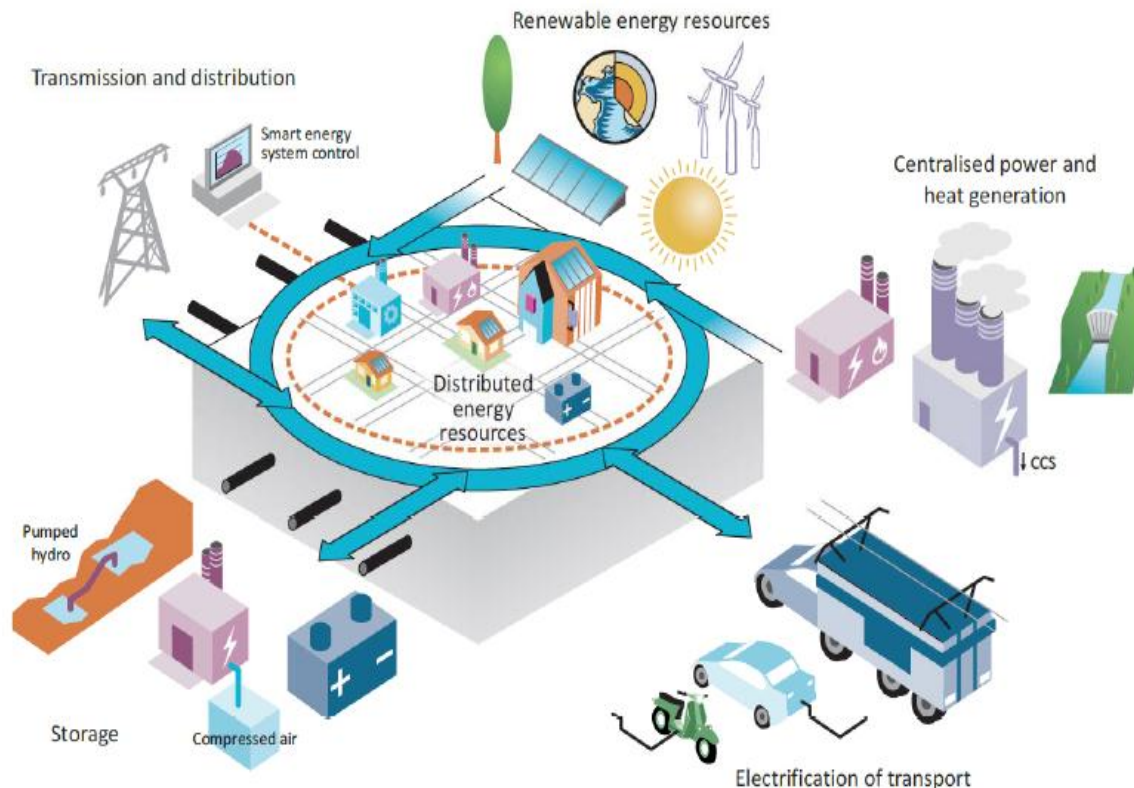


The Dutch (petro)chemical industry



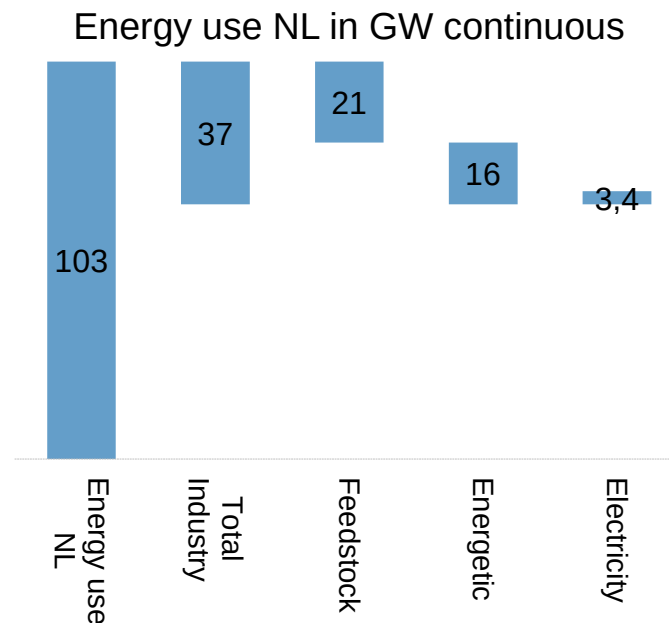
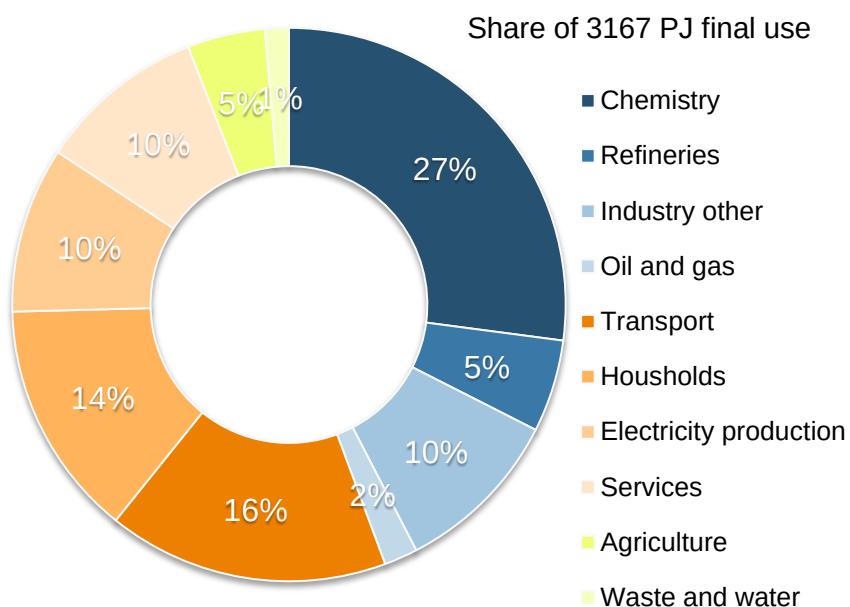
The Energy system Outlook

Electricity will play an increasingly important role in energy systems of the future, both in sustainable generation, smart distribution, and **smart end-use consumption**



Source: Energy Technology Perspectives 2014 - Harnessing Electricity's Potential.

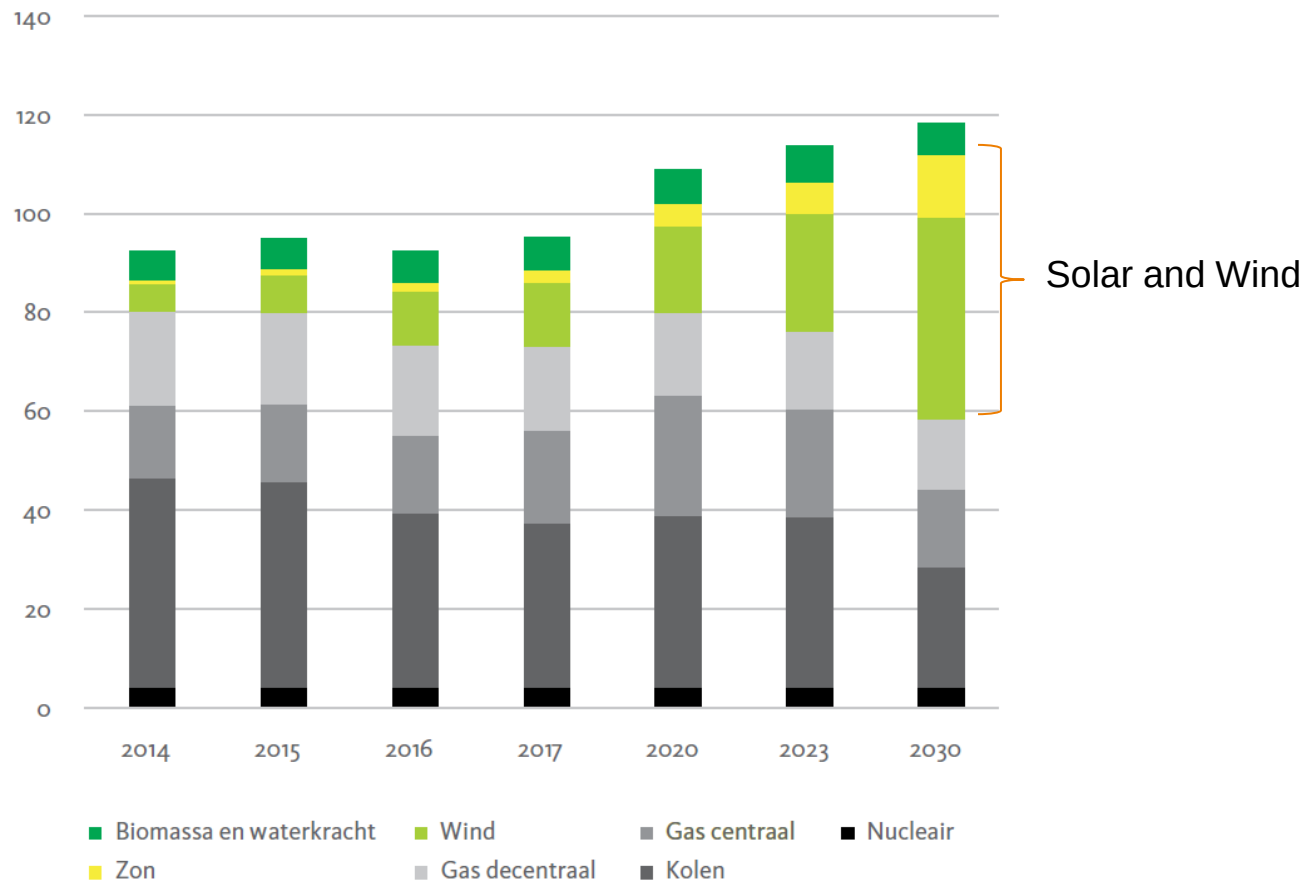
Energy use in the Dutch chemical industry



Year	Source	GW _{eq cont}	GW _{installed}
2013	Total electricity generated	13.5	30
2013	renewable electricity	1.4	
2030	Total electricity generated	14.1	
2030	renewable electricity (53%)	7.5	
2030	intermittent solar/wind (87%)	6.5	26

Increasing share of renewable energy

Elektriciteitsproductie
(terawattuur)

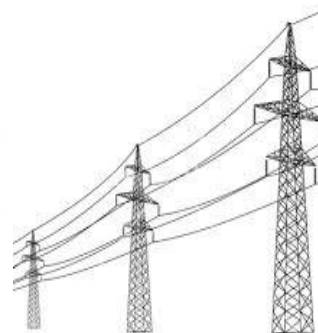
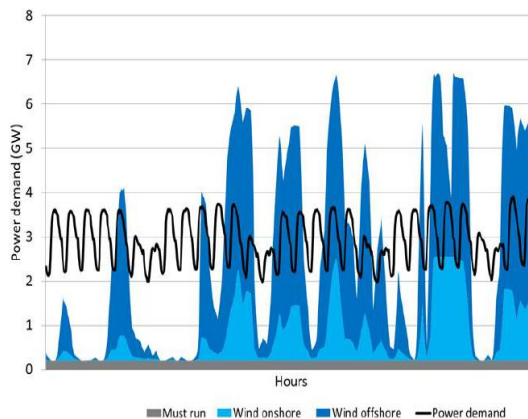


Renewables have a variable supply

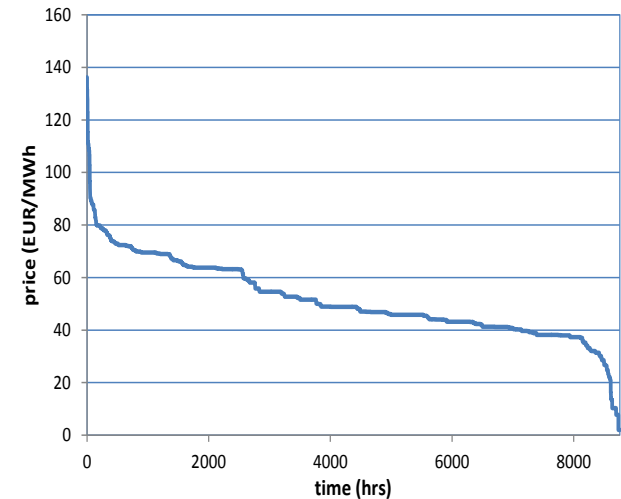
Variability of supply
and demand

Transport
limitations

Variable price



Price duration curve (2030)



Time

Place

Price

Sources of flexibility

Flexible supply



Demand response
& conversion



Interconnection



Energy Storage

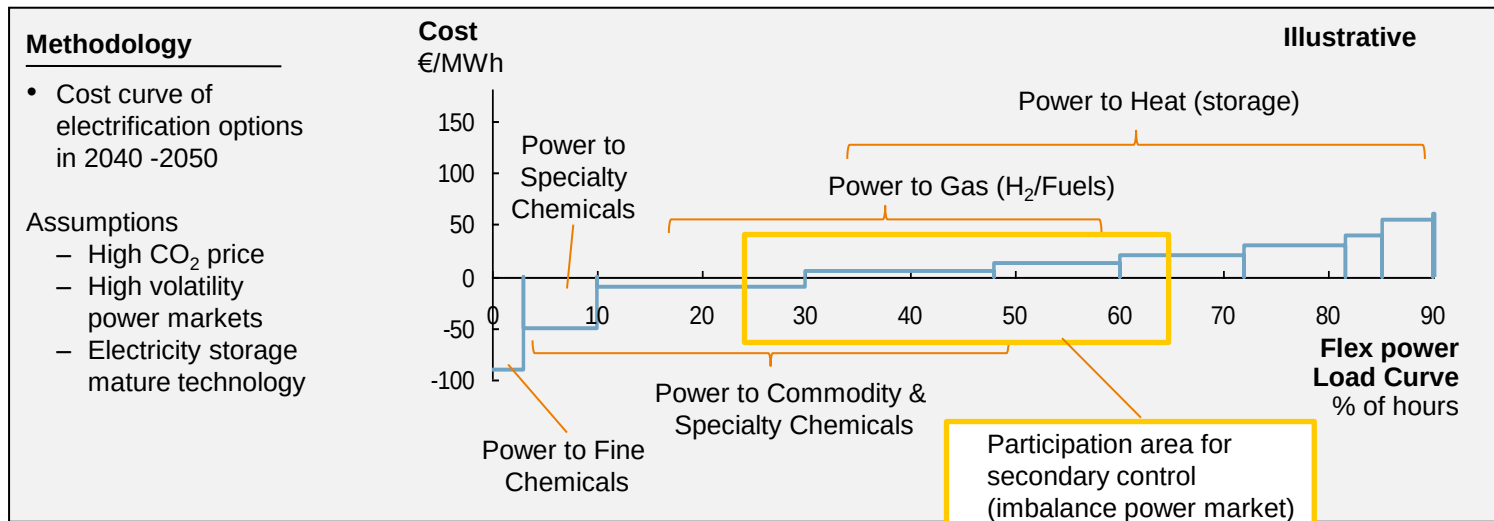


Elements: the value of electricity in chemical industry

- › Value as heat
 - › Electricity replaces conventional heating using mostly natural gas
- › Value as intermediates
 - › Electricity is used to make intermediates (e.g. hydrogen, NH_3)
- › Product value
 - › Electricity used directly to make end products

Electrification technologies

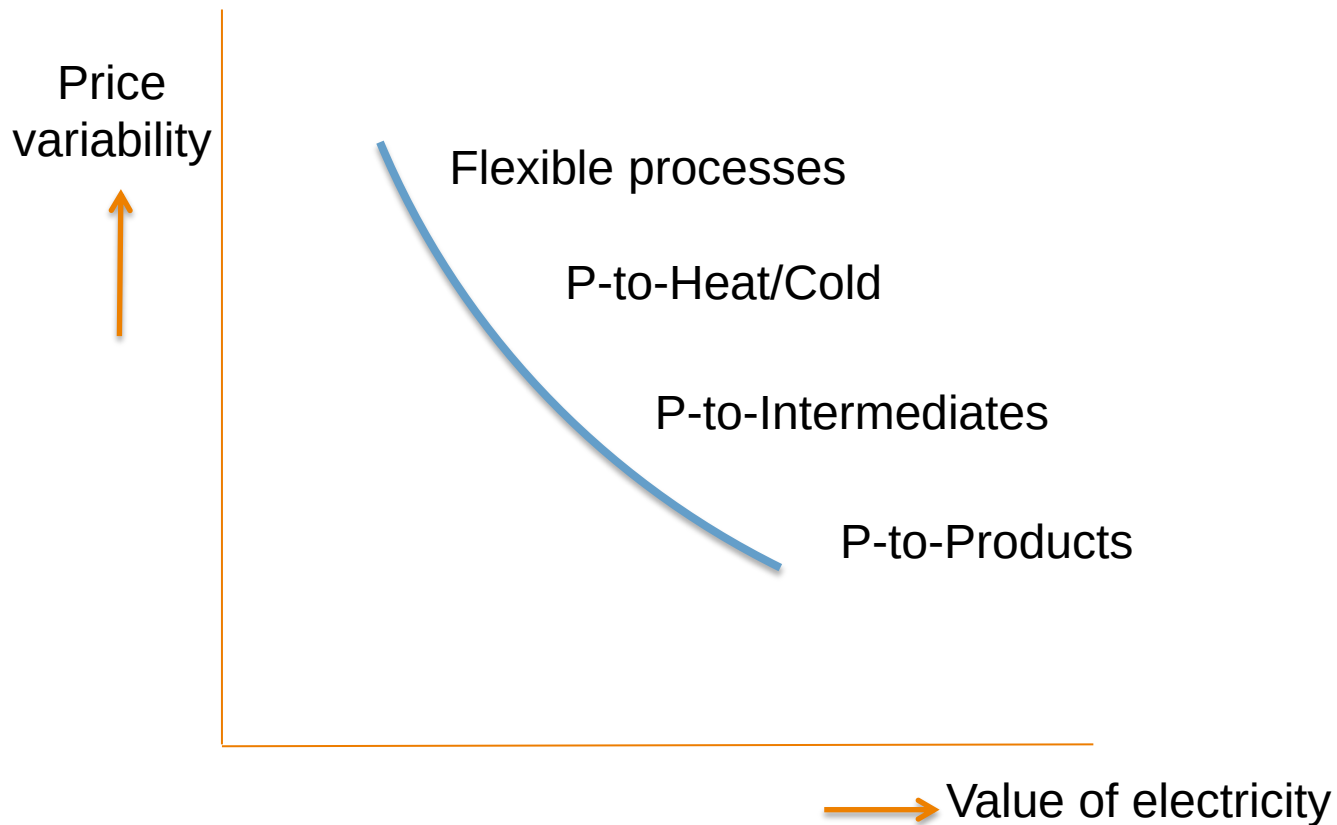
Illustrative cost curve of demand-side response (estimation 2040 – 2050)



- › Economics of demand-side response options determine their dispatch strategy:
 - › Power to fine and specialty chemicals - mainly base-load power off-take.
 - › Power to heat - wide range of profitable application (e.g. E-grid management, imbalance market or day ahead options).
 - › Power to gas – Imbalance market, intraday and day ahead markets.

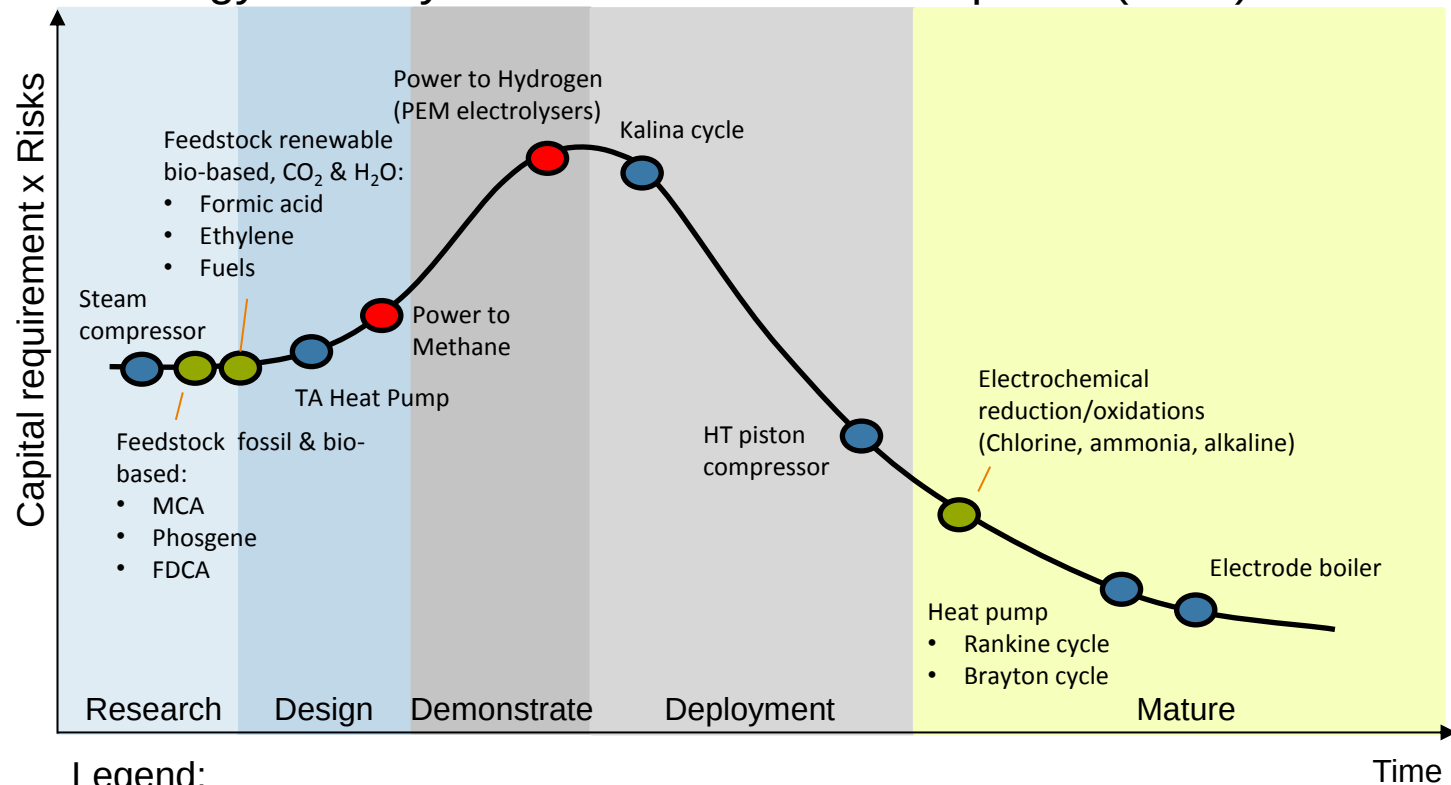
The impact of variability

A higher added value of electricity in the process means a lower incentive for making use of the price variability



Electrification technologies

Technology Maturity Curve of electrification options (2015)



High level Road Map of Electrification

