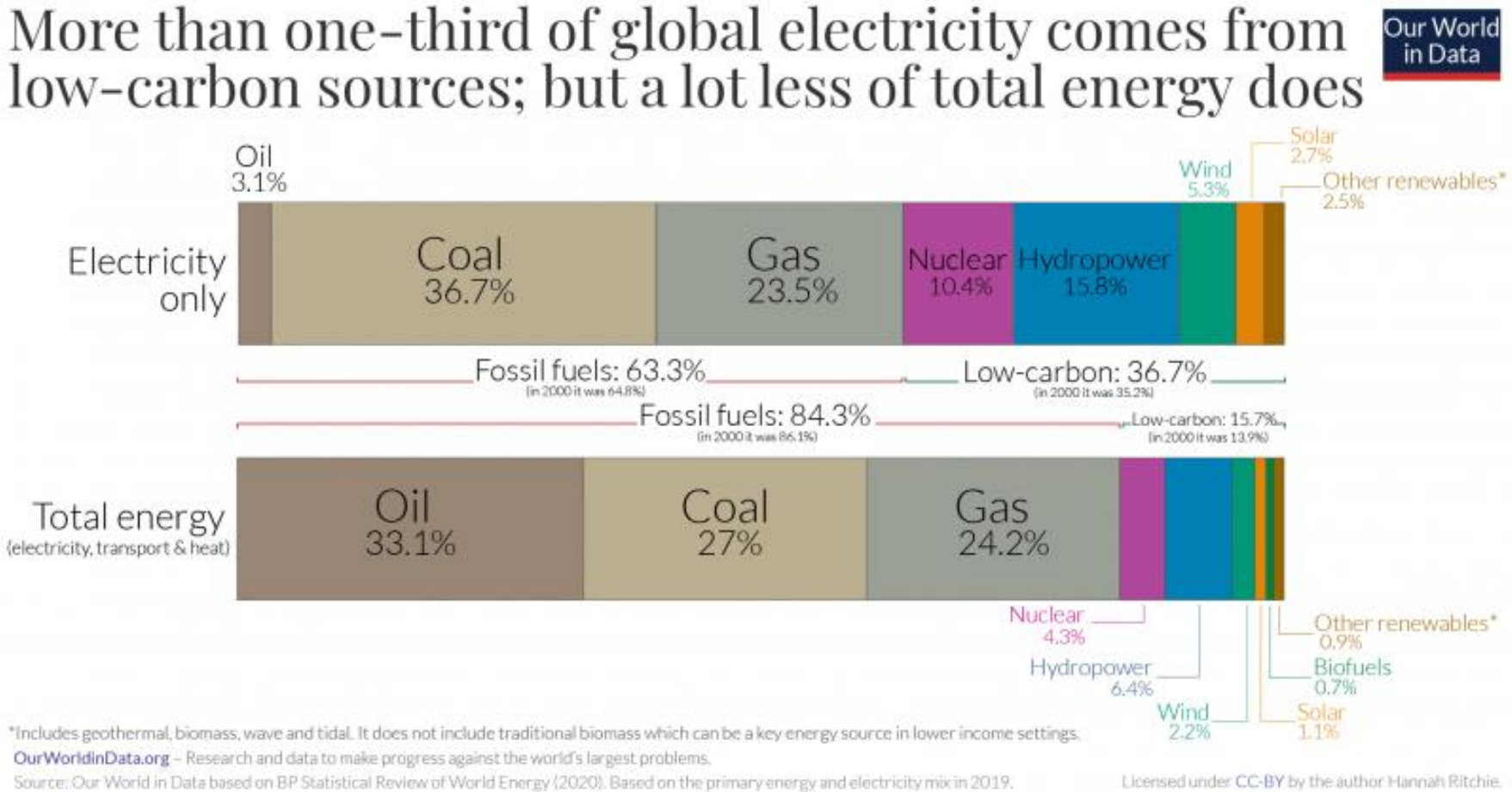
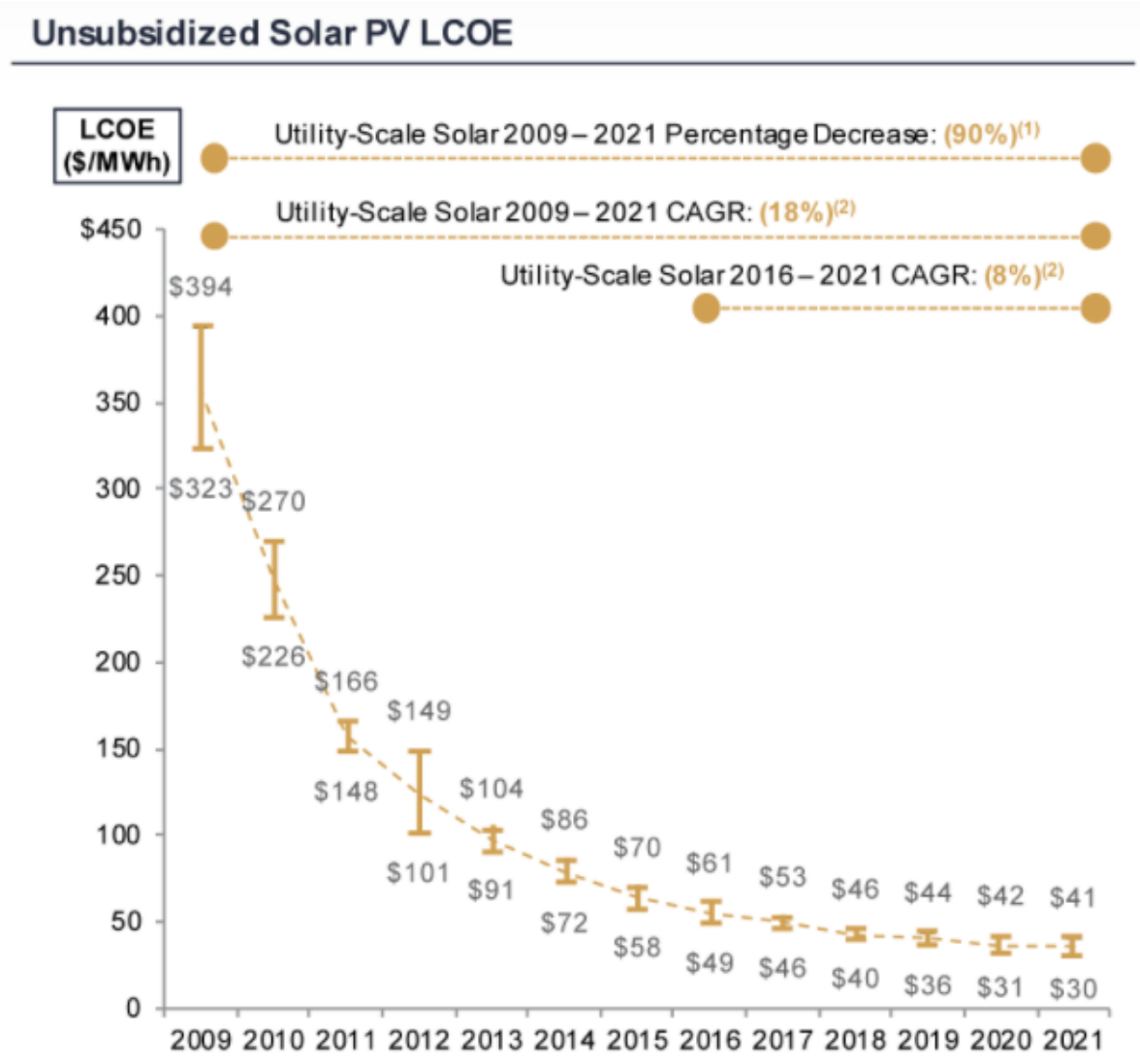
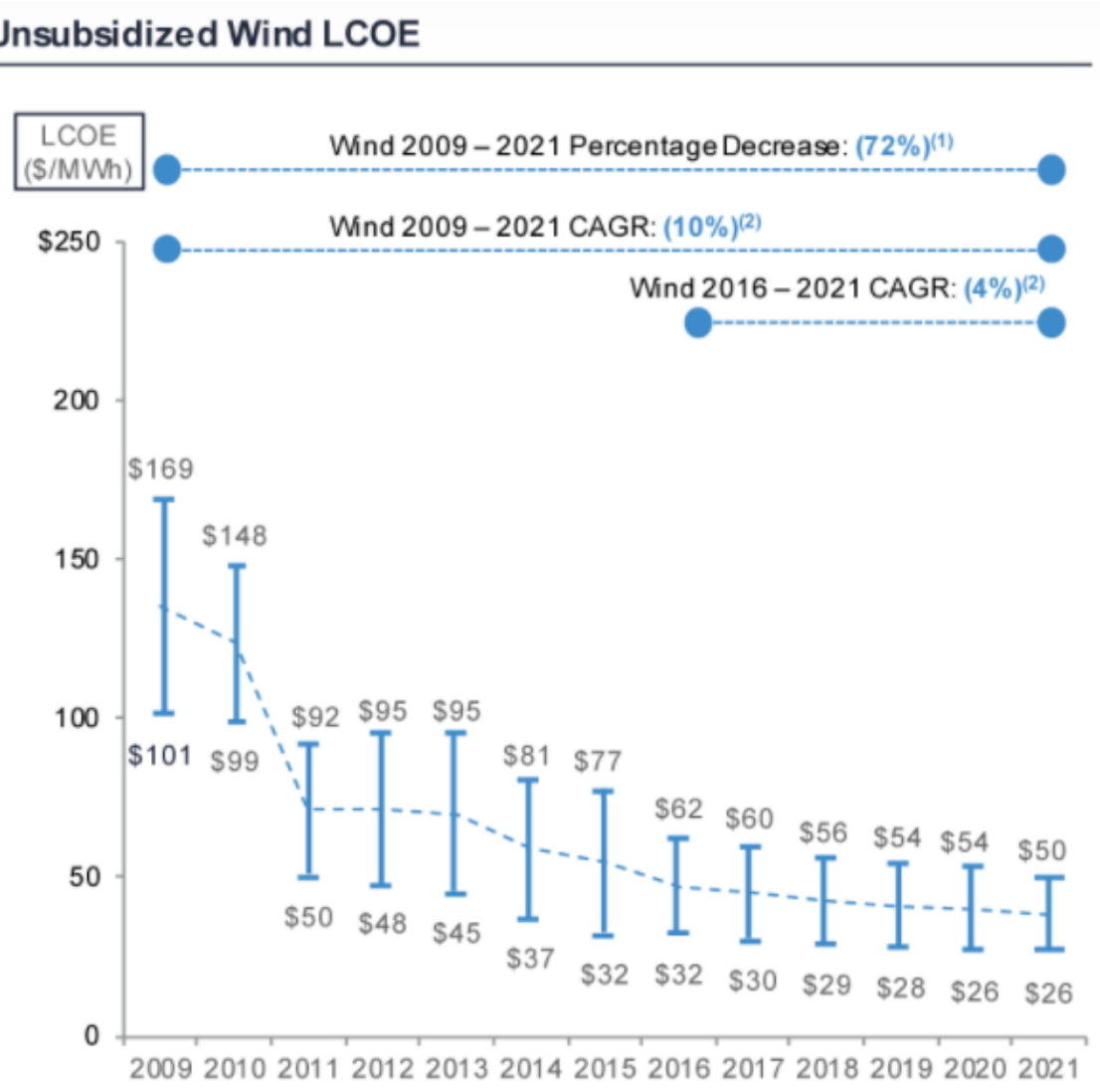
Renewable energy and money

Transition optimists, calm down

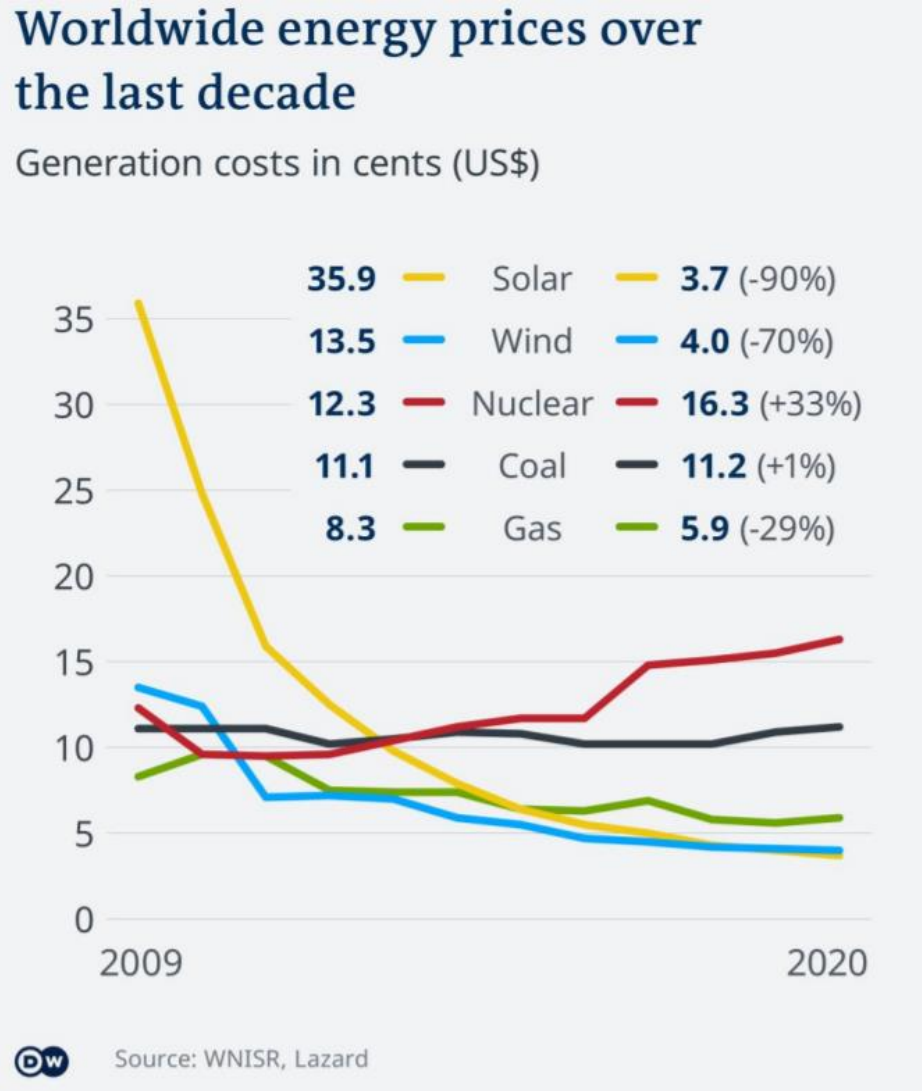


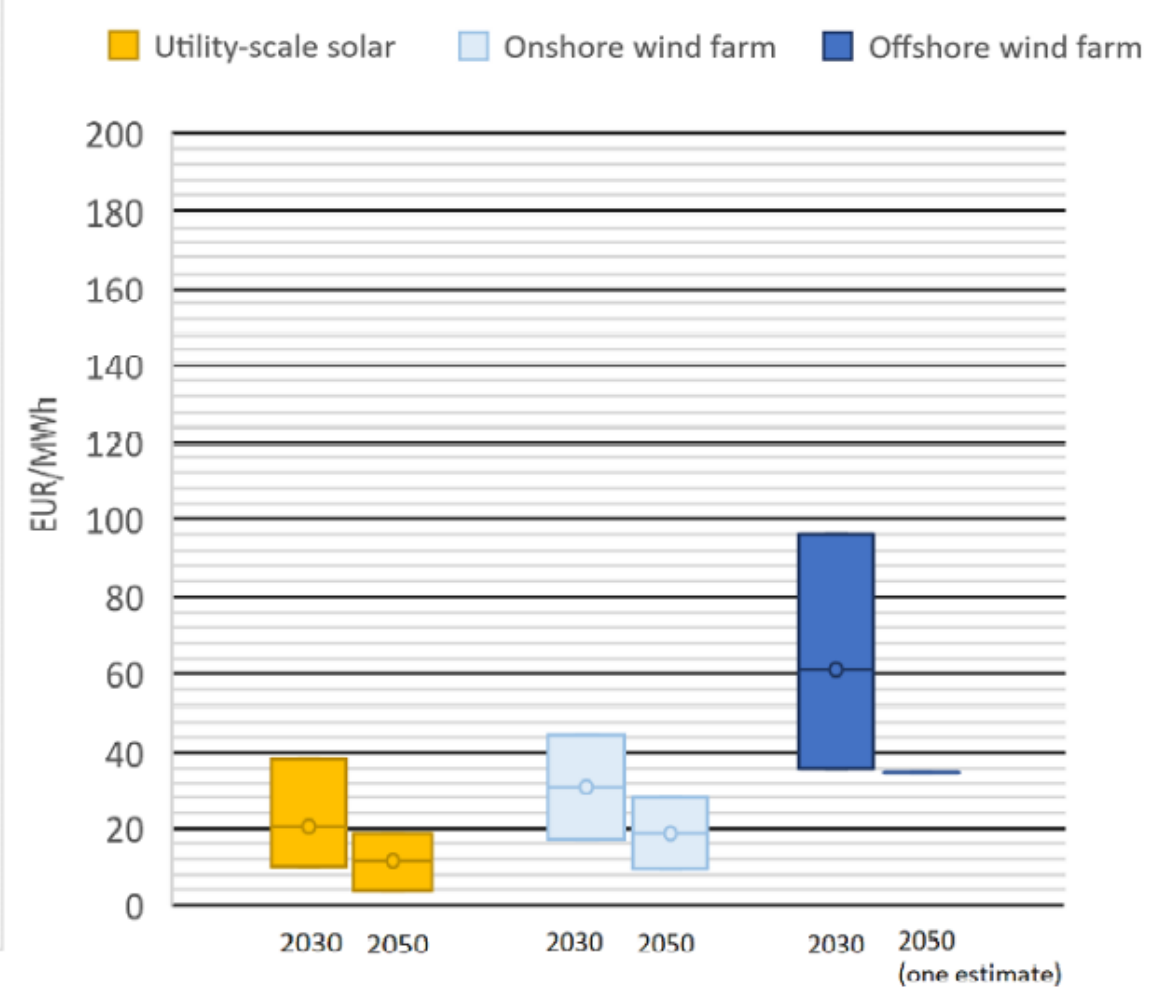
However, vRES are the success story of the decade





Recent and future worldwide LCOE estimates

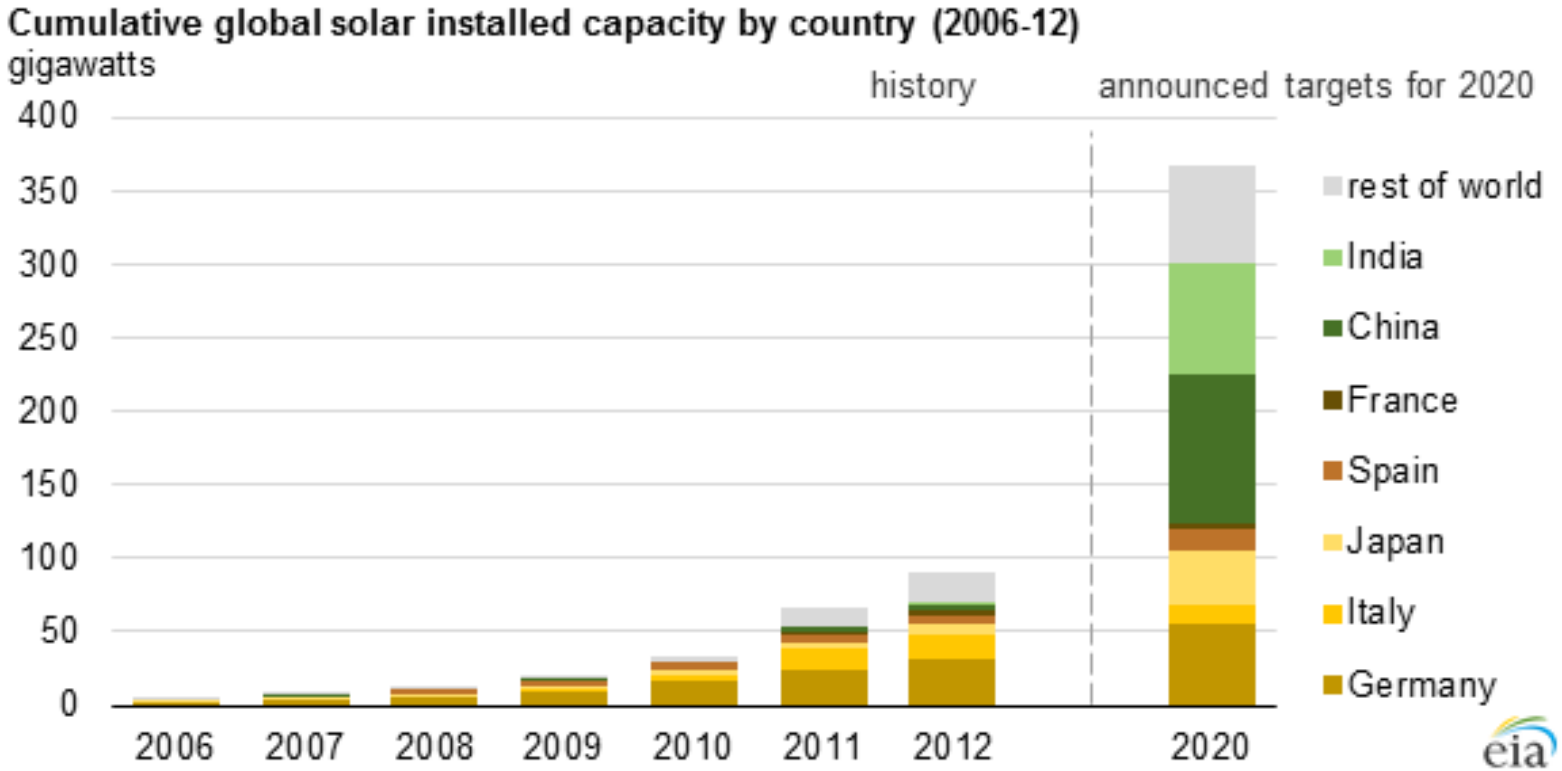




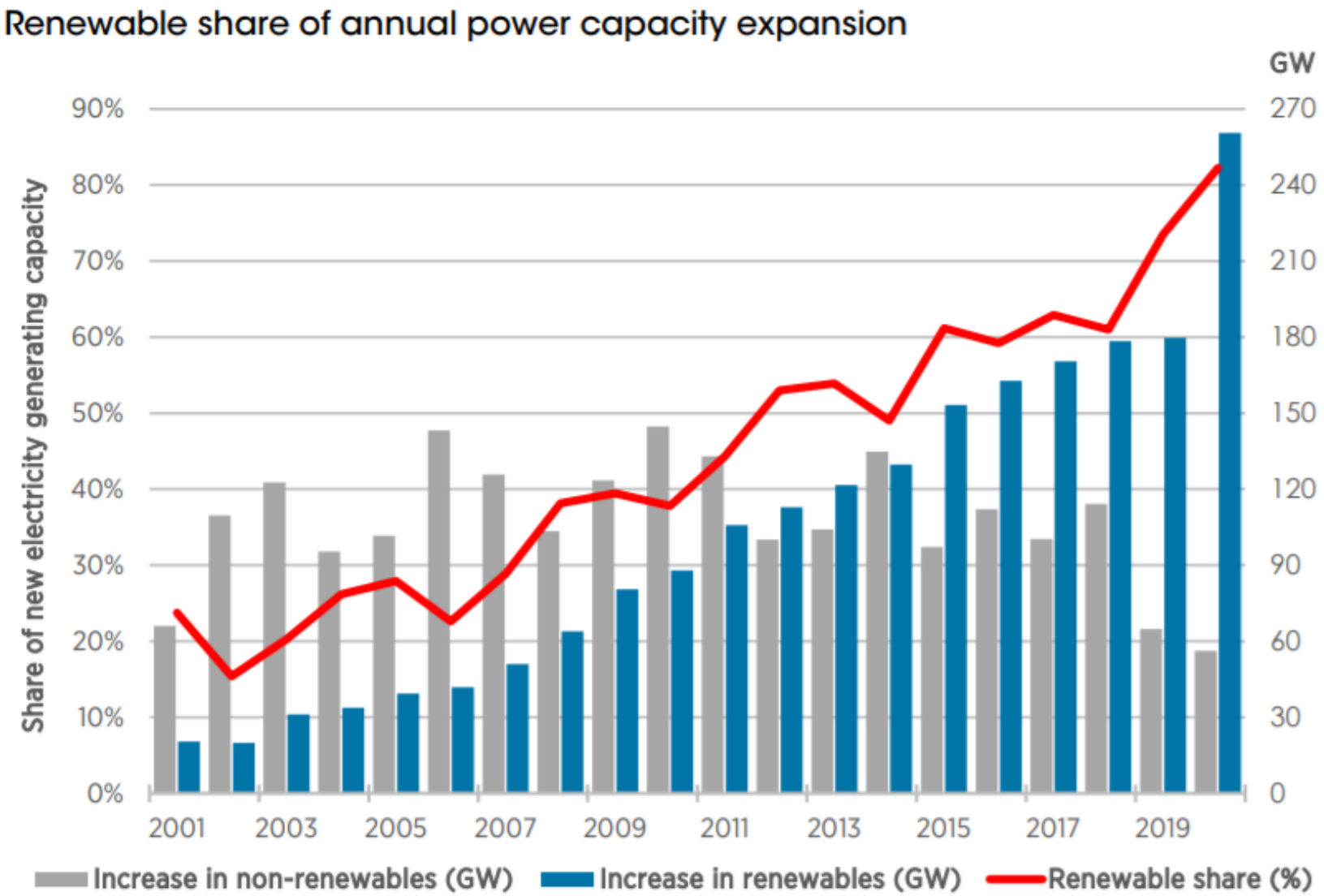
Source: FSR using data from: IEA (2020), BloombergNEF (2020), IRENA (2020), Lazard (2020)

How did we get here?

- Demand pull
- Low barriers to entry
- Homogenous products
- Mature silicon industry (PV)

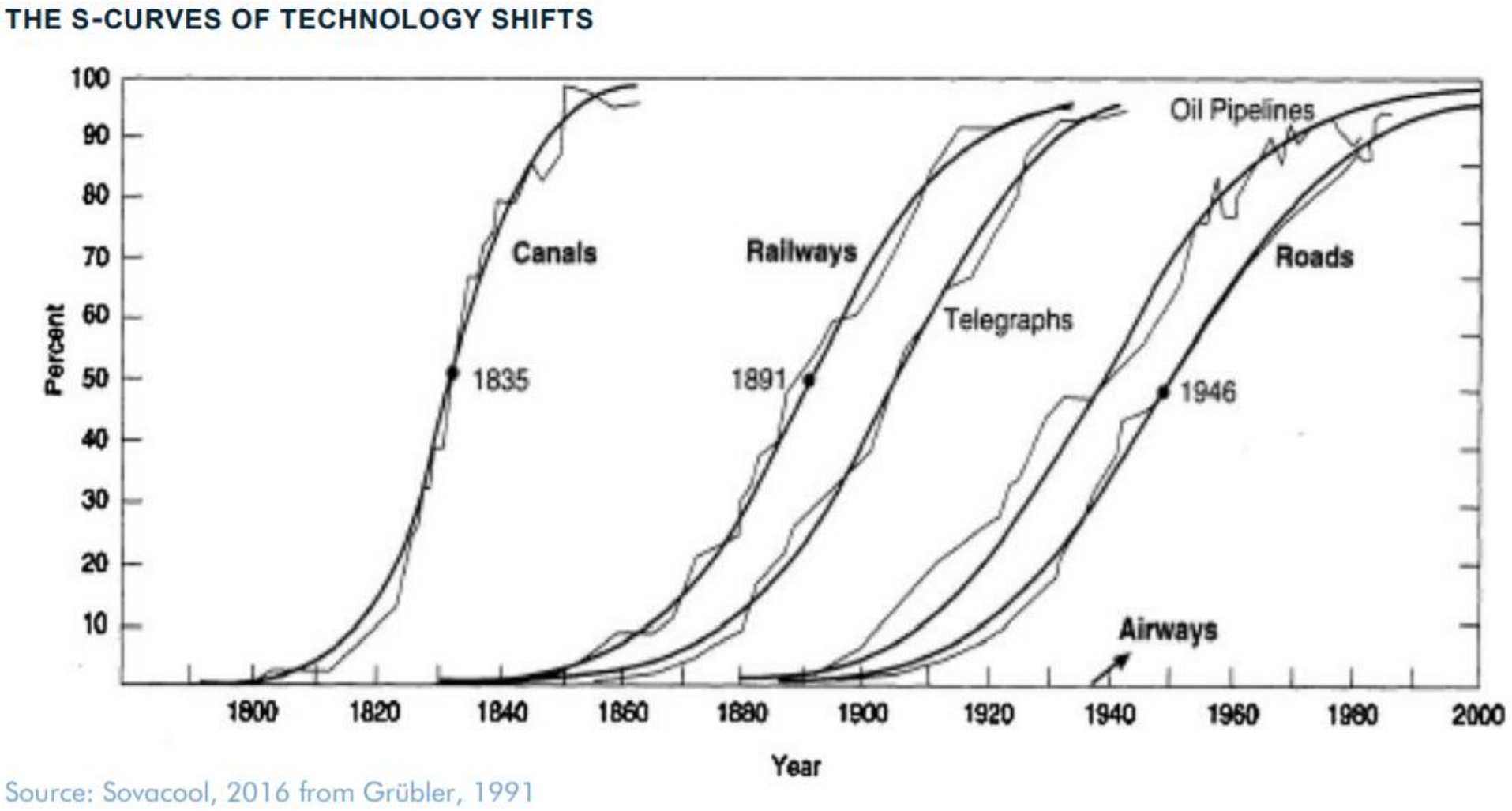


Future in the making



Source: IRENA

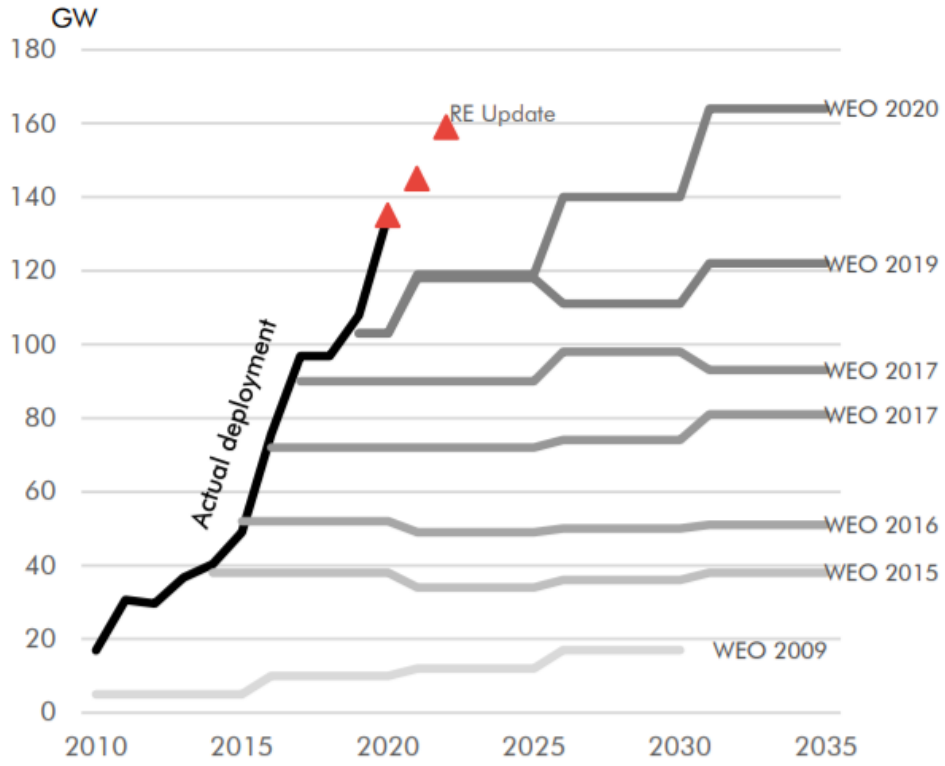
Transition pessimist, calm down



Source: [Carbon Brief]

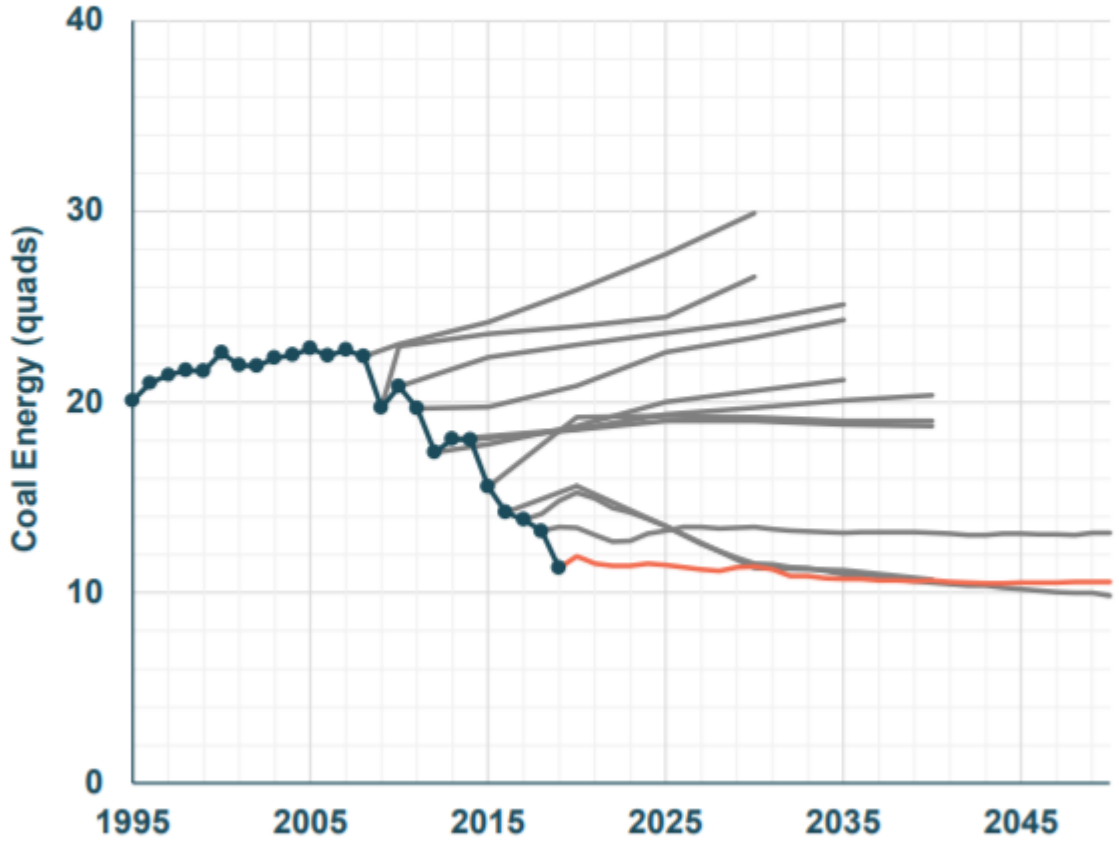
Where next? The transition feedback loops

3.1 IEA FORECASTS OF SOLAR DEPLOYMENT



Source: Carbon Brief; Notes: projections represent the IEA's Stated Policies Scenarios (STEPS) taken from the World Energy Outlook (WEO); RE Update from the IEA's Renewable Energy Market Update[30]

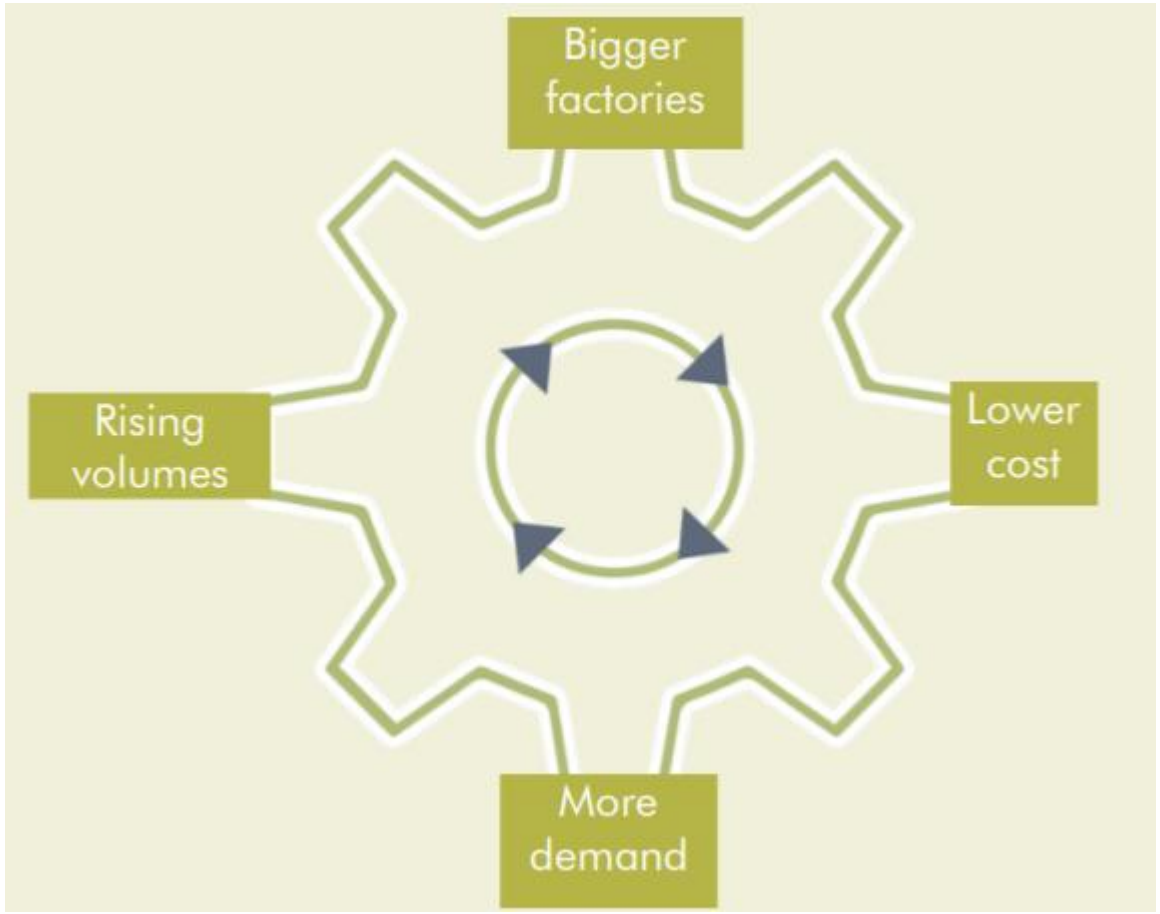
Figure 6. Disruption of Coal Power in the United States

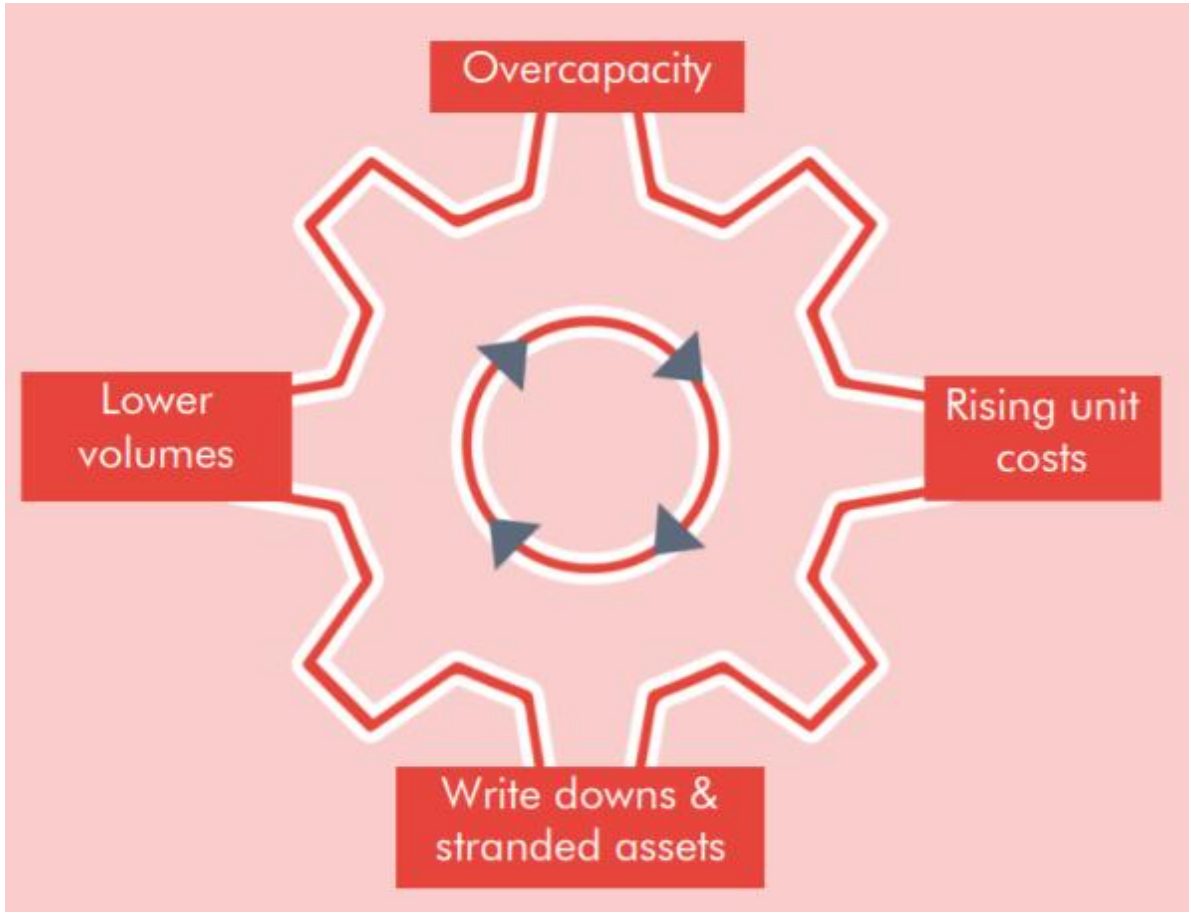


Source: US EIA Annual Energy Outlook series, 1995-2020.[14]

Sources: Carbon Brief, RethinkX

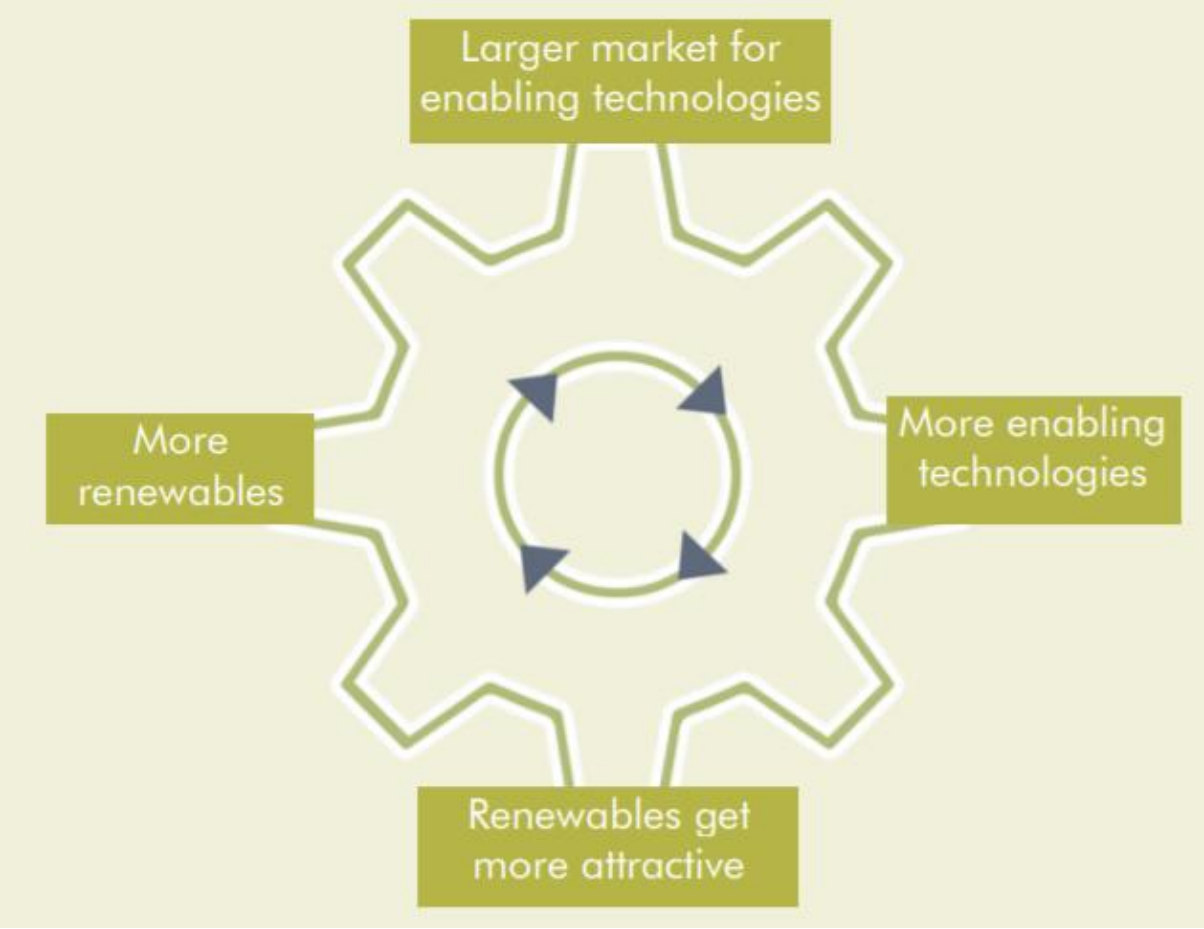
The volume-cost loop

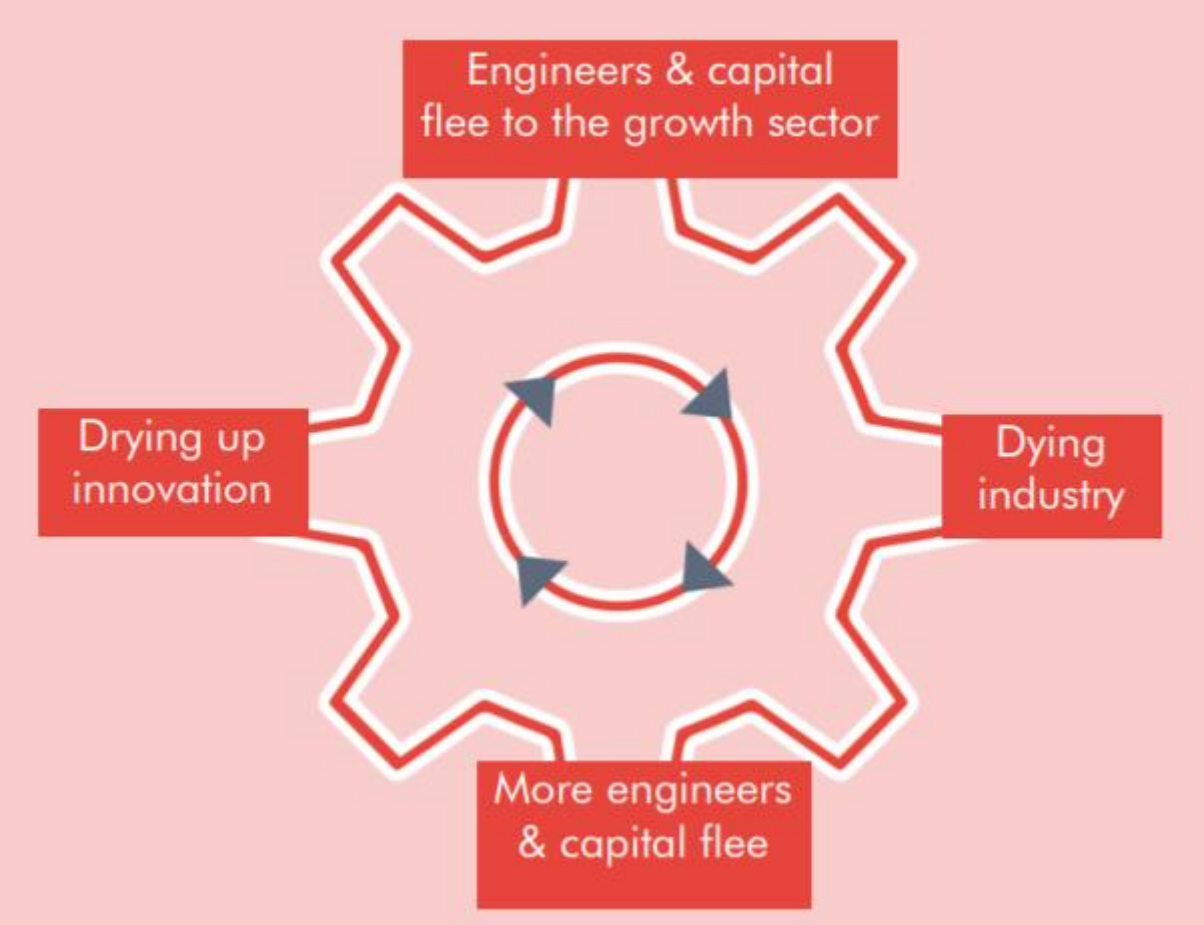




Source: [Carbon Brief]

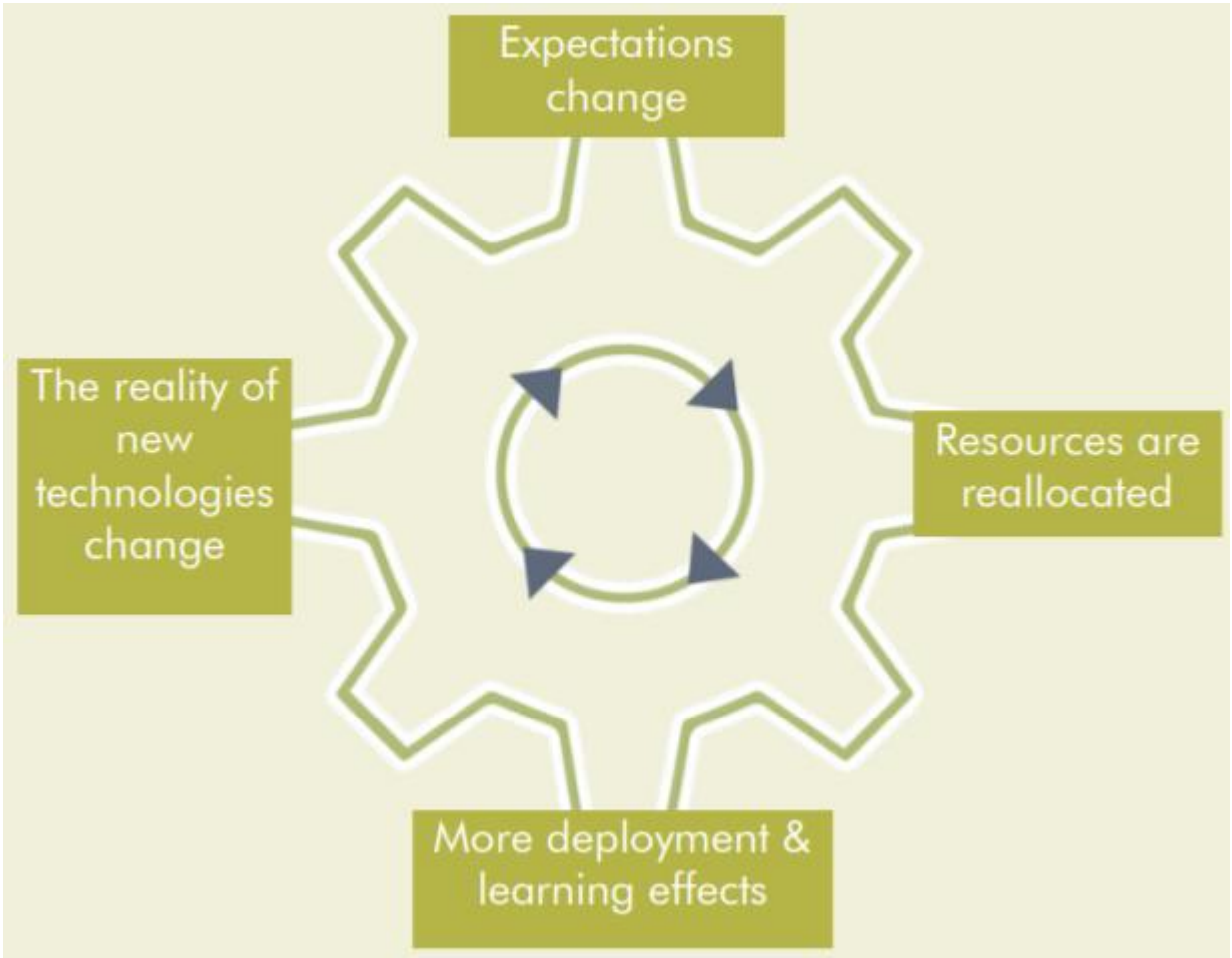
The technology loop

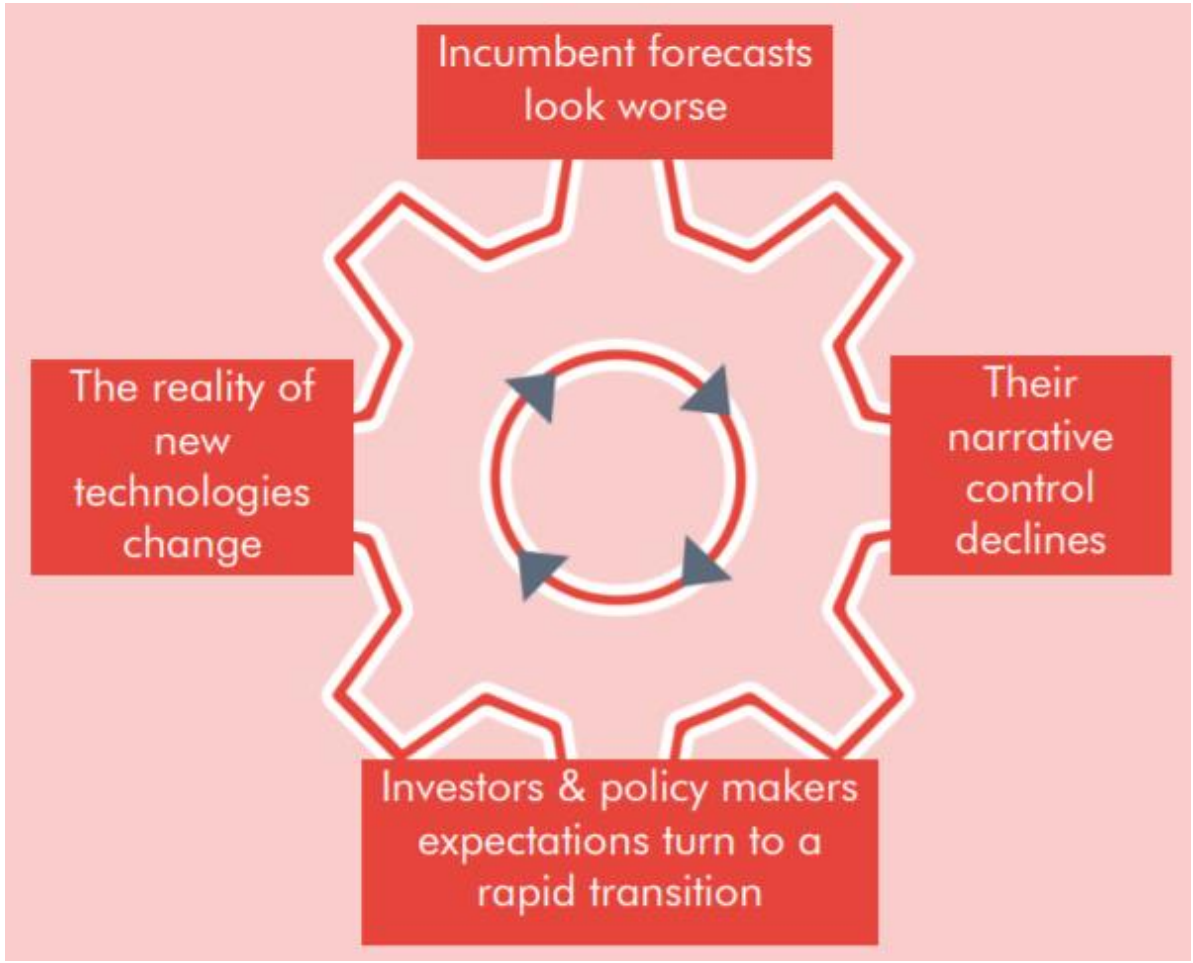




Source: [Carbon Brief]

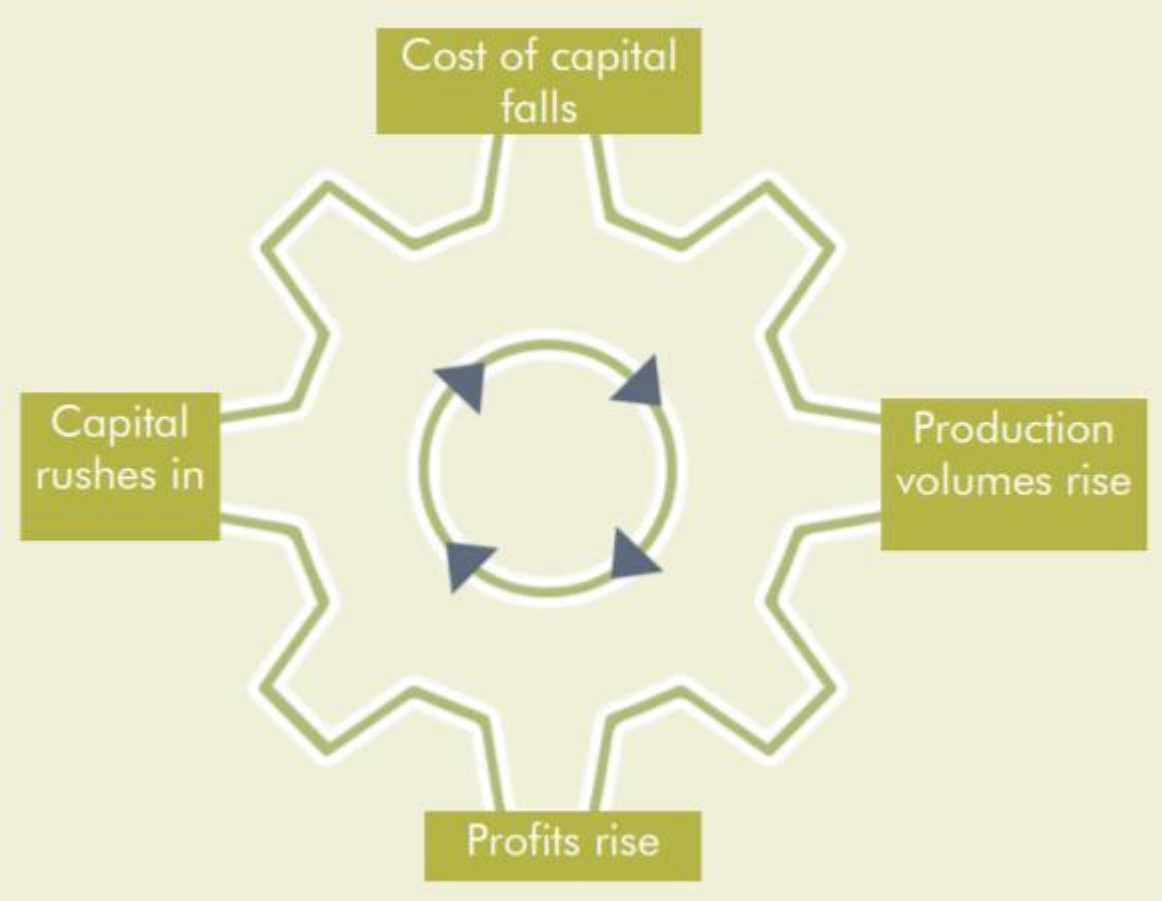
The expectations loop

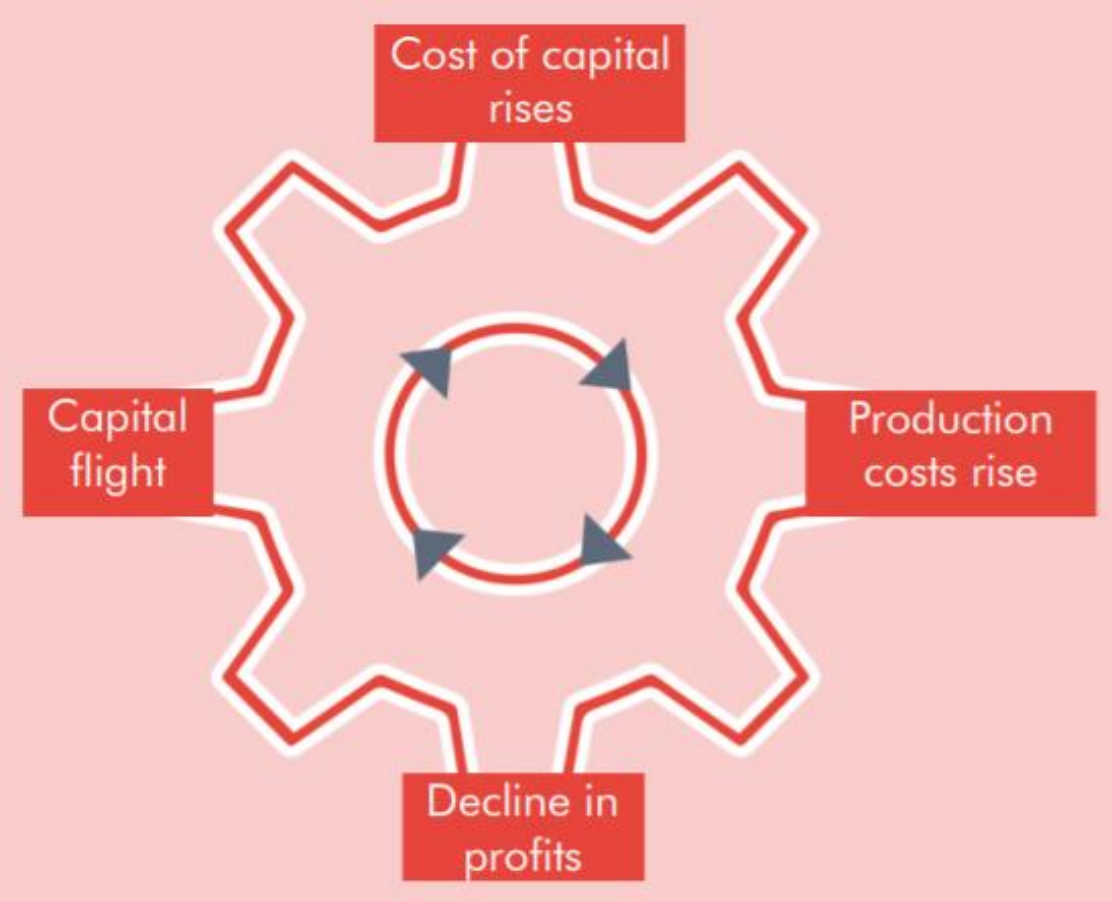




Source: [Carbon Brief]

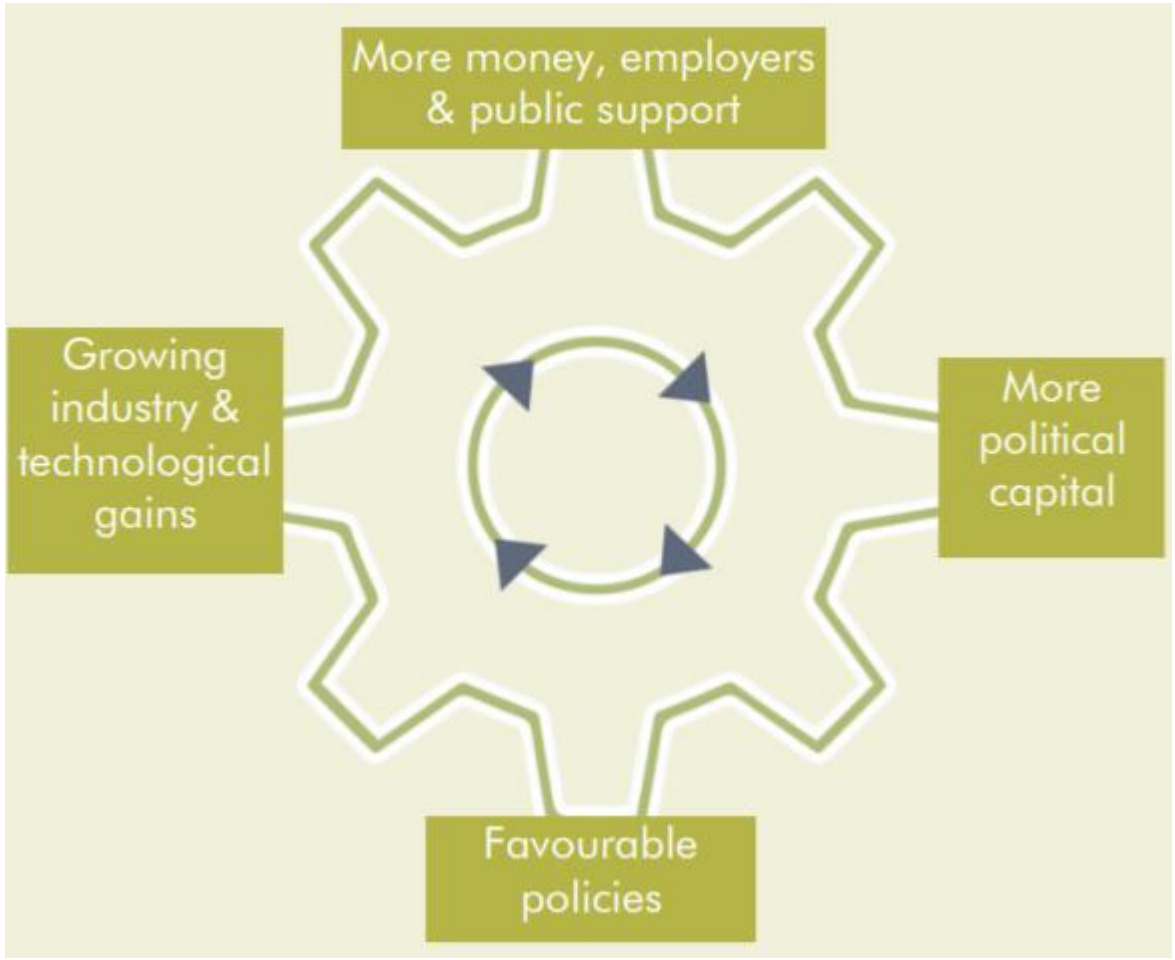
The finance loop

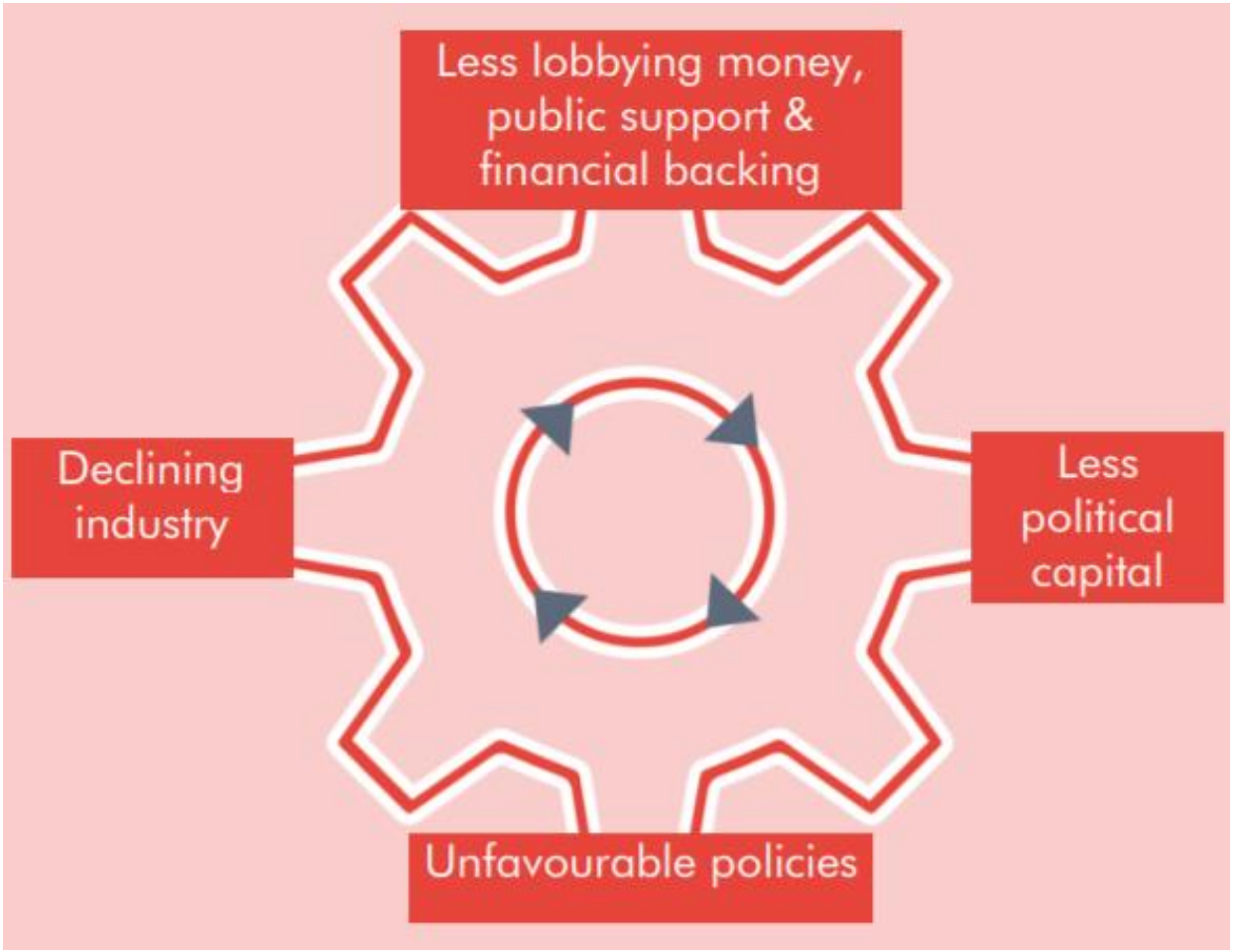




Source: [Carbon Brief]

The politics loop





Source: [Carbon Brief]

Getting there: support policies

- Feed-in tariffs and quotas
- Feed-in premium
- Auctions
  - RES in
  - Fossil fuels out

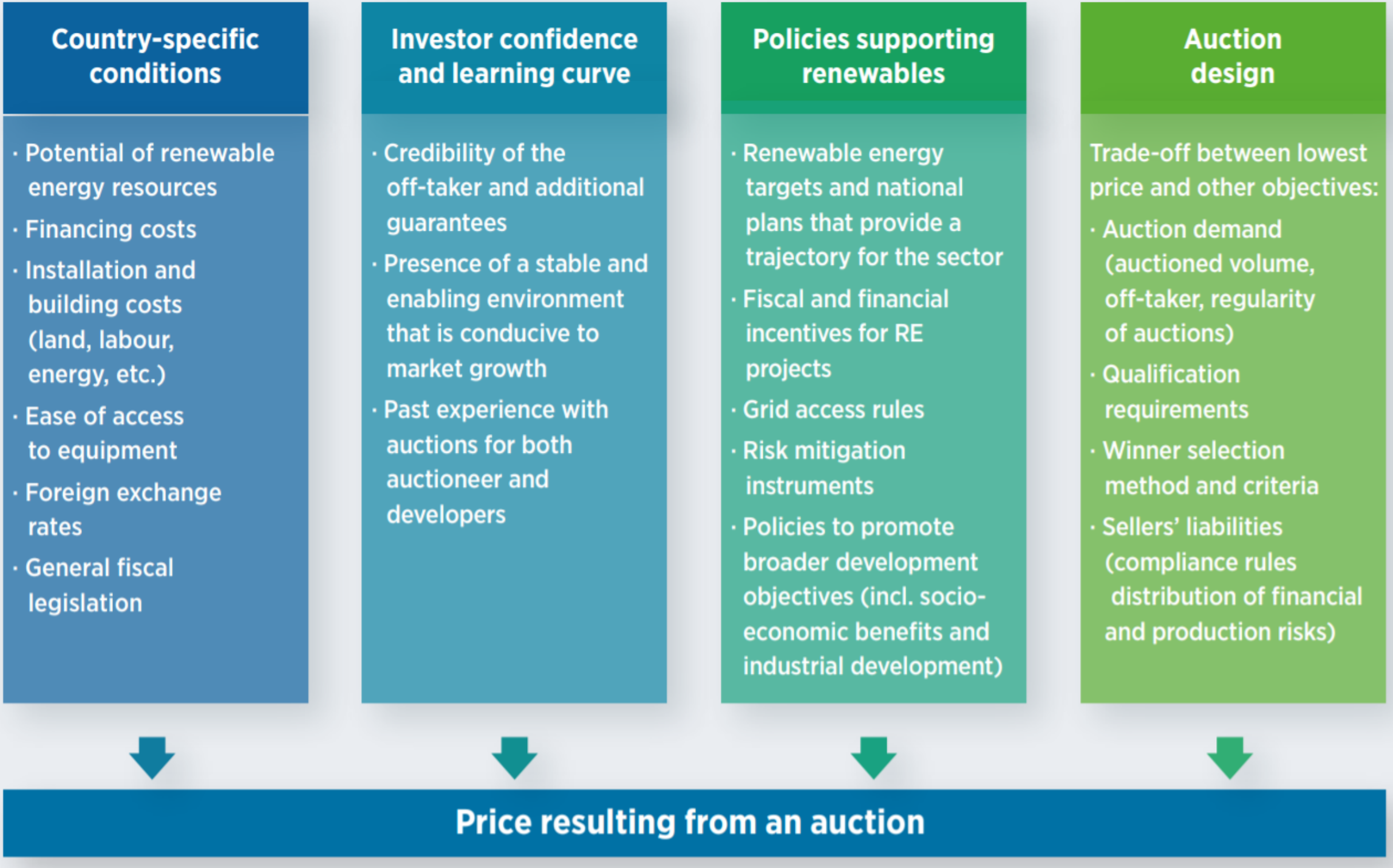
Additional info on auctions:
https://auresproject.eu/sites/auresproject.eu/files/media/documents/design_elements_october2015.pdf

4.1. AUCTION-SPECIFIC DESIGN ELEMENTS

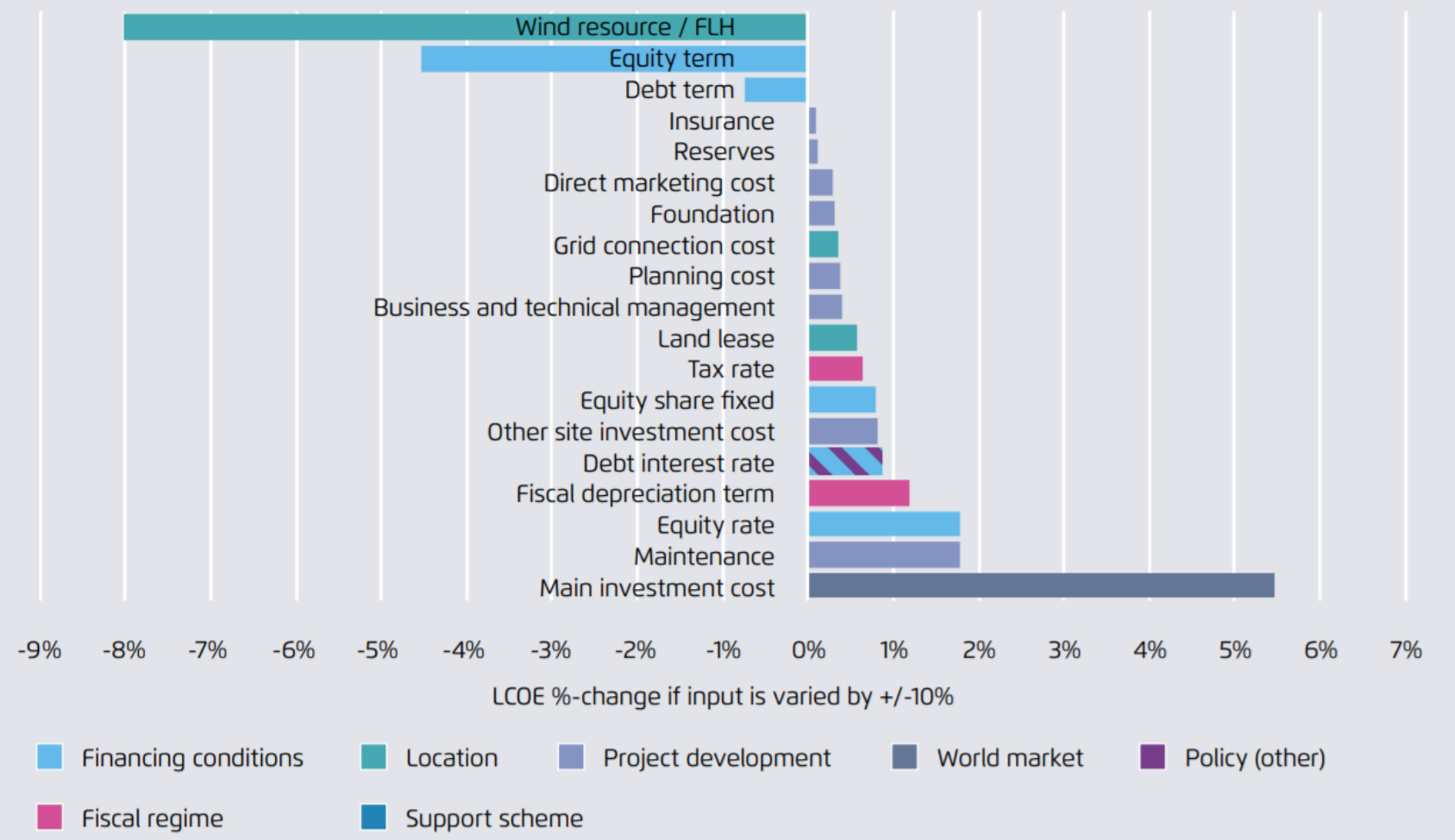
- 4.1.1. Price-only/multi criteria auctions
- 4.1.2. Type of auction: auction formats and pricing rules
- 4.1.3. Price ceilings and minimum prices
- 4.1.4. Other
  - 4.1.4.1. Seller concentration rules
  - 4.1.4.2. Information provision
  - 4.1.4.3. Web-based vs. in-person auctions
  - 4.1.4.4. Secondary market

4.2. ADDITIONAL RES AUCTION-SPECIFIC DESIGN ELEMENTS

- 4,2.1. Targets/Scope/Volume auctioned
  - 4.2.1.1 How to set the volume auctioned?
  - 4.2.1.2. Energy or capacity-related remuneration
  - 4.2.1.3. Volumes auctioned
  - 4.2.1.4. Number and frequency of rounds
  - 4.2.1.5. Volume auctioned in each round
  - 4.2.1.6. What to do with the amounts not awarded and not built
- 4.2.2. Diversity: Technological, size, actors, geographical
  - 4.2.2.1. Technological diversity
  - 4.2.2.2. Size diversity
  - 4.2.2.3. Geographical diversity
  - 4.2.2.4. Actor diversity
  - 4.2.2.5. Other diversity types
- 4.2.3. Prequalification criteria
- 4.2.4. Duration of contract
- 4.2.5. Penalties for non-compliance/delays
- 4.2.6. Updating of remuneration over time
- 4.2.7. Other design elements
  - 4.2.7.1. Local content rules
  - 4.2.7.2.. Deadlines and grace periods.


Country-specific conditions
· Potential of renewable energy resources
· Financing costs
· Installation and building costs (land, labour, energy, etc.)
· Ease of access to equipment
· Foreign exchange rates
· General fiscal legislation
Investor confidence and learning curve
· Credibility of the off-taker and additional guarantees
· Presence of a stable and enabling environment that is conducive to market growth
· Past experience with auctions for both auctioneer and developers
Policies supporting renewables
· Renewable energy targets and national plans that provide a trajectory for the sector
· Fiscal and financial incentives for RE projects
· Grid access rules
· Risk mitigation instruments
· Policies to promote broader development objectives (incl. socio-economic benefits and industrial development)
Auction design
Trade-off between lowest price and other objectives:
· Auction demand (auctioned volume, off-taker, regularity of auctions)
· Qualification requirements
· Winner selection method and criteria
· Sellers' liabilities (compliance rules distribution of financial and production risks)
Price resulting from an auction

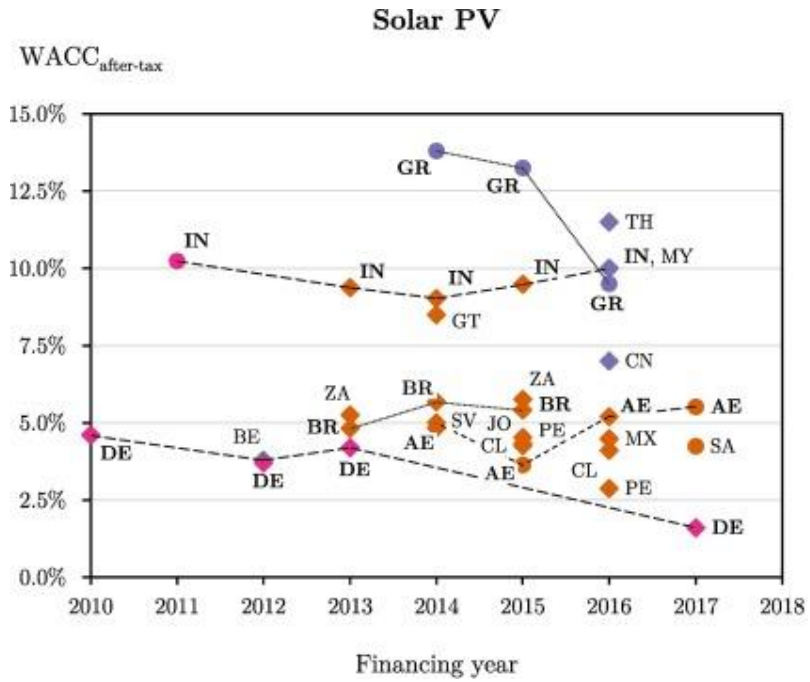
Market design matters:
LCOE sensitivity to a +/- 10% change in input parameters (onshore wind, PEF)



PEF: At, Be, Fr, De, Lux, Nl, Sui

Source: Agora EW

Costs of capital (WACC)



Elicitation of project finance data
- Egli et al 2018
- Shrimali et al 2013

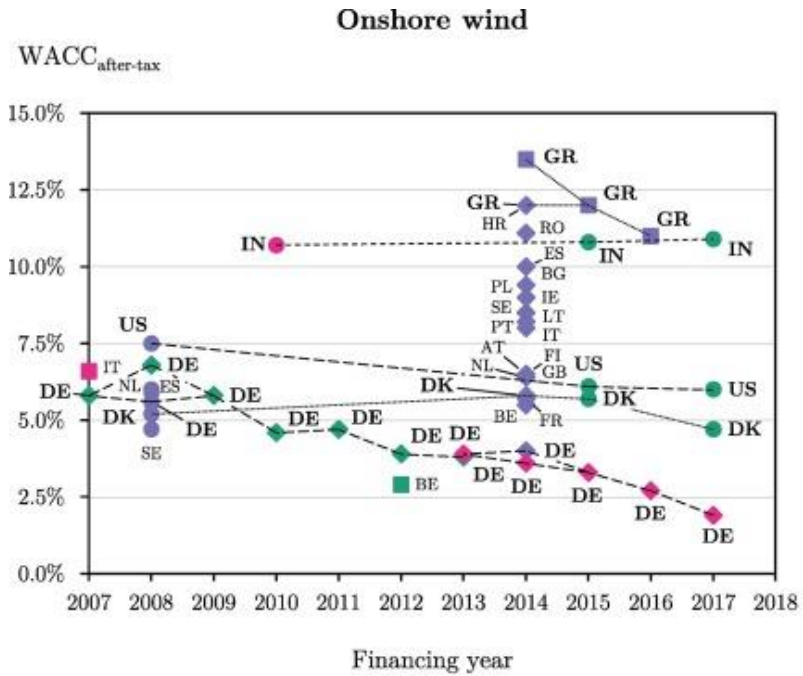
Survey of expert estimates
- Angelopoulos et al 2017
- Kumar et al 2017

Replication of auction results
- Apostoleris et al 2018
- Dobrotkova et al 2018

Analysis of financial market data
- Estache/Steichen 2015

Abbreviations:
AE United Arab Emirates, **BR** Brazil, **BE** Belgium, **CL** Chile, **CN** China, **DE** Germany, **GR** Greece, **GT** Guatemala, **IN** India, **MX** Mexico, **MY** Malaysia, **PE** Peru, **JO** Jordan, **SA** Saudi Arabia, **SV** El Salvador, **TH** Thailand, **ZA** South Africa

Note: Only countries with at least 50 MW installed capacity end of 2017 are shown.



Elicitation of project finance data
- Egli et al 2018
- Lorenzoni/Bano 2009
- Shrimali et al 2013

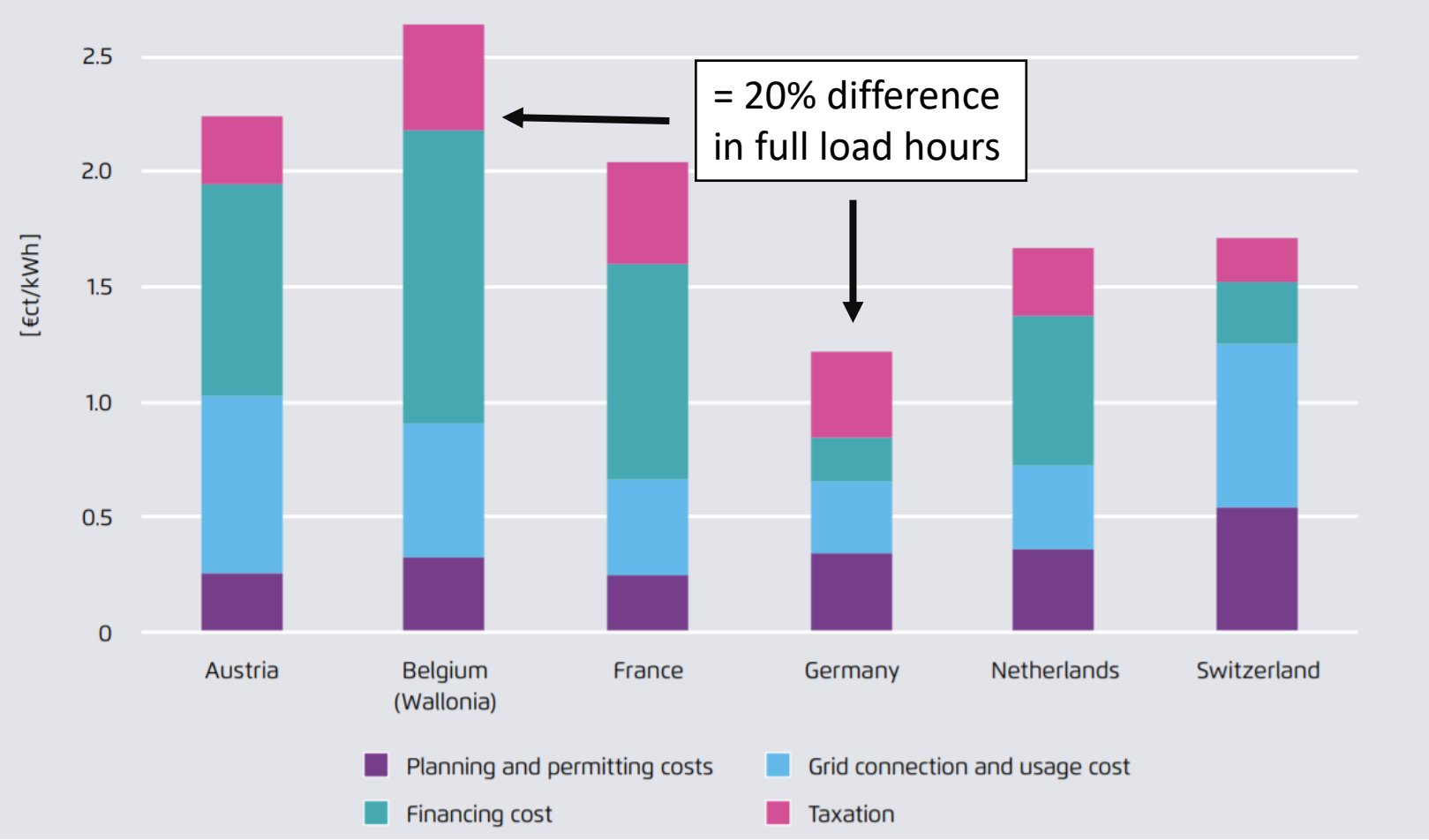
Survey of expert estimates
- Angelopoulos et al 2016
- Angelopoulos et al 2017
- Wood/Ross 2012

Analysis of financial market data
- Estache/Steichen 2015
- Partridge 2018
- Werner/Scholtens 2016

Abbreviations:
AT Austria, **BG** Bulgaria, **BR** Brazil, **BE** Belgium, **DE** Germany, **DK** Denmark, **ES** Spain, **FI** Finland, **FR** France, **GB** United Kingdom, **GR** Greece, **HR** Croatia, **IE** Ireland, **IN** India, **IT** Italy, **LT** Lithuania, **NL** Netherlands, **PL** Poland, **PT** Portugal, **RO** Romania, **SE** Sweden, **US** United States

Note: Only countries with at least 50 MW installed capacity end of 2017 are shown.

LCOE breakdown (onshore wind, PEF)

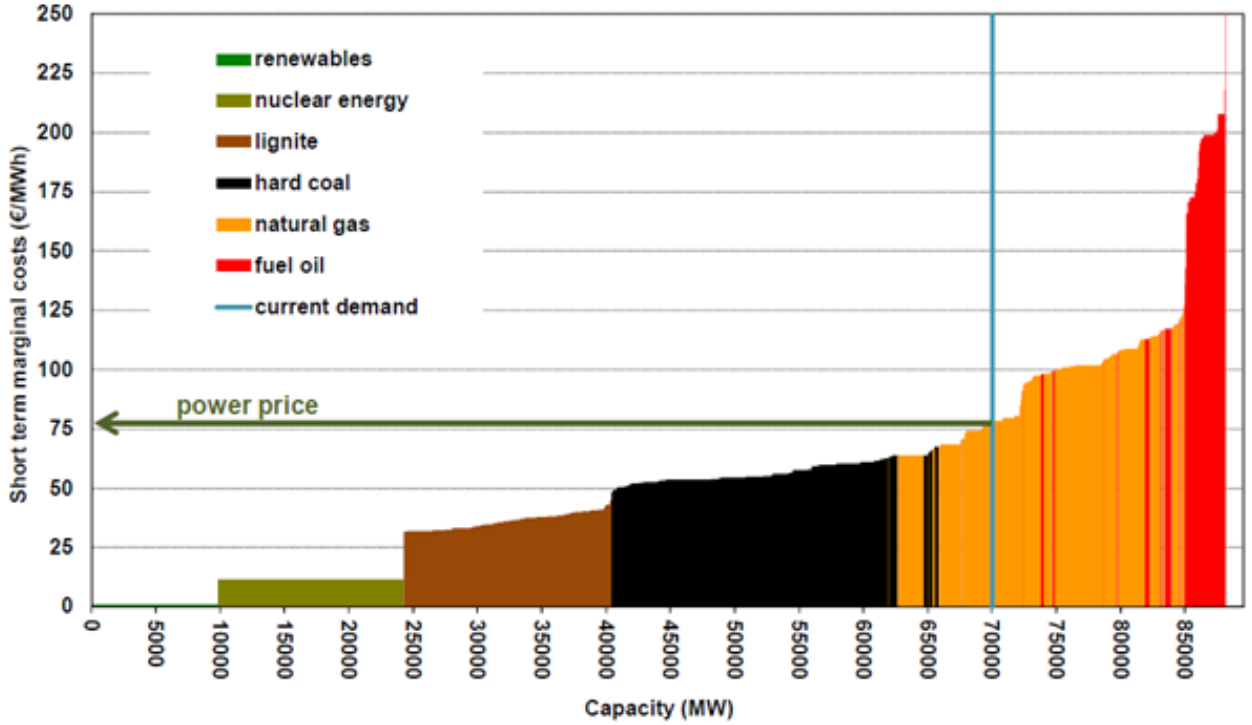


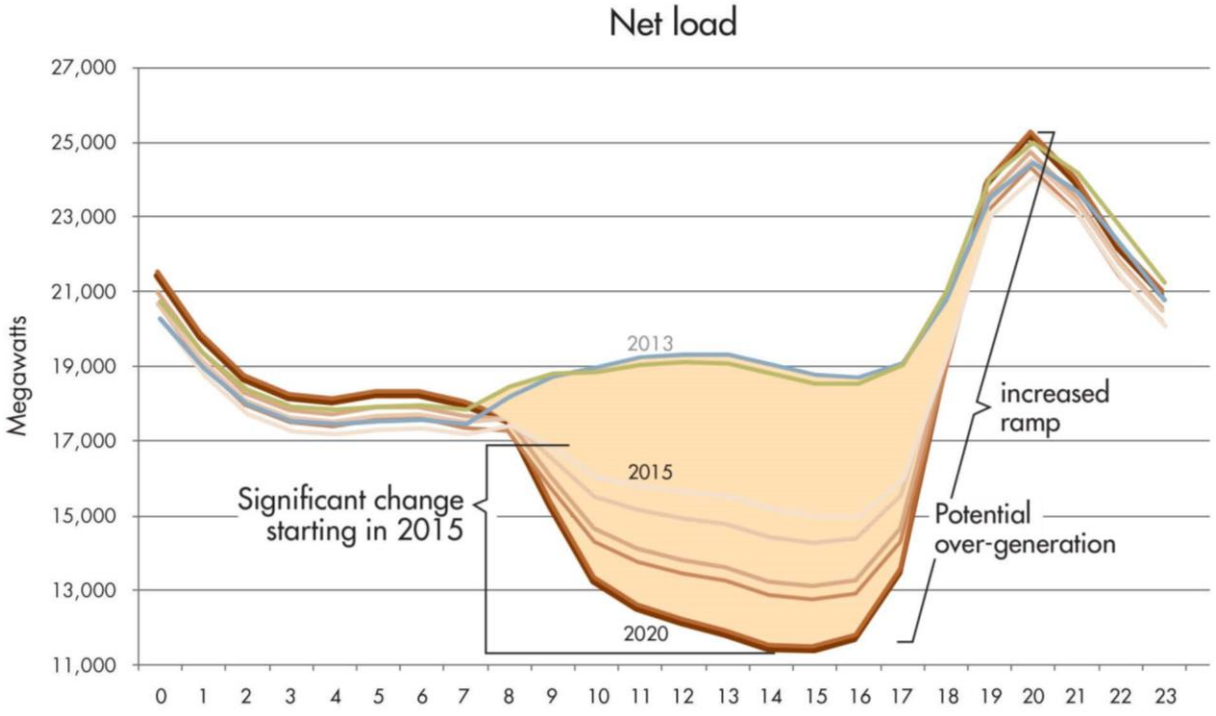
PEF: At, Be, Fr, De, Lux, Nl, Sui

Source: Agora EW

=> regulatory environment effects can be larger than cost effects from differences in resource availability

Towards a new market design





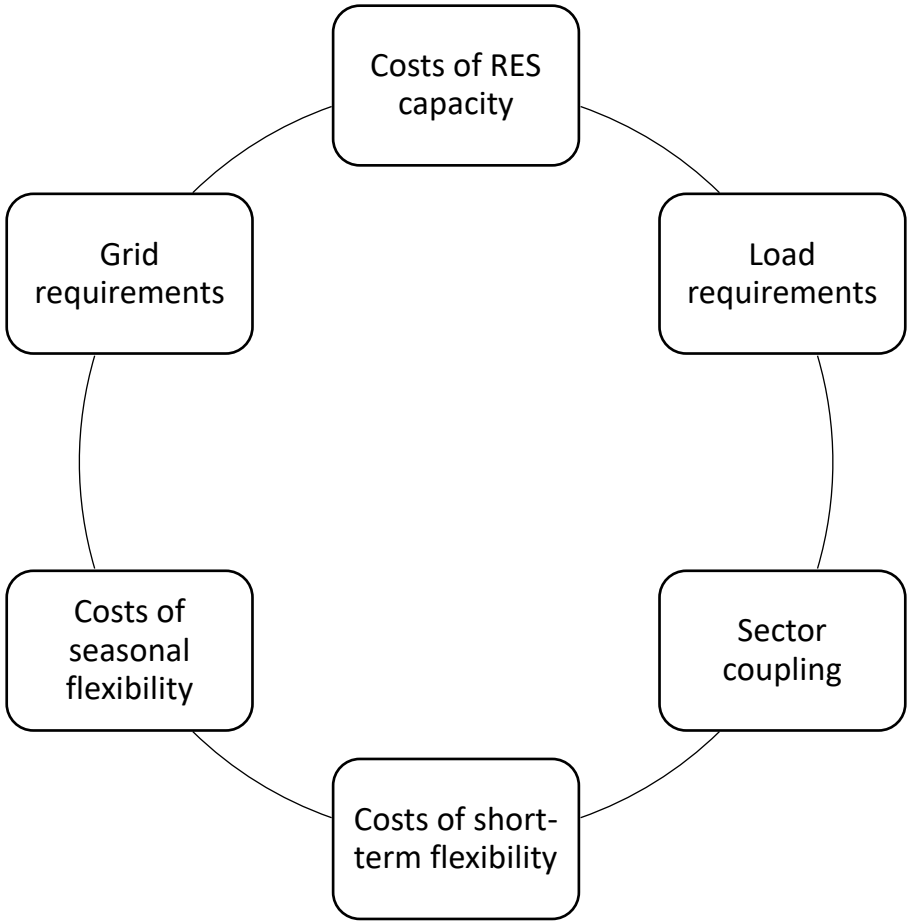
Integrating RES: re-imagining the market

A few examples from

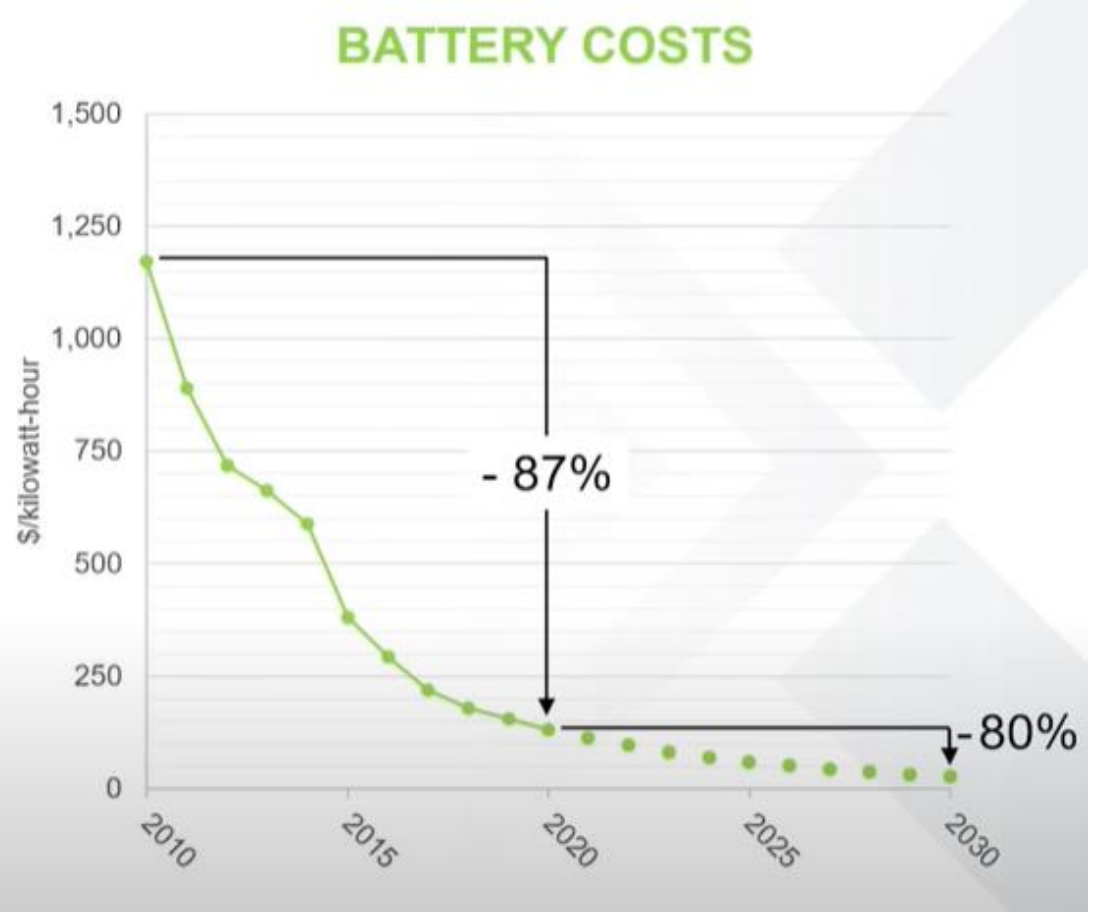
FSR's design ideas overview

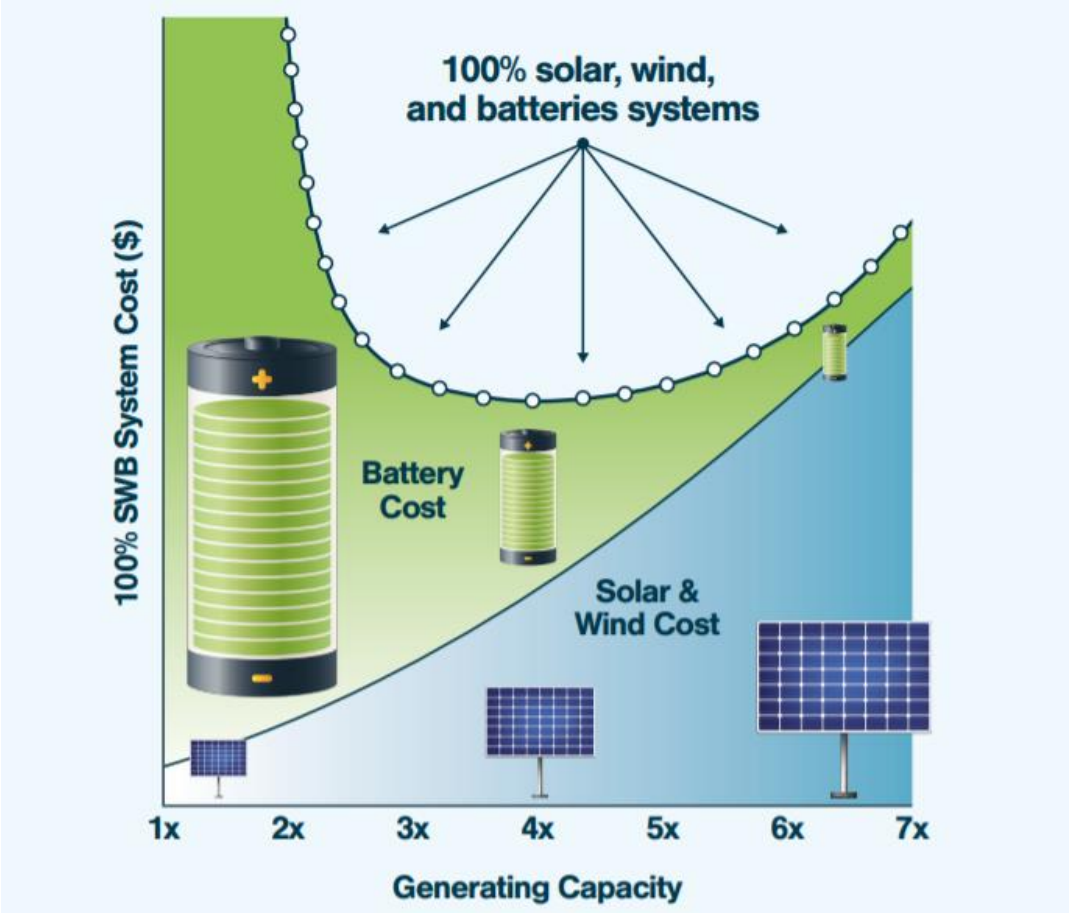
- Power-only market
- National + local energy markets
- Capacity + flexibility markets

Future market inputs



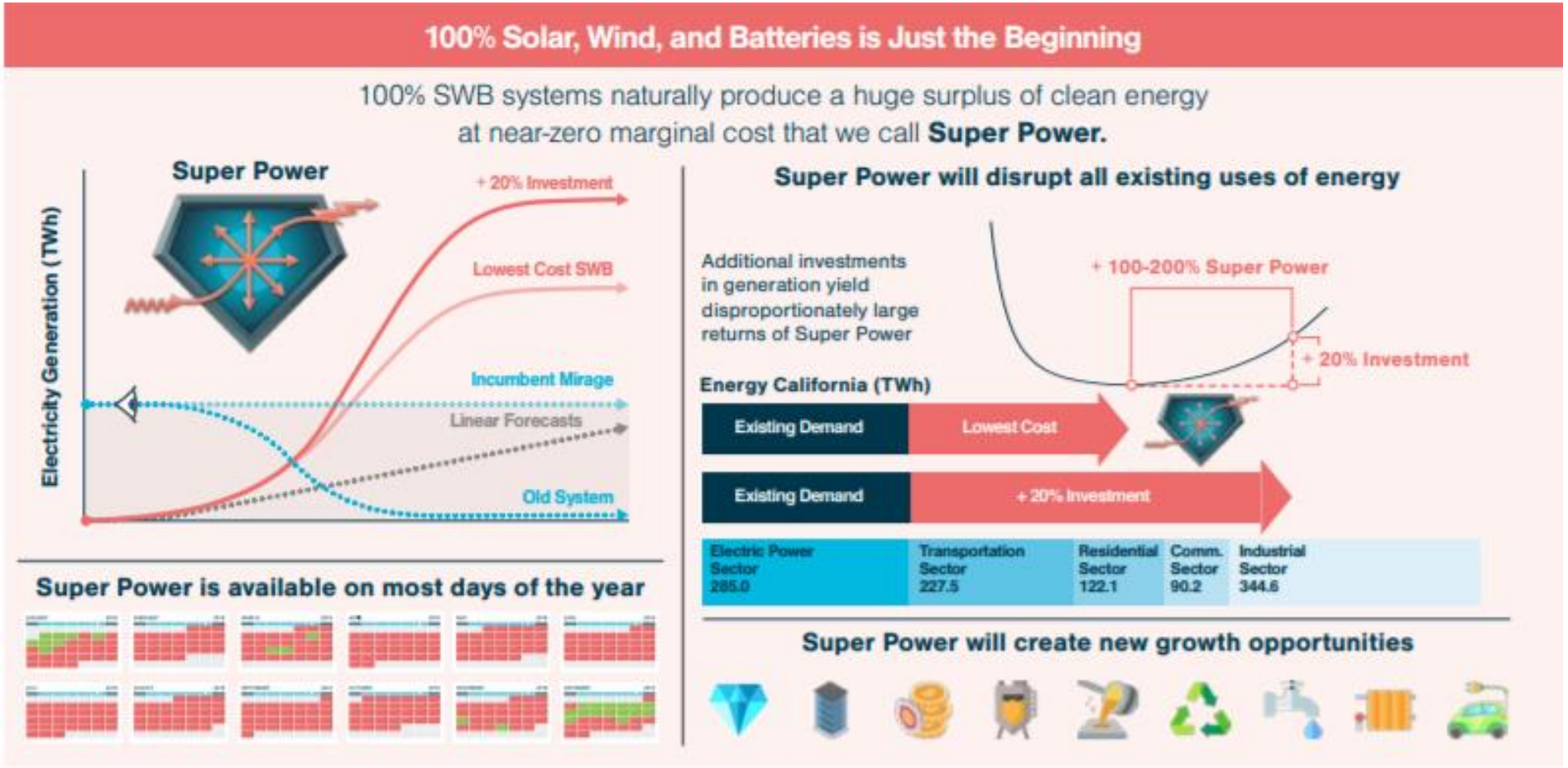
Where next? Solar, wind, battery systems





Source: [RethinkX]

Towards extreme abundance?



Source: [RethinkX]