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Enhancing Federal Clean Energy Innovation Workshop

Thinking Globally

Washington D.C. (remote)

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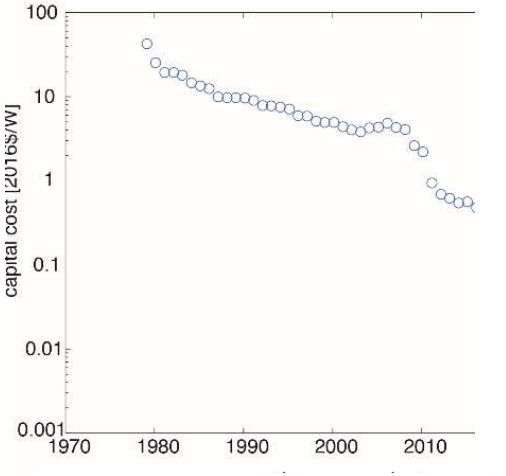
Overview

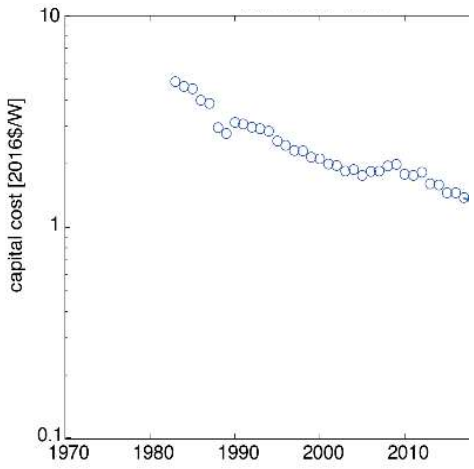
1. Innovation trends in energy technologies
2. Landscape of technology push policies
3. Landscape of market pull policies
4. Selected global cleantech manufacturing trends
5. Competition and collaboration in international energy innovation

Historical improvements in energy technologies

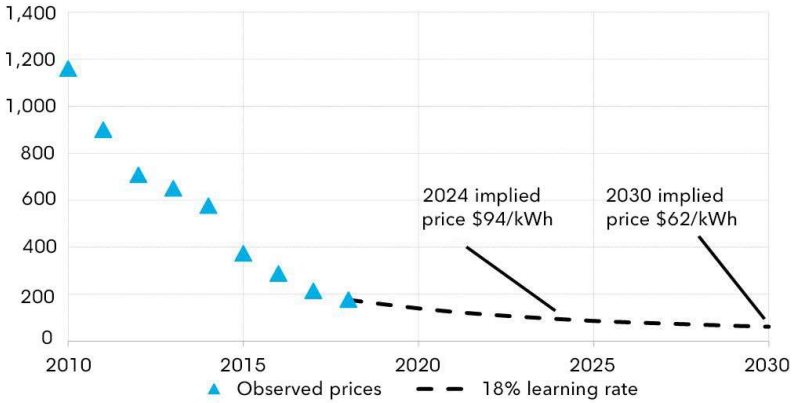
Crystalline Si PV cap. cost (2016 $/W)



Onshore wind turbine cost (2016 $/W)



Lithium-ion battery prices and outlook ($2018/kWh)



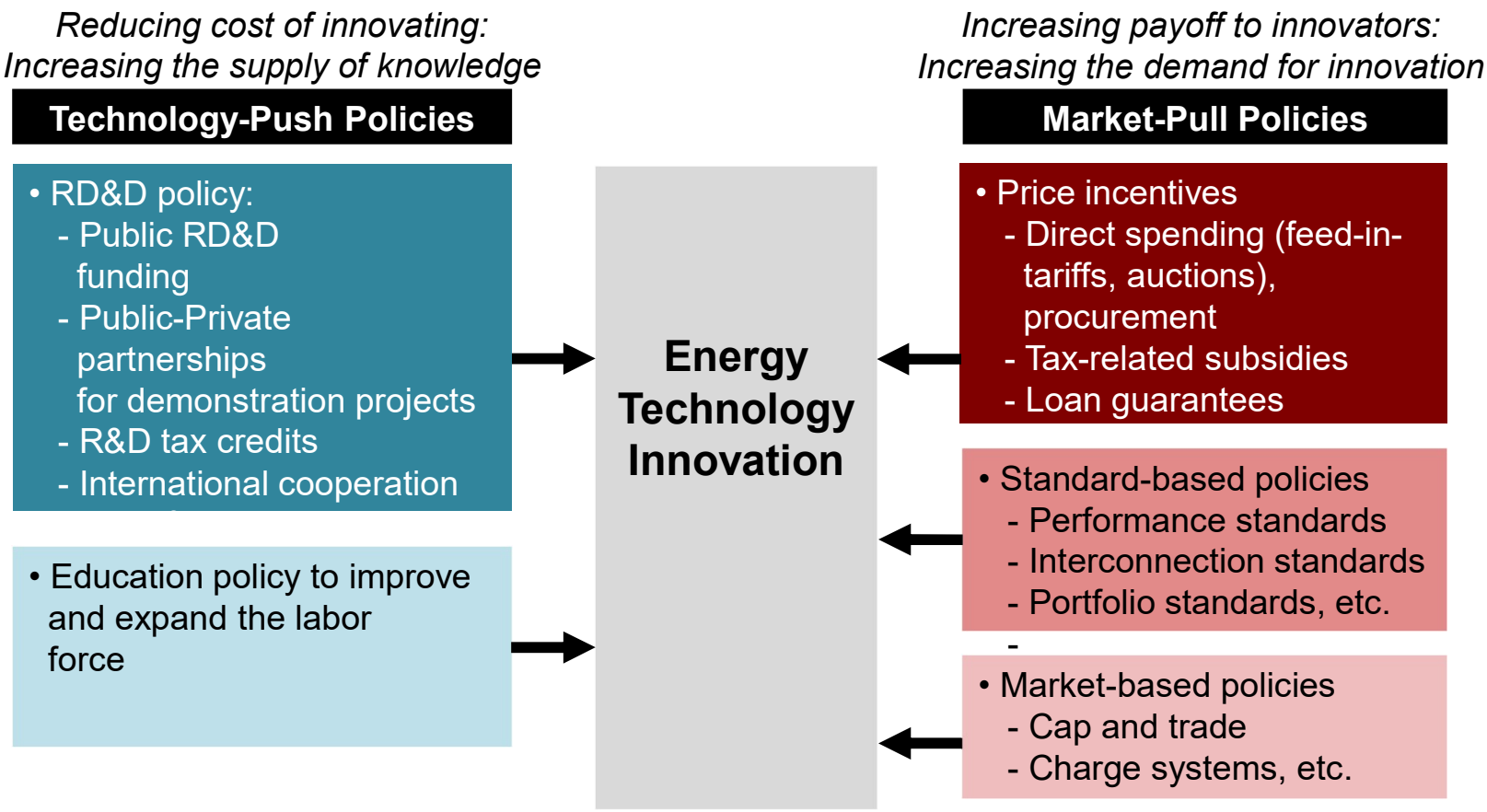
Source: BloombergNEF

Recent cost reductions:

- solar PV modules have come down approx. by 82% over 10 years
- onshore wind turbines have come down approx. by 43% in 10 years
- cost of power from offshore wind turbines in the UK has come down by about 50%
- lithium ion batteries by 89% over the past 8 years
- cost per flux in LED packages went down by 98% since 2009

Meng, Verdolini, Anadon (2020). Under review;
Weinold, Kolesnikov, Anadon (2020) Ongoing.

These improvements (and others) are partly explained by tech push and market pull government policies internationally



Anadon and Holdren (2009), *Brookings Press (*adapted from Mowery and Rosenberg (1979)

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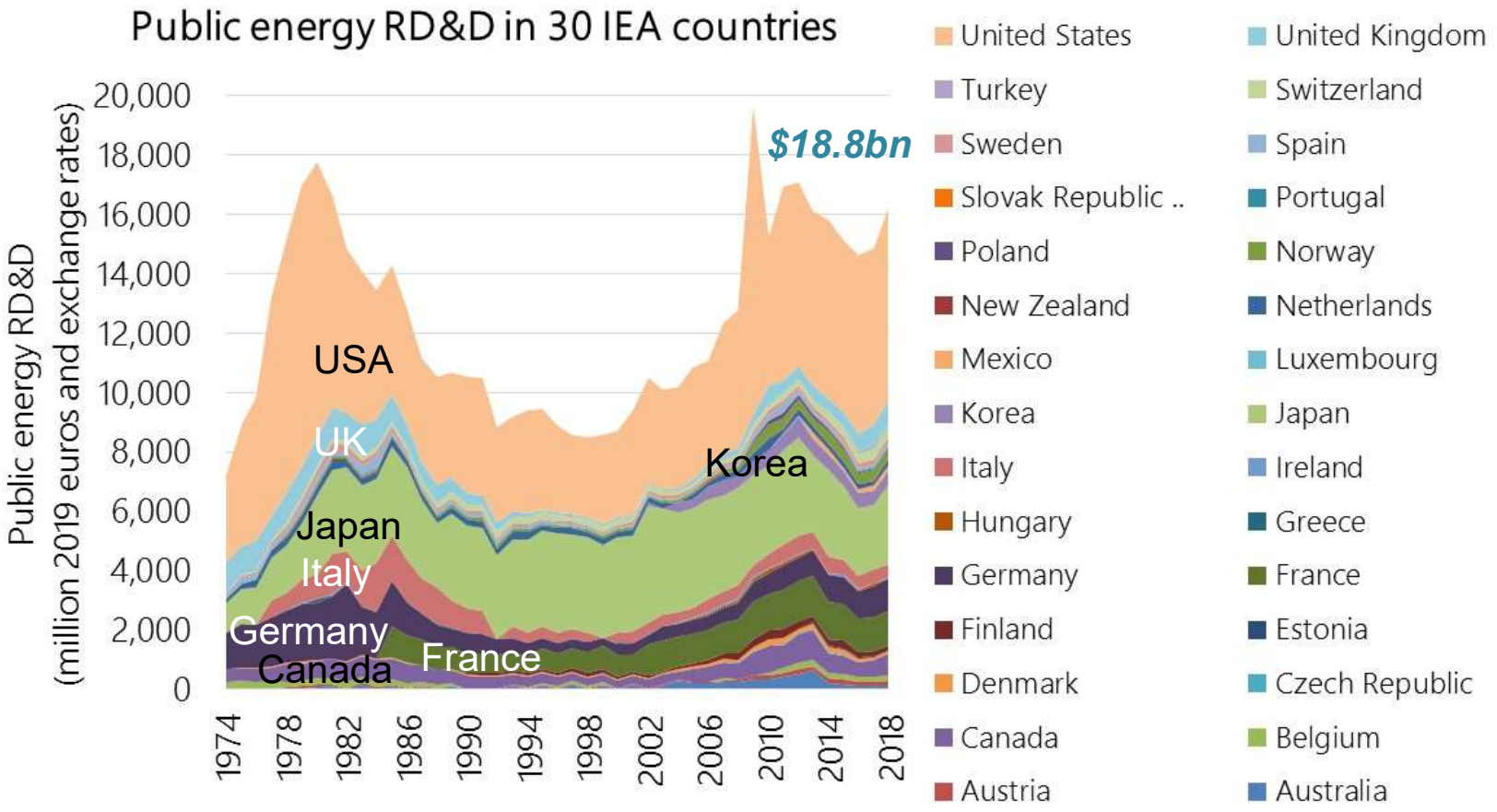
2. Technology push landscape

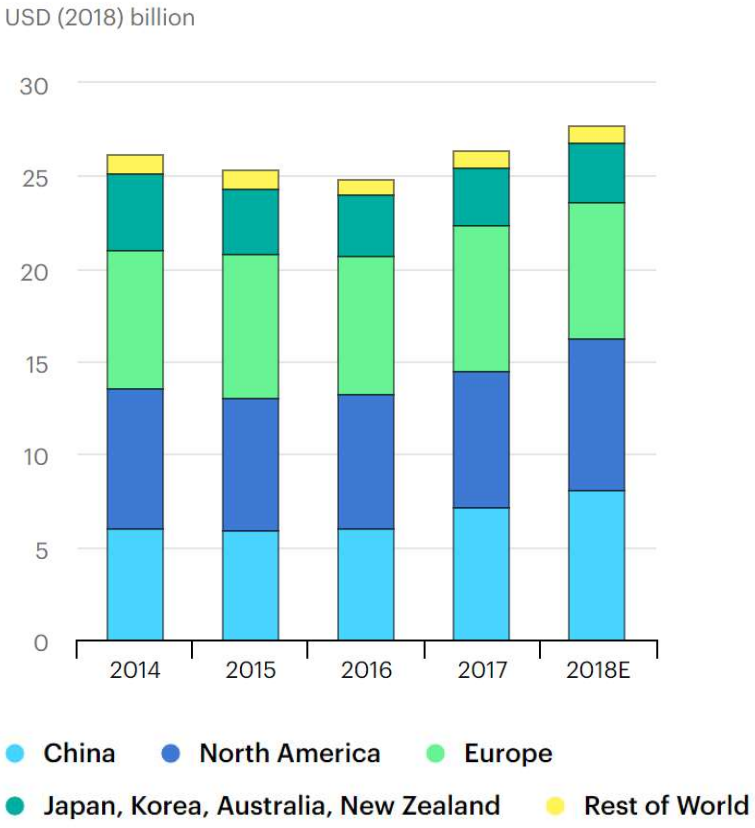
Public energy RD&D investments are increasing in IEA countries

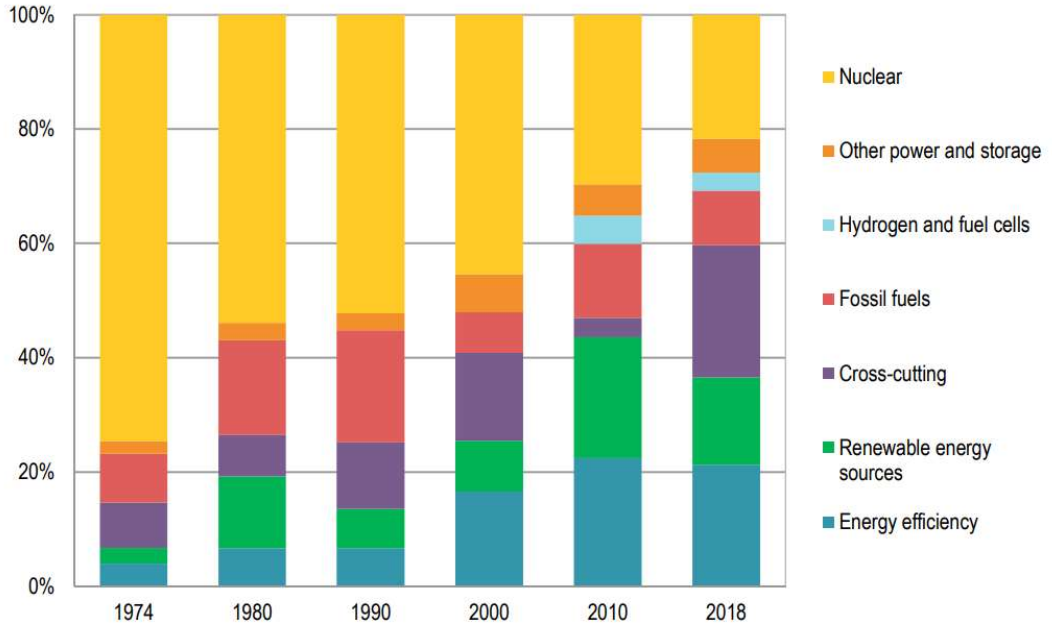


- Global increase since the early 2000s
- Slow down after 2009 crisis
- Renewed increase post Paris 2015

Own elaboration using IEA RD&D database (2020)

China‘s role has increased even just since 2014 and the technology internationally has changed significantly

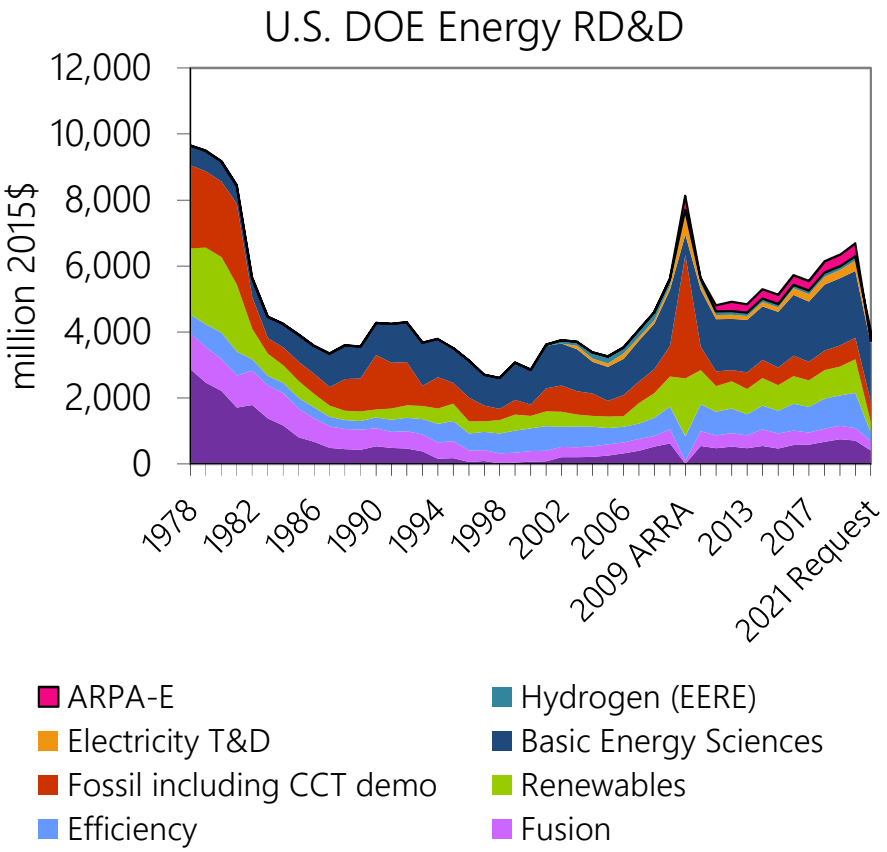




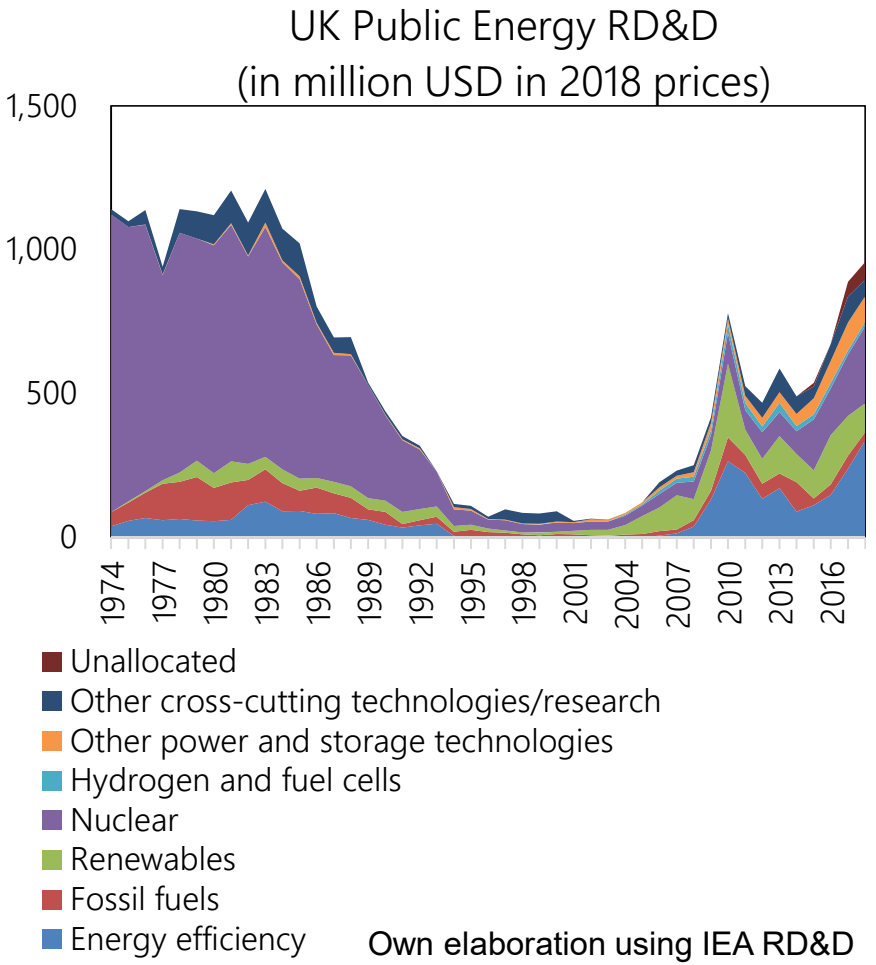
- More focus on efficiency and renewable energy and on cross-cutting research (e.g. BES) and less on nuclear

Source: IEA figures from IEA RD&D Database (2019)

Some countries are ramping up more rapidly
In UK, more recent focus on efficiency and storage, very little fossil



Absolute amounts in US 7X larger



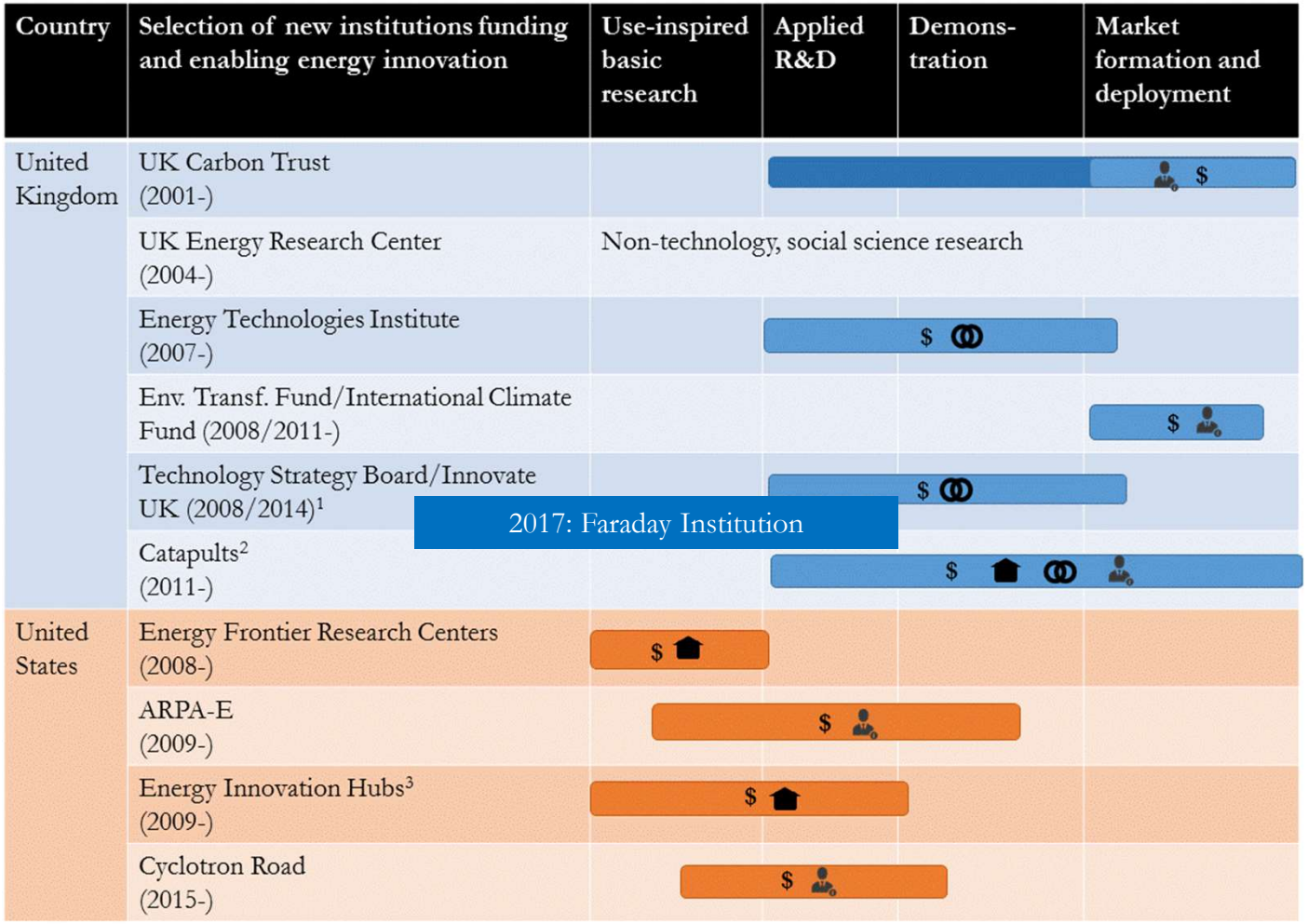
Anadon, Gallagher, Holdren (2017). *Nature Energy*; Gallagher & Anadon (2020) Database - Belfer Harvard, Fletcher Tufts, CEENRG -Cambridge

Own elaboration using IEA RD&D database (2019)

US/UK institutional innovation in energy R&D since 2000

- $: provision of funds
- circles: direct private sector involvement in decision-making
- house: creation of new entity during the funding
- person: provision of expertise in the form of business or technical advice

Updated and adapted from Anadon (2012) *Research Policy* by Chan et al. *Nature* (2017)



China

- Between 2002 and 2017 China increased its public RD&D investments by a factor of 6 (to around $5 bn USD), nuclear still very important
- Each five year plan associated with increases
- Since 2015 (start of the 13th FYP), the largest amount of funding is allocated to central R&D institutions (e.g., national lab 'equivalents') vs. CAS, universities or enterprises
- In 2016 there was a reorganization with the National Key R&D Program (merging 863, 973 and Gongguan), with a large large focus on efficiency and storage

➔ [National research institutions are also playing a growing role in **Germany**]

Ongoing work Xu & Anadon (2020) and Galeazzi and Anadon (2020)

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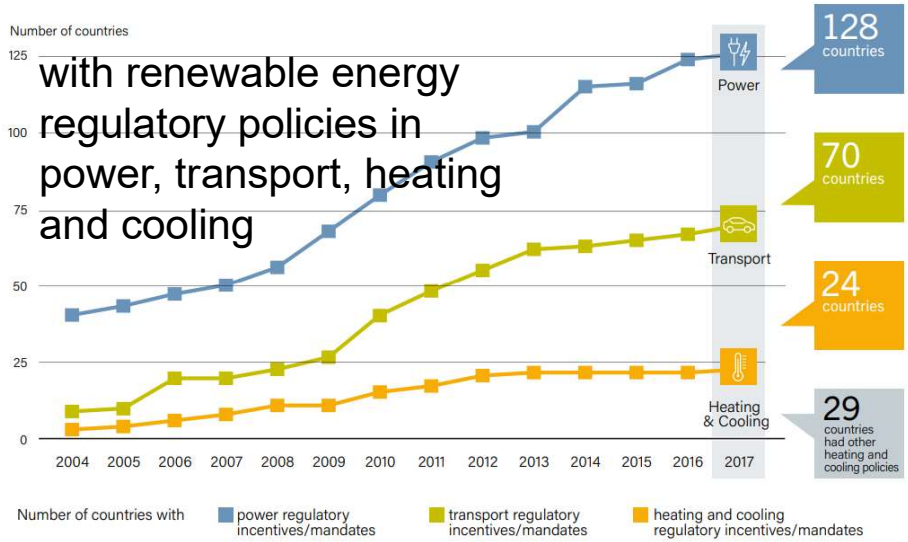
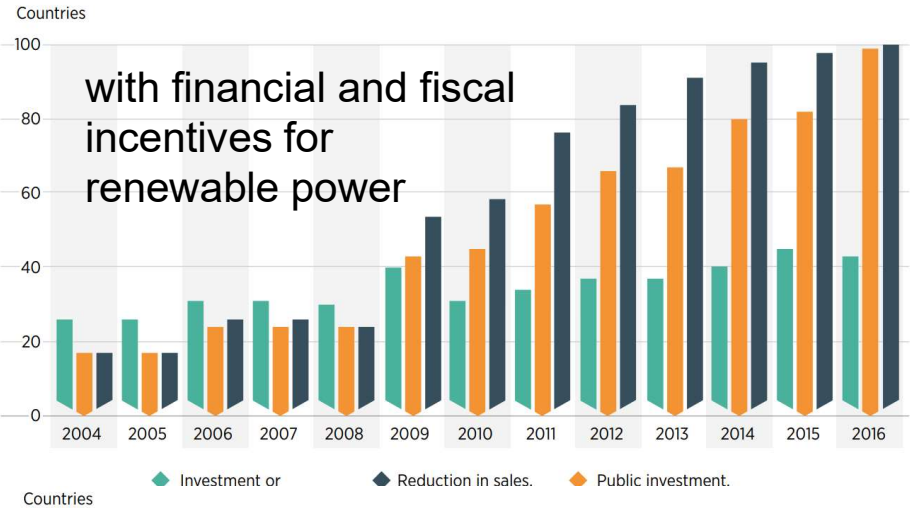
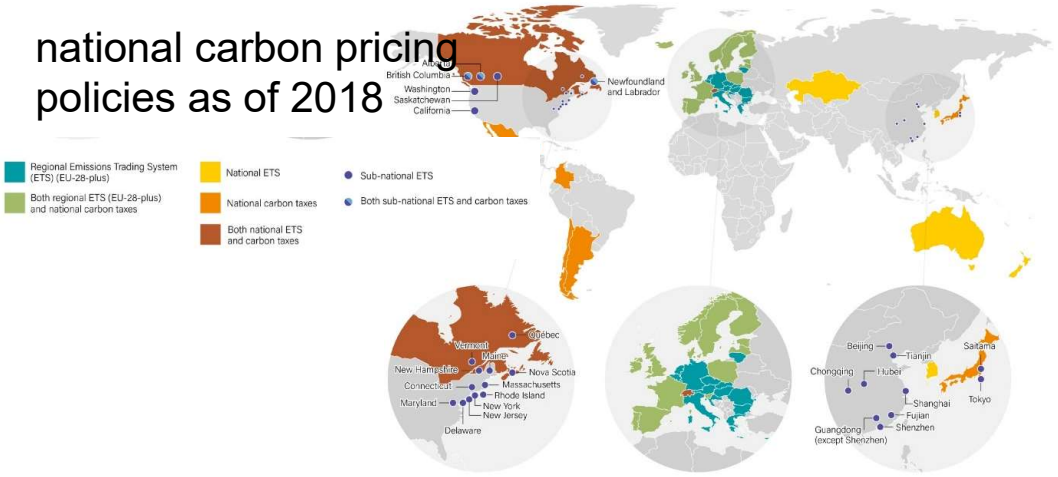
3. Market pull landscape

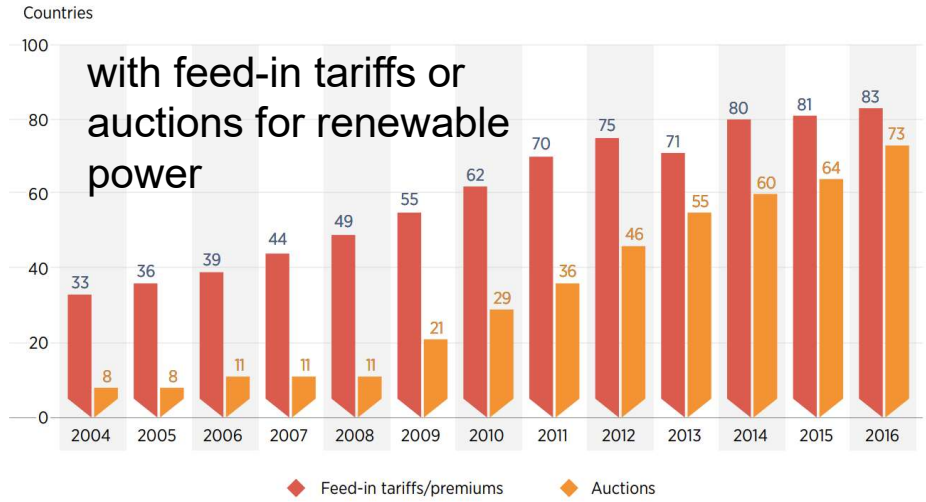
Market pull policies essential bringing down costs – they will need to be expanded/redesigned and complemented for NetZero





national carbon pricing policies as of 2018





Figures from REN21 (2018, 2019)

The interaction between energy innovation policy and politics

Recent political science literature on cobenefits and interest groups

- **Co-benefits shape public opinion**

Understanding if and how different policy instruments can be used to lower trade-offs among the diverse set of societal goals or to promote 'additional benefits' can change public opinion

[Deng et al., (2018); Stokes and Warshaw, (2017); Ansolabehere and Konisky, (2014) Roberts and Zeckhauser (2011); Hulme (2009)]

- **Energy innovation shapes interest groups in climate and energy policy**

New industries create new actors ('winners'), which form new interest groups that make policy 'sticky'

[Breetz, Mildenberger, & Stokes (2018); Stokes & Breetz (2018); Meckling et al. (2017); Schmidt & Severin (2016); Schmidt & Huenteler (2016)]

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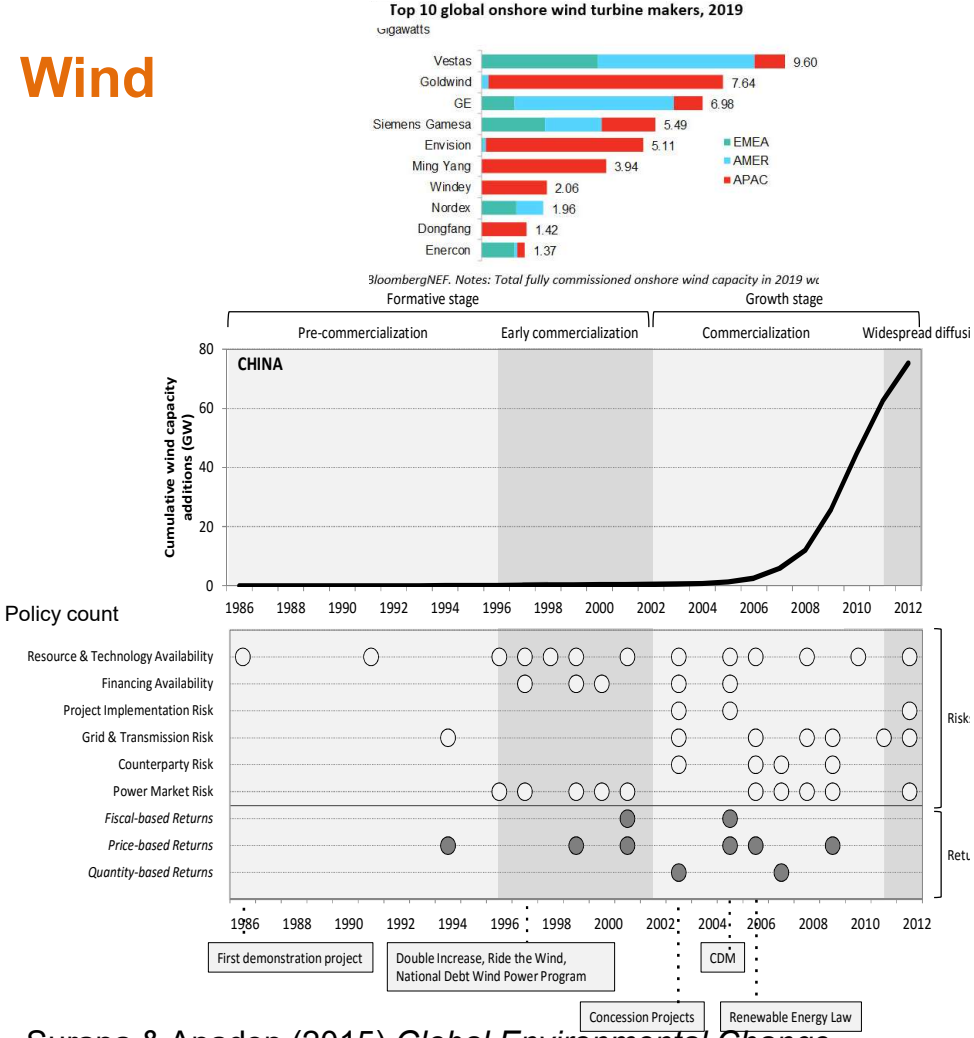
4. Selected global cleantech manufacturing trends

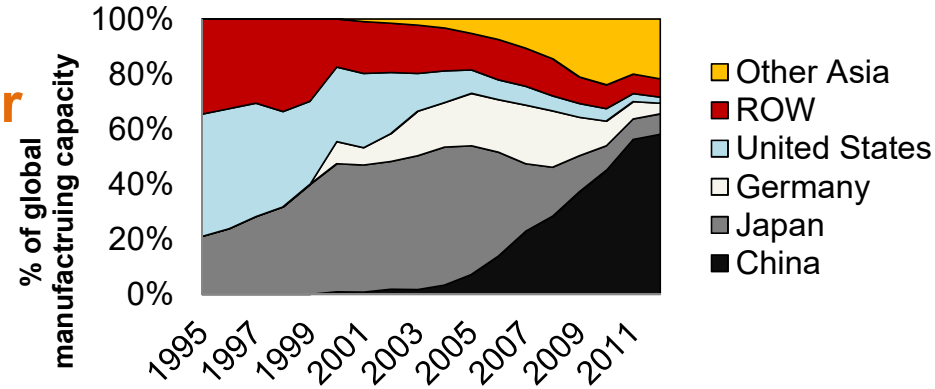
China has captured a large part of manufacturing but with different strategies and timeframes

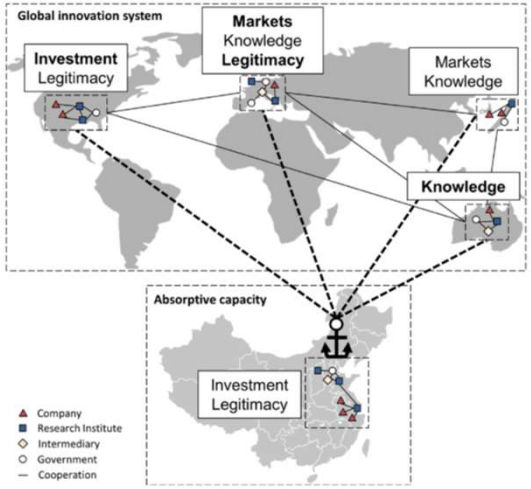
Wind



Surana & Anadon (2015) *Global Environmental Change*

Solar





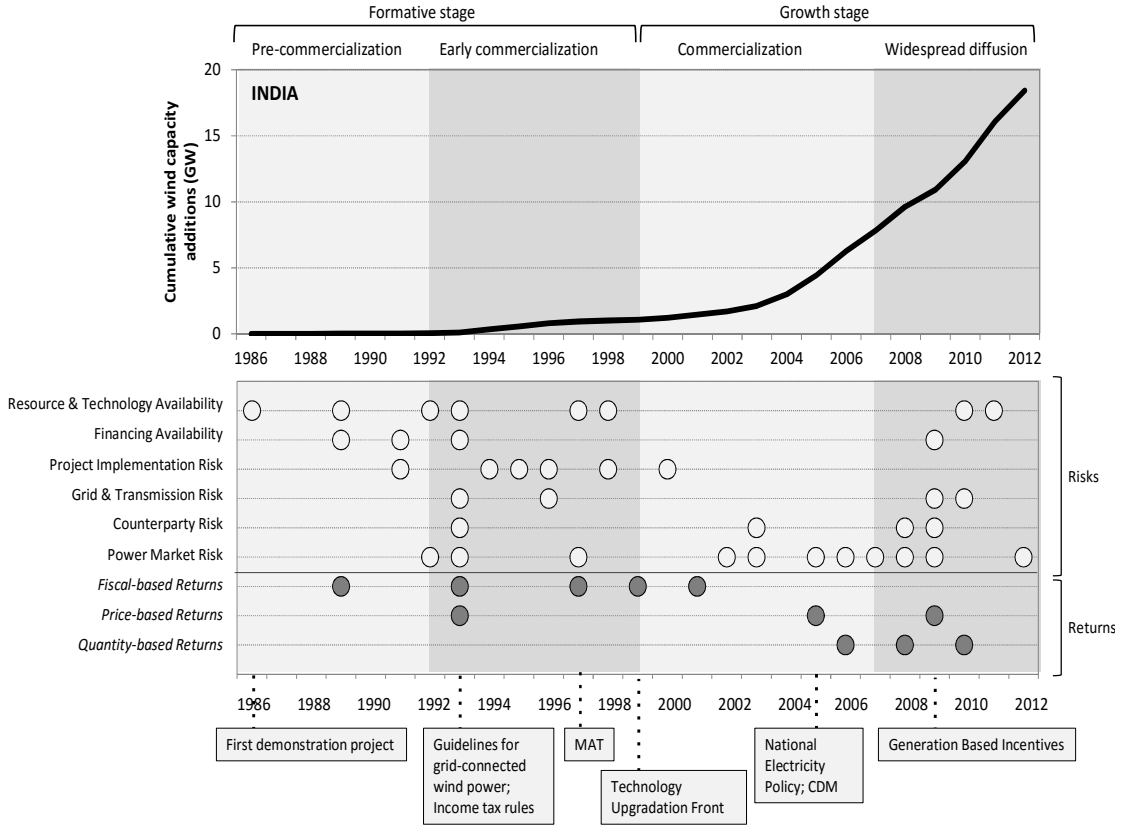
- Less targeted policy intervention, faster, and more reliance on international resources

Binz & Anadon (2018) *EIST*

India also started policies promoting wind in the 1980s, and started promoting solar more recently

Wind

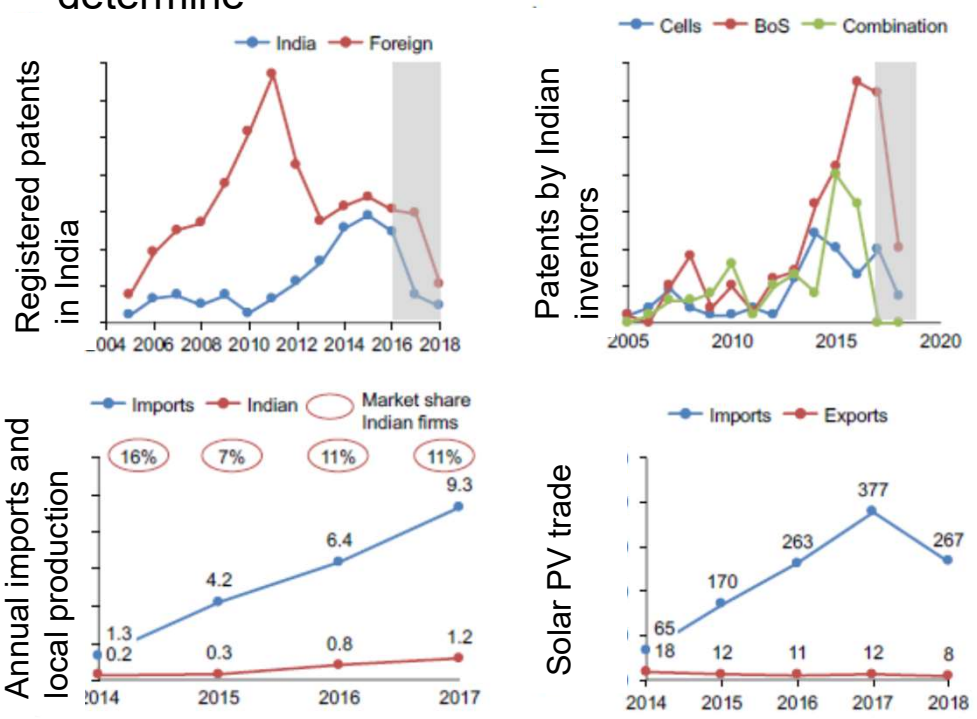
- Little wind turbine exports in spite of policies over decades



Surana & Anadon (2015) *Global Environmental Change*

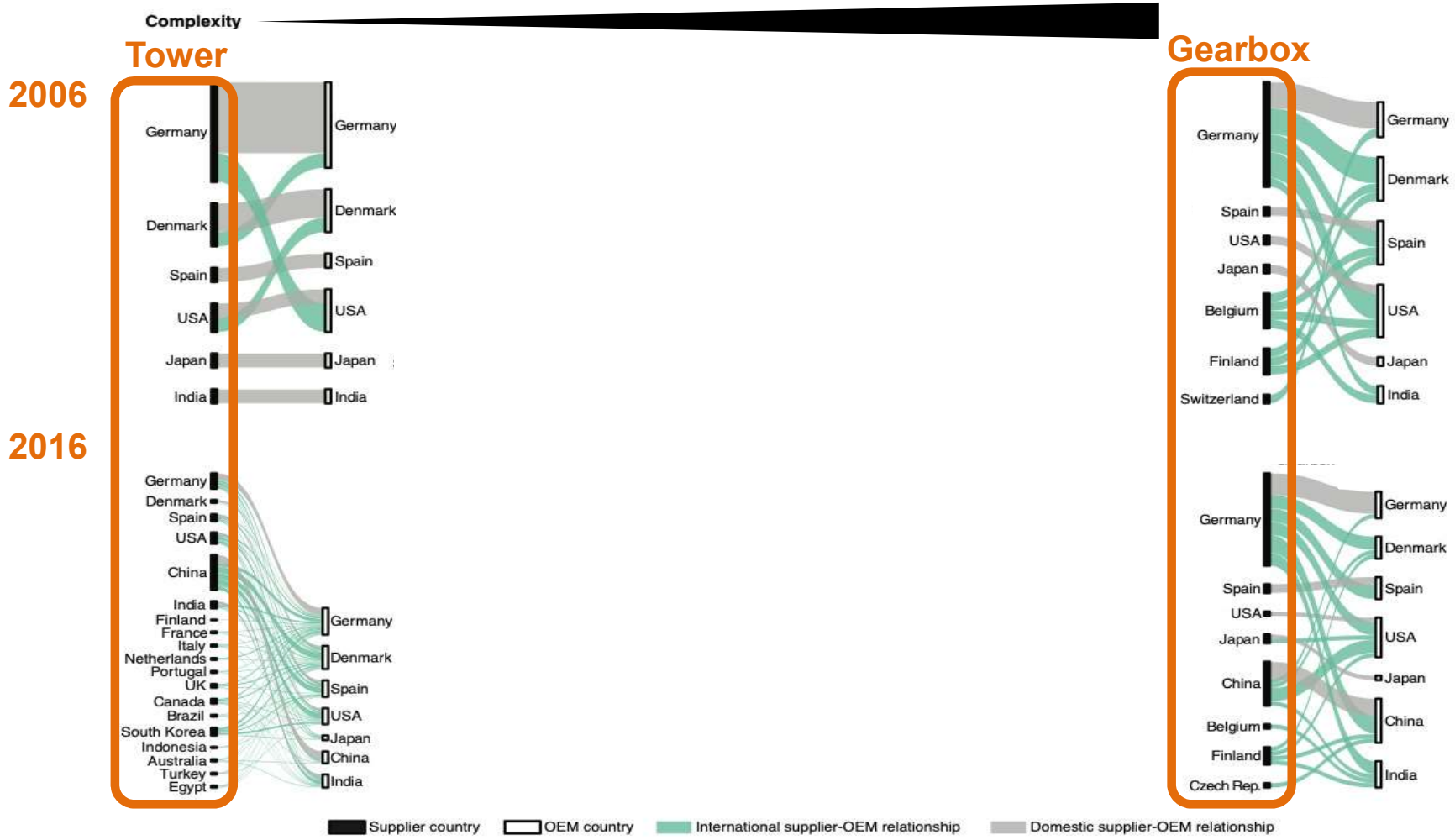
Solar

- 2014-17 local content requirements: power cost up, impact on innovation and competitiveness hard to determine



Probst, Anatolitis, Kontoleon, Anadon (2020) *Nature Energy*. Forthcoming.

Supply chains matter: emerging evidence that more complex wind component suppliers are present in less countries



Surana, Doblinger, Hultman & Anadon (2020) *Nature Energy.* Forthcoming.

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5. International collaboration and competition

Policy makers in the international sphere are paying attention to energy and energy innovation

- Paris Agreement 2015

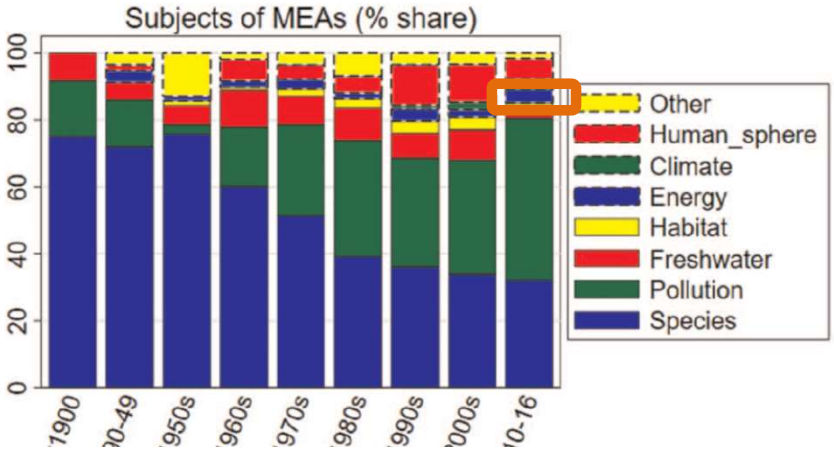
"accelerating, encouraging and enabling innovation is critical for an effective, long-term global response to climate change"

- Mission Innovation Pledge (goal of doubling RD&D in 5 years)
- Breakthrough Energy Coalition
- Green Climate Fund (launched in 2010, pledges of $10 bn in 2014, $1 bn spent in 2018)

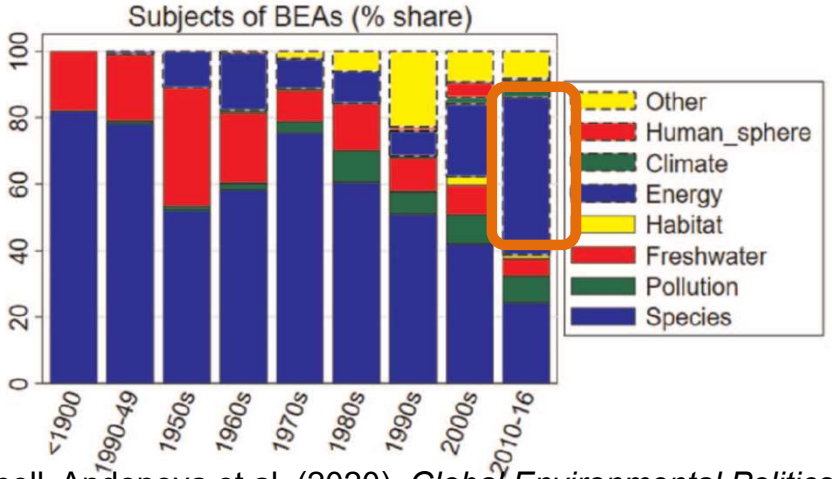
…

➔ **And the majority of Bilateral Environmental Agreements are now in Energy**

Topic of **Multilateral** Environmental Agreements (% share)



Topic of **Bilateral** Environmental Agreements (% share)



Mitchell, Andonova et al. (2020). *Global Environmental Politics*

Domestic push & pull policies have been main drivers. What to do cooperatively building on this and the apetite for bilateral action?

- The cooperation vs. competition dynamic is real
- Few examples of real RD&D collaboration (e.g. ITER)
- Roles of international cooperation include
  - **Setting goals, priorities and agendas** (e.g., COPs, MI)
  - **Reducing transaction costs** (e.g., through sectoral rules and standards)
  - **Reducing costs and/or risk** (e.g., shared demonstrations, Nordhaus 2015 Climate Club proposal)
  - **Building capacity** (e.g., through incentives such as Germany's GetFit)
  - Reducing information asymmetries
  - Internalizing (transnational) environmental externalities
  - Reducing social distance (between local populations & transnational actors)

Anadon et al. (2014). *Harvard Sustainability Science Program*

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Thank you for your attention!

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