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Escaping lock-ins in accelerating low-carbon transitions:

Lessons from electricity and auto-mobility systems

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Structure of talk

1. Introduction
2. Rethinking lock-in (and the Multi-Level Perspective)
3. Accelerating low-carbon transitions in electricity and mobility systems
4. Lessons about escaping lock-in
5. Conclusions

1. Introduction

- Keeping climate change below 2C requires **rapid system transitions** (IPCC, 2018; 2023)
- Difficult because lock-in mechanisms stabilise existing systems

- To accelerate low-carbon transitions, it is important to

1) Escape current system lock-ins
2) Create new lock-ins to low-carbon innovation trajectories

→So, lock-ins are ‘not always bad’ (conference website)

→They are also necessary to accelerate, because diffusion and strong actor commitment require (some degree of) stabilisation

This beginning to happen empirically

- Although **global** emissions continue to rise, there are hopeful developments since AR5 (IPCC, 2014) and 1.5C report (IPCC, 2018):

a) decreasing emissions in more than 18 **countries** (IPCC, 2023),

b) accelerated diffusion and deployment of solar, wind, EVs, LEDs

→ Let's analyse this to draw lessons

Goals of talk

1. Rethink path dependence and lock-in (conference goal)
2. Draw lessons about 'unlocking' from accelerating low-carbon transitions in electricity and mobility systems

2. Rethinking lock-in (and the Multi-Level Perspective)

Two diagnostic propositions:

1) Lock-in and path dependence are middle-range concepts that can be operationalised in different ways (depending on discipline and ontology) [→ there is no single theory of lock-in]

2) Lock-in and path dependence are discussed in three kinds of academic debates:

a) Emerging innovations and existing entities (systems/regimes)
b) Determinism vs. agency ('path dependence' and 'path creation')
c) Views on 'unlocking'

a) Lock-in of emerging innovations and existing entities

Stabilising emerging innovations (in technology, policy, organisations)

- **Evolutionary economics**: Lock-in refers to the selection of a dominant technical design, which reduces the initial variety (David, 1985 QWERTY; and IRA from Arthur, 1989)
- **Political science**: Lock-ins help stabilise new policies (due to policy feedbacks) so that they can withstand contestation (Skocpol, 1992; Pierson, 2000)
- **Organization studies**: Lock-in helps generate new organizational paths (Sydow et al., 2009) by articulating new organisational structures and routines and increasing commitments

→ Lock-in is positive and necessary

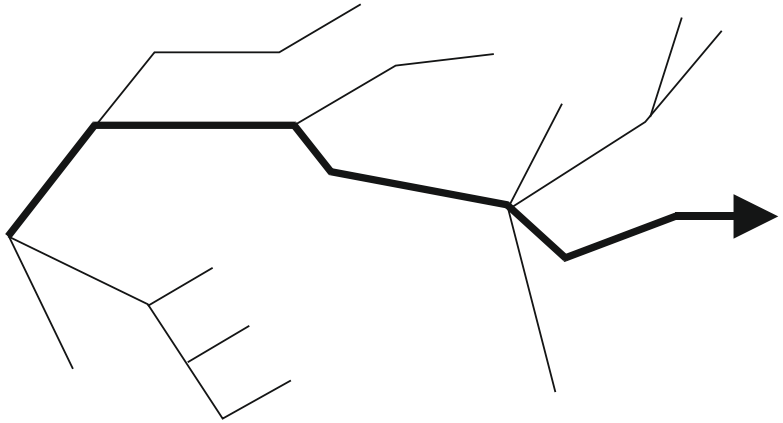


Figure 1: Technological trajectory as evolutionary process (Schot, 1991)

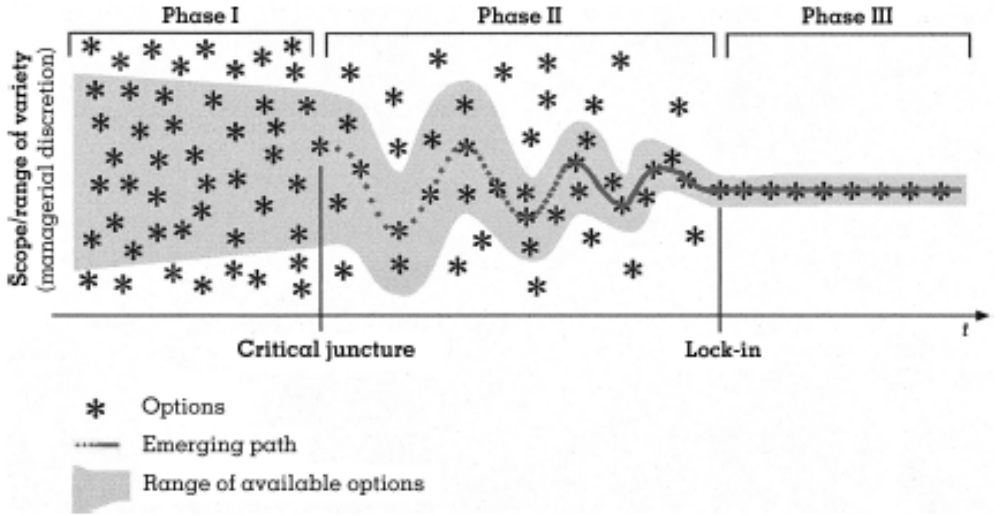


Figure 2: The constitution of an organizational path (Sydow et al., 2009: 692)

Lock-ins hamper radical change in existing entities (leading instead to trajectories of incremental change)

- (Socio)technical systems are stabilised by technological regimes/paradigms (Dosi, 1982; Nelson and Winter, 1982); see also energy and climate change studies (Unruh, 2000; Klitkou et al., 2015; Seto et al., 2016)

- Organizational fields and ways of doing are stabilised by organizational templates and institutional logics (Powell and DiMaggio, 1983; Scott, 1995; Greenwood and Hinings, 1993; Thornton et al., 2012)

- Policy paradigms and policy regimes lead to incremental policy making (Hall, 1993; Wilson, 2000) because of established ideas/cognitions, institutional arrangements, and interests/power

- User practices, habits, and routines are stabilised by (unconscious) repeated behaviour (Barnes et al., 2004; Warde and Southerton, 2012; Salonen, 2021).

→ Lock-in is 'bad' and prevents transitions by stabilising status quo

Attempted cross-disciplinary synthesis of different lock-in mechanisms (Geels, 2021)

No single theory of lock-in

Different kinds of lock-in mechanisms with different degrees of 'depth'

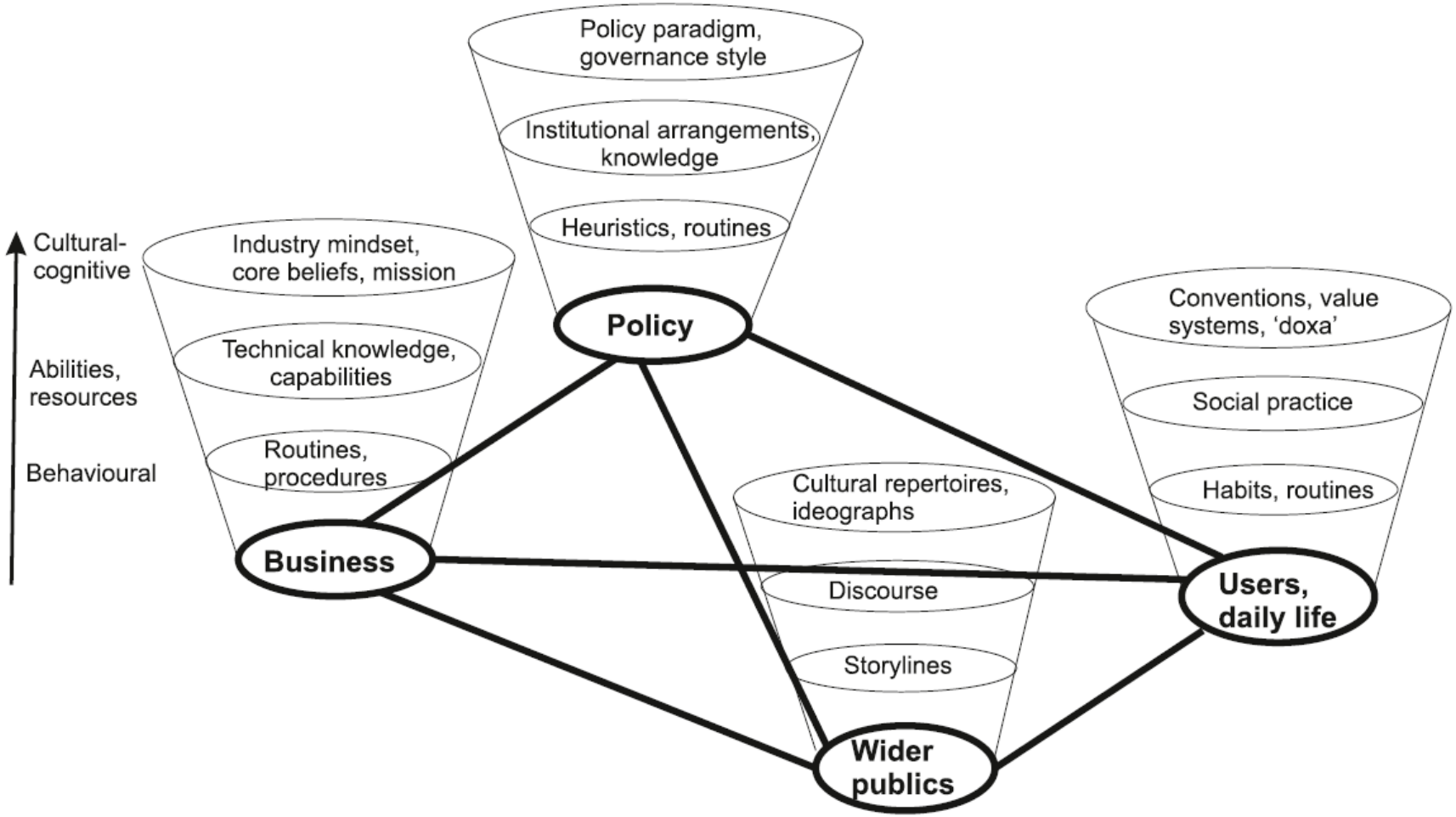


Fig. 1. Configurational elements of incumbent actor groups.

Geels, F.W., 2021, From leadership to followership: A suggestion for interdisciplinary theorising of mainstream actor reorientation in sustainability transitions, *Environmental Innovation and Societal Transitions*, 41, 45-48.

b) Determinism vs. agency

- **Path dependence**: accommodates some agency through early random 'events', but lock-in mechanisms are impersonal, automatic, economic/material and deterministic (scale economies, network externalities, sunk investments, cost reductions)

- **Path creation**: paths are always enacted and open-ended because socio-cognitive (networks, ideas, commitments) and interests-based mechanisms are reactive (actors responding to each other) and potentially reversible (Mahoney, 2000; Garud and Karnoe, 2000; Sydow et al., 2012)

Mahoney, J., 2000, Path dependence in historical sociology, *Theory and Society*, 29(4), 507-548.

Garud, R. and Karnøe, P. (eds.), 2001, *Path Dependence and Creation*, Mahwah, NJ: Lawrence Earlbaum Associates

Sydow, J., Windeler, A., Müller-Seitz, G., Lange, K., 2012, Path constitution analysis: A methodology for understanding path dependence and path creation, *Business Research*, 5 (2), 155-176.

c) Different views on ‘unlocking’

1) **External shocks/crises** create critical junctures (common in more deterministic approaches) (Capoccia and Keleman, 2007; Soifer, 2012)

2) **Agentic struggles** between dominant groups (‘incumbents’) and challengers and ‘niche actors’ (in agentic approaches) (Mahoney and Thelen, 2010; Fligstein and McAdam, 2012; Roberts and Geels, 2019)

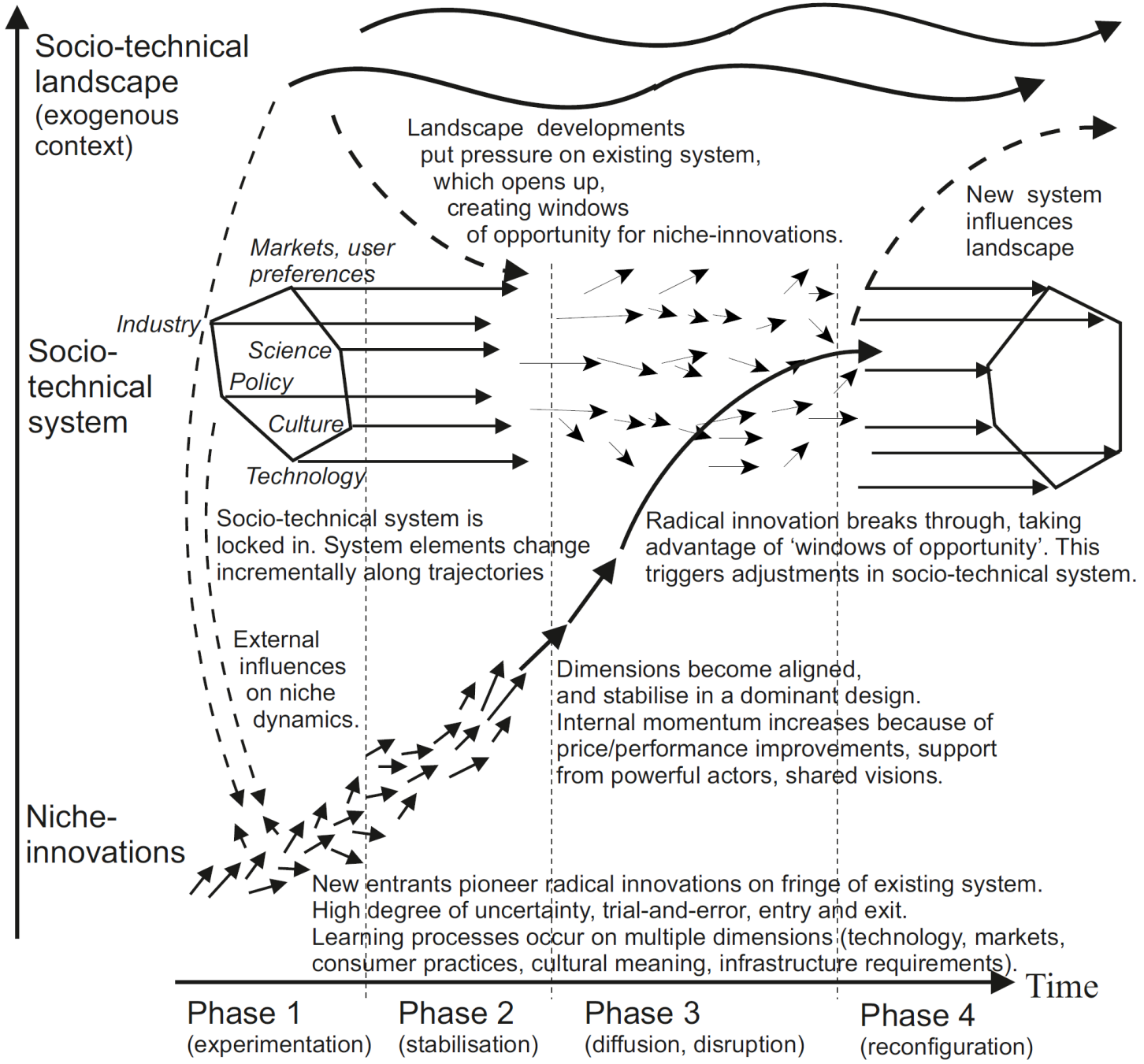
3) **Erosion/weakening** of existing system/regime (e.g. persistent bottlenecks, ‘reverse salient,’ ‘diminishing returns’, delegitimatisation) (Rosenberg, 1976; Hughes, 1987; Freeman and Perez, 1988; Turnheim and Geels, 2012)

Accommodation of various aspects in Multi-Level Perspective on sustainability transitions (Geels):

1) Lock-in of existing systems/regimes and emerging niche-innovations dependent system (incremental change)

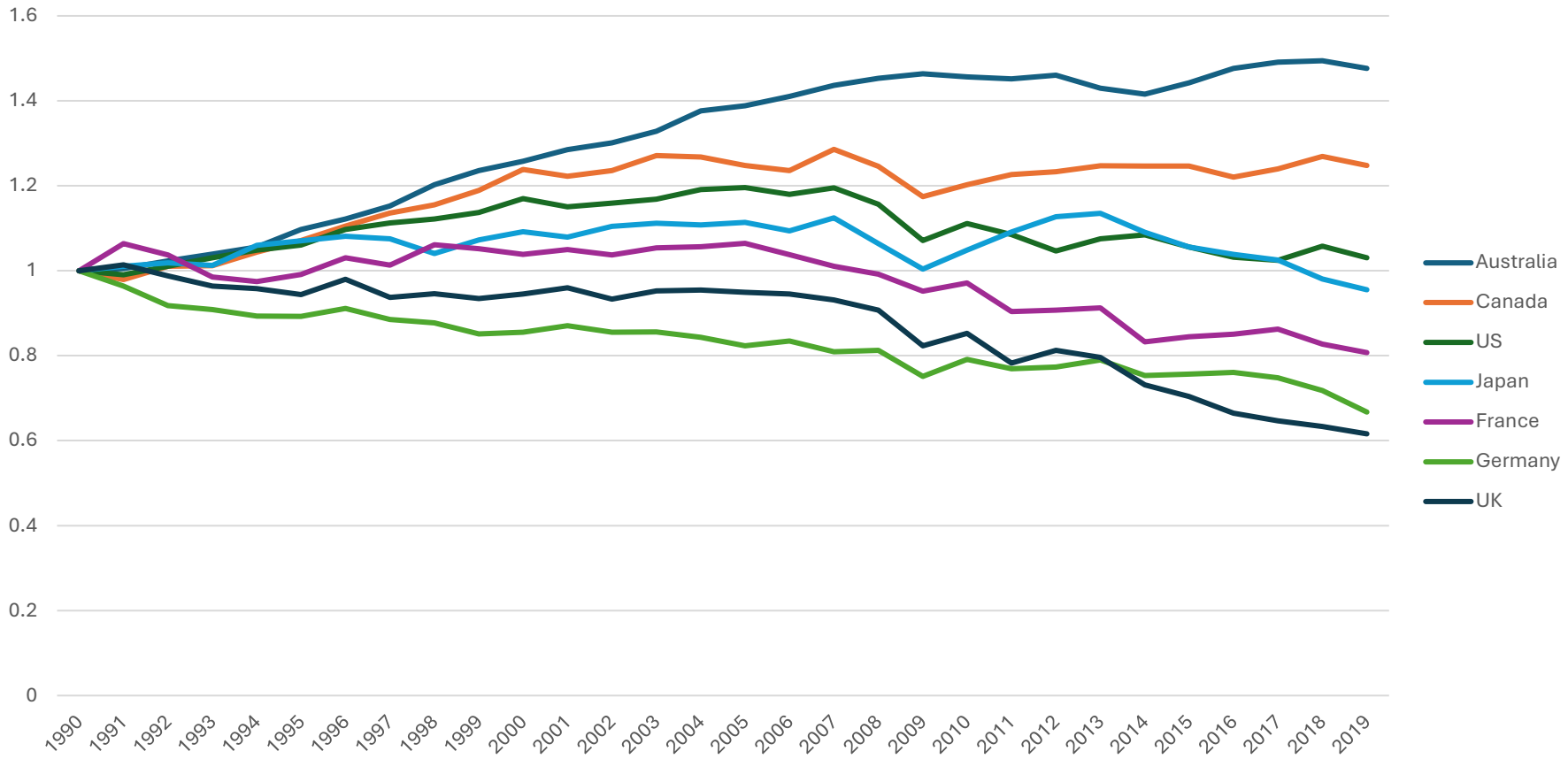
2) Path dependence and path creation

3) Unlocking through external shocks, regime destabilisation, and multi-dimensional actor struggles

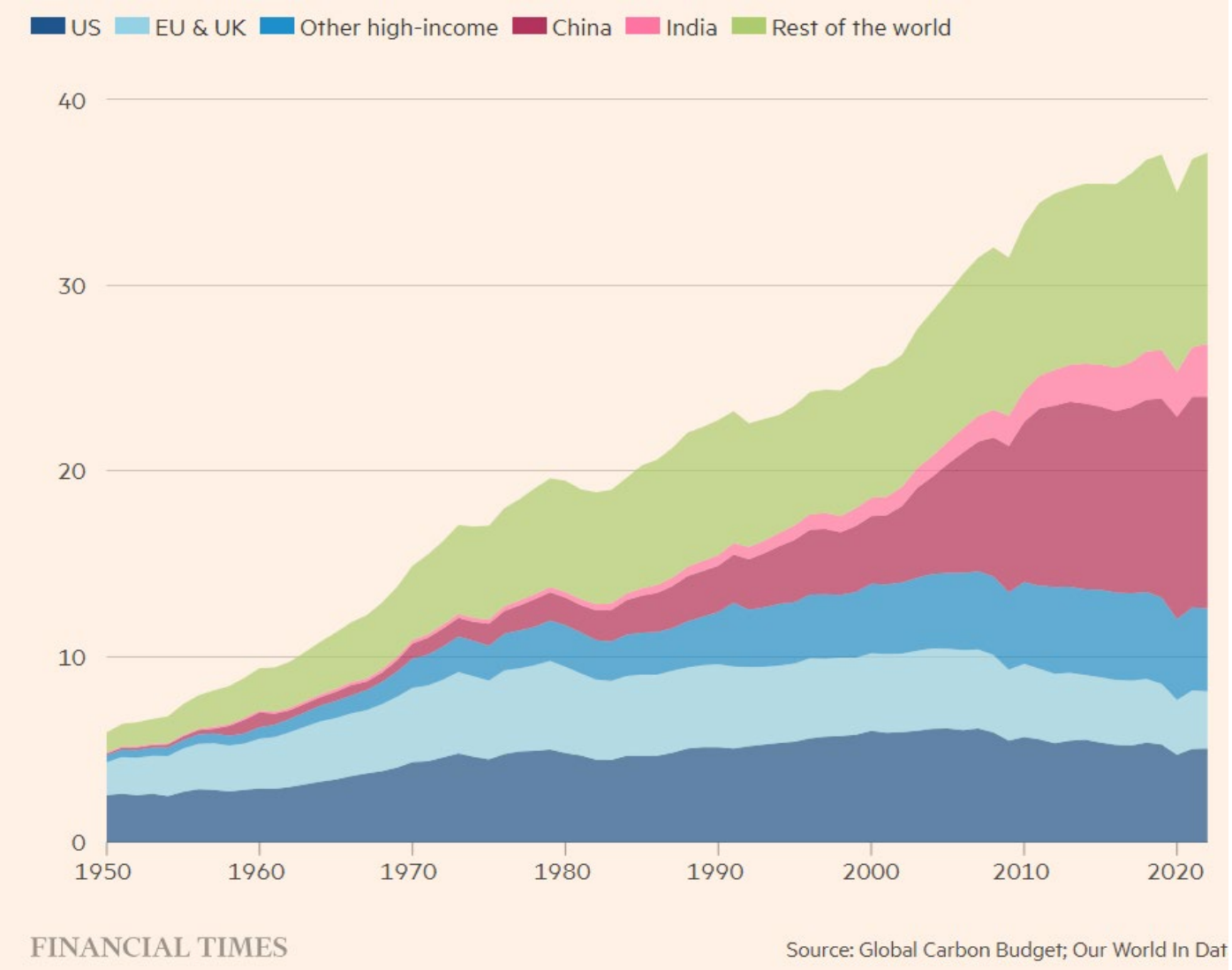


3. Accelerating low-carbon transitions in electricity and mobility systems

- GHG emissions decreasing in about 18 countries (IPCC, 2022), e.g. 40% in UK since 1990

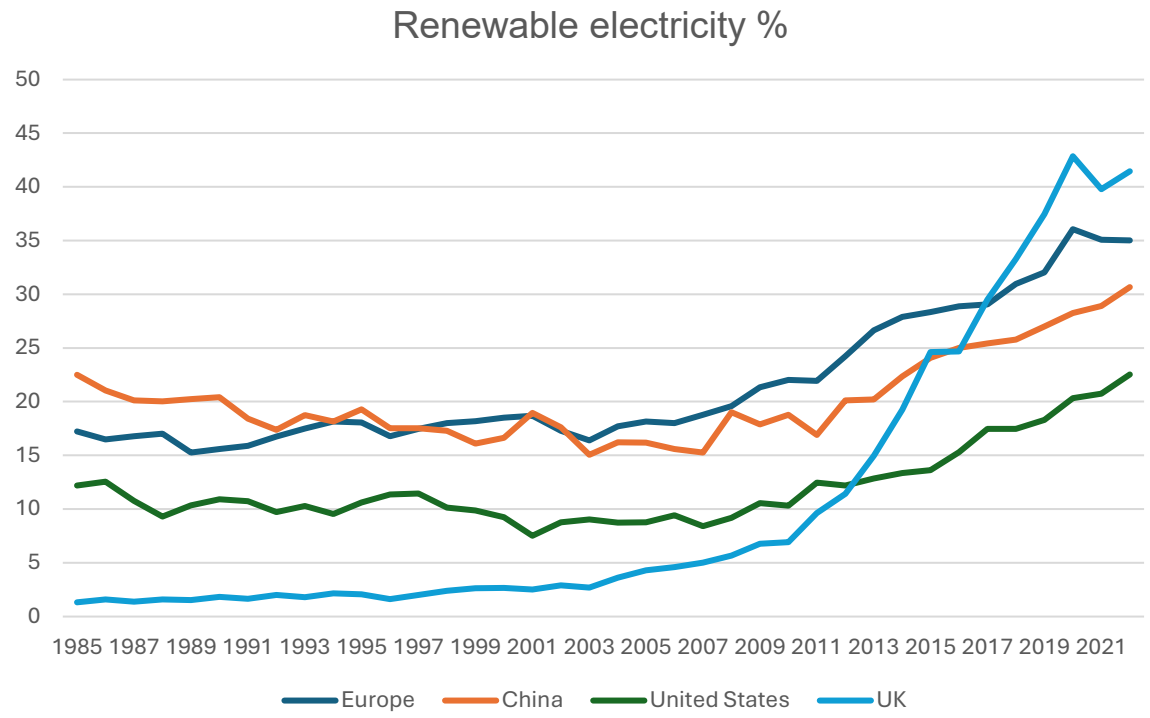


Global emissions continue to rise, but mostly because of emerging economies (although China may soon reach ‘peak emissions’)



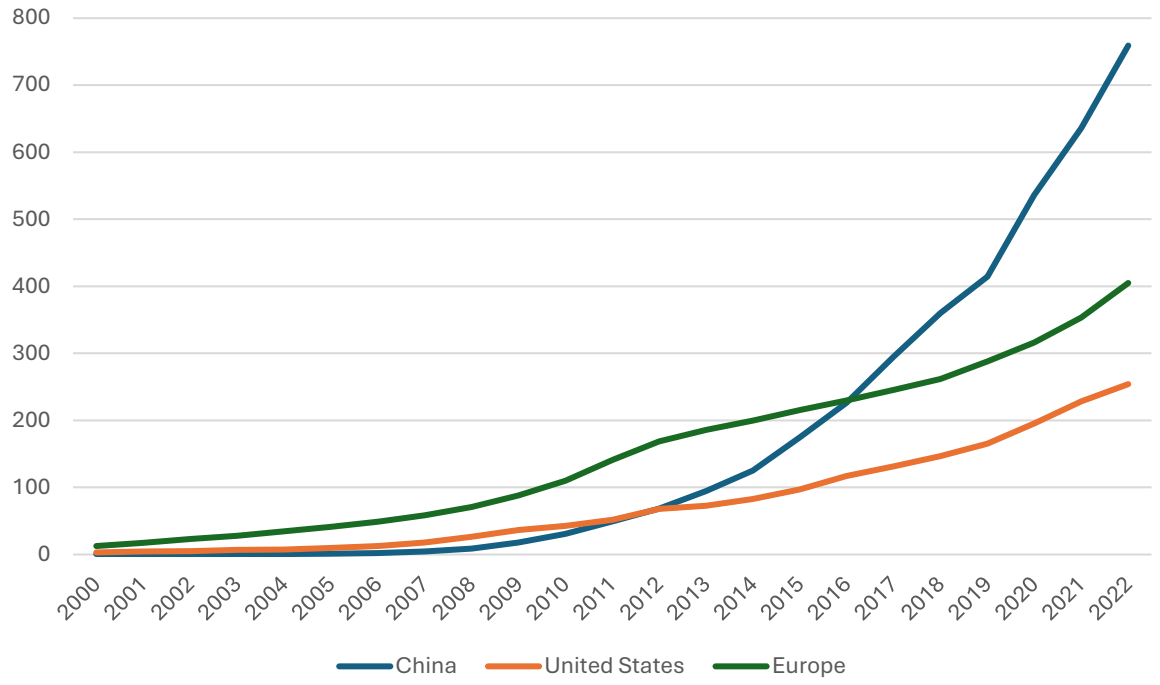
Increasing renewable electricity deployment across world

Europe leads in RET share (%) of electricity



Share of electricity production from renewables (in percentages) in selected regions, 1985-2022 (data from Our World in Data)

But China leads in absolute deployment (GW)

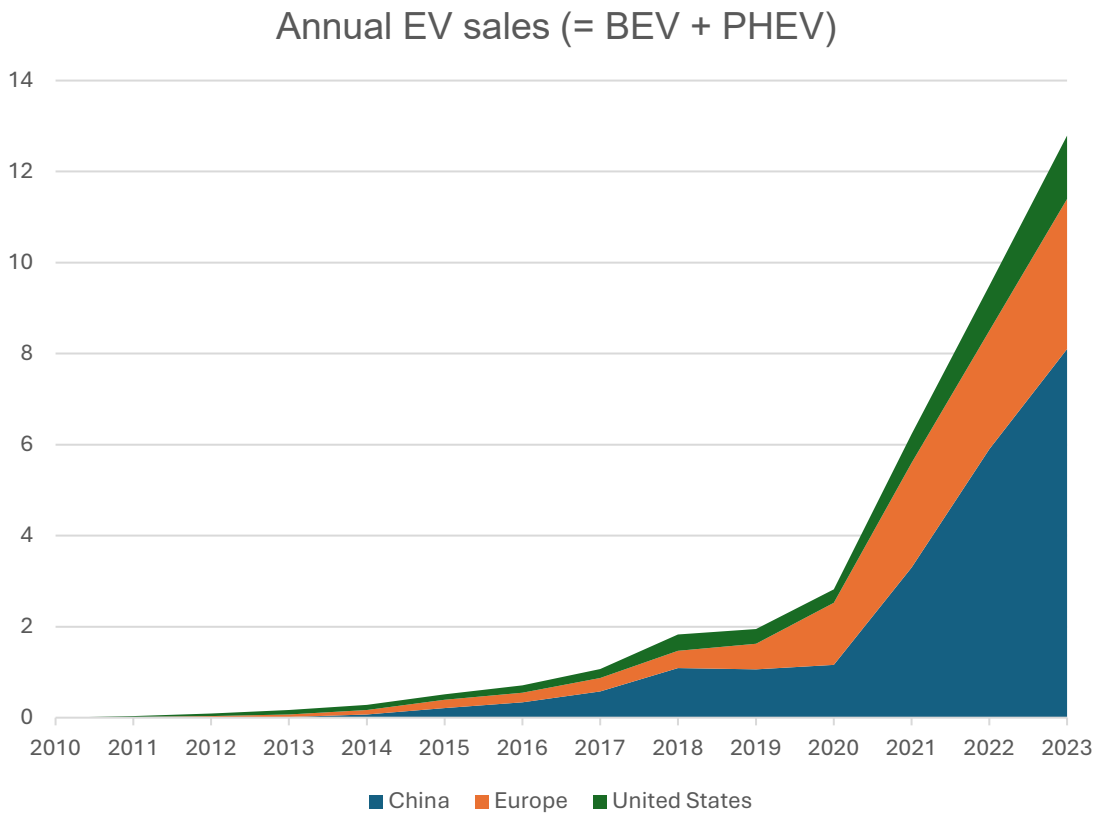


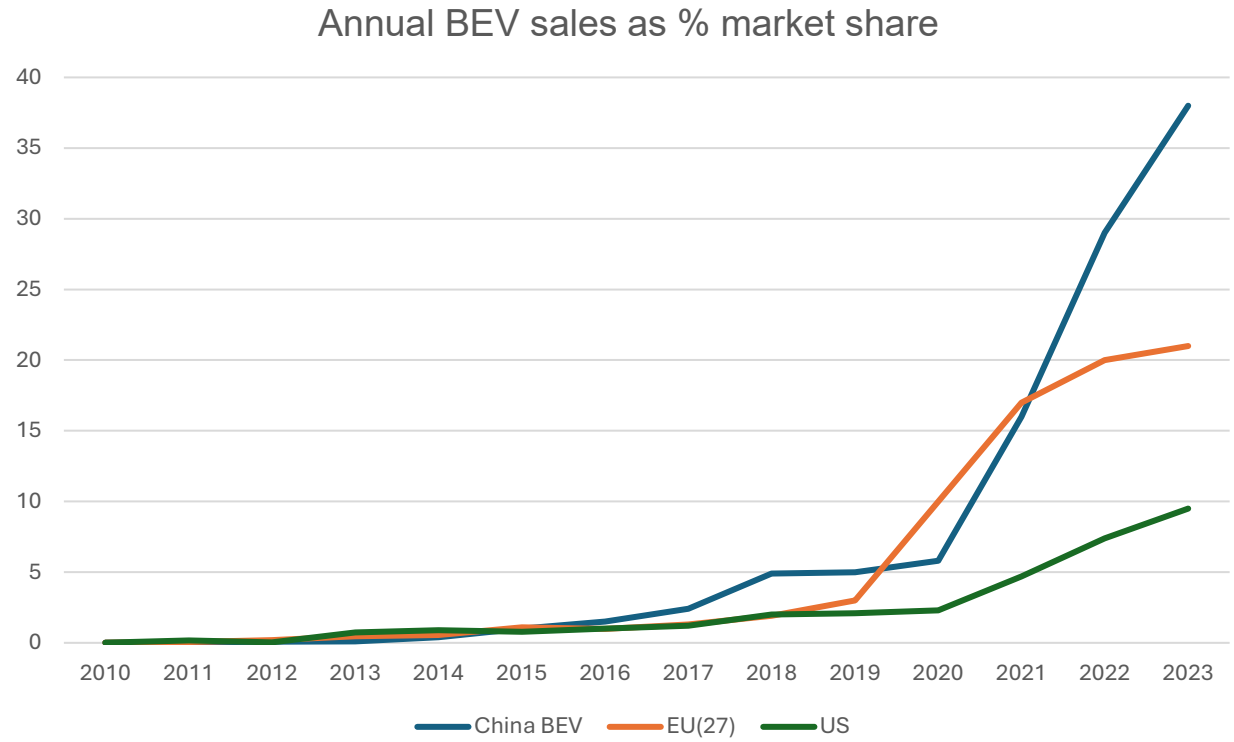
***China leads in** cumulative installed capacity (GW) of solar-PV and wind energy in China, the United States, and European Union (27), 1990-2022*

Accelerating EV sales and deployment

(18% of global new car sales in 2023)

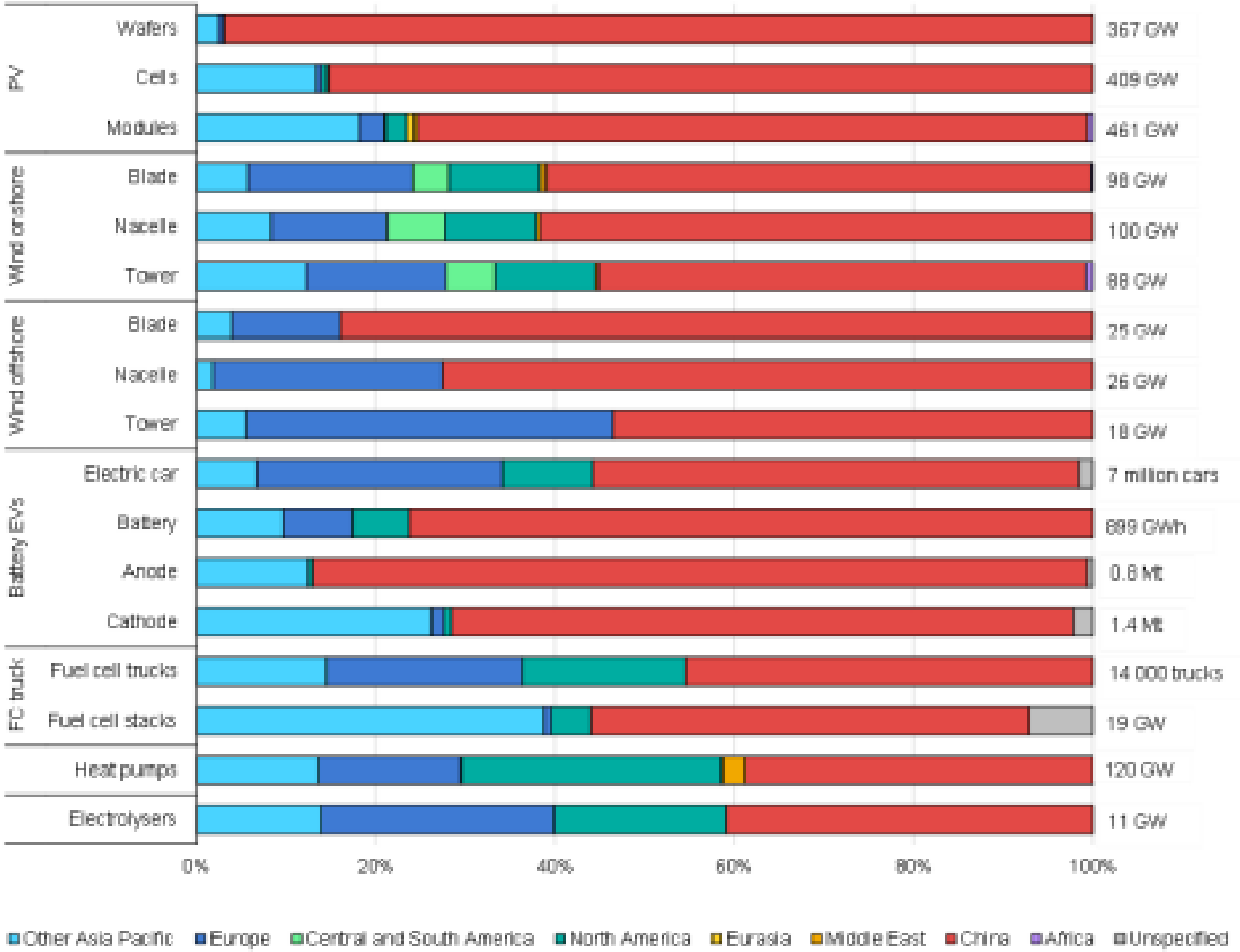
China leads in both absolute numbers and market share (%)



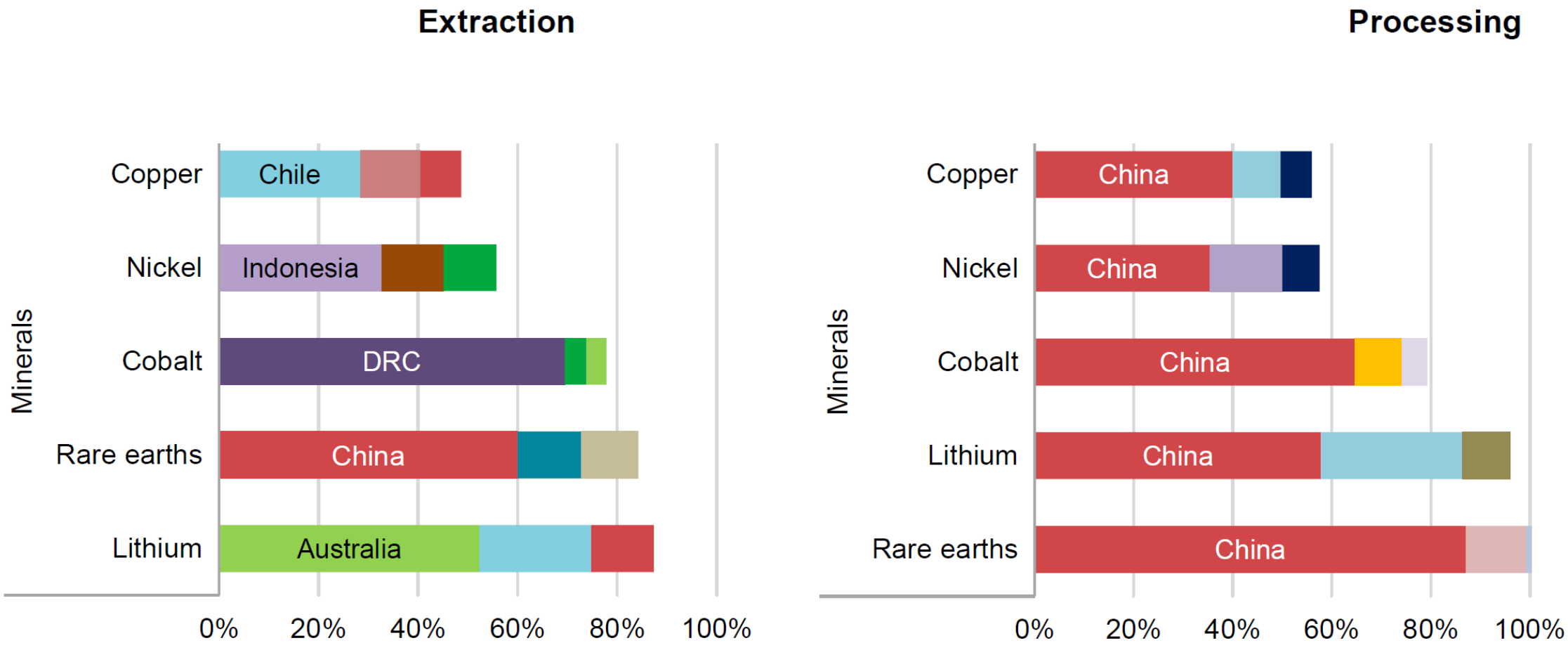


Annual sales (in millions and % market share) of electric vehicles in China, Europe, and the United States from 2010 to 2023 (data from the IEA, 2024)

China dominates low-carbon manufacturing
(IEA, 2023)



And China also dominates the processing of core minerals(IEA, 2022)

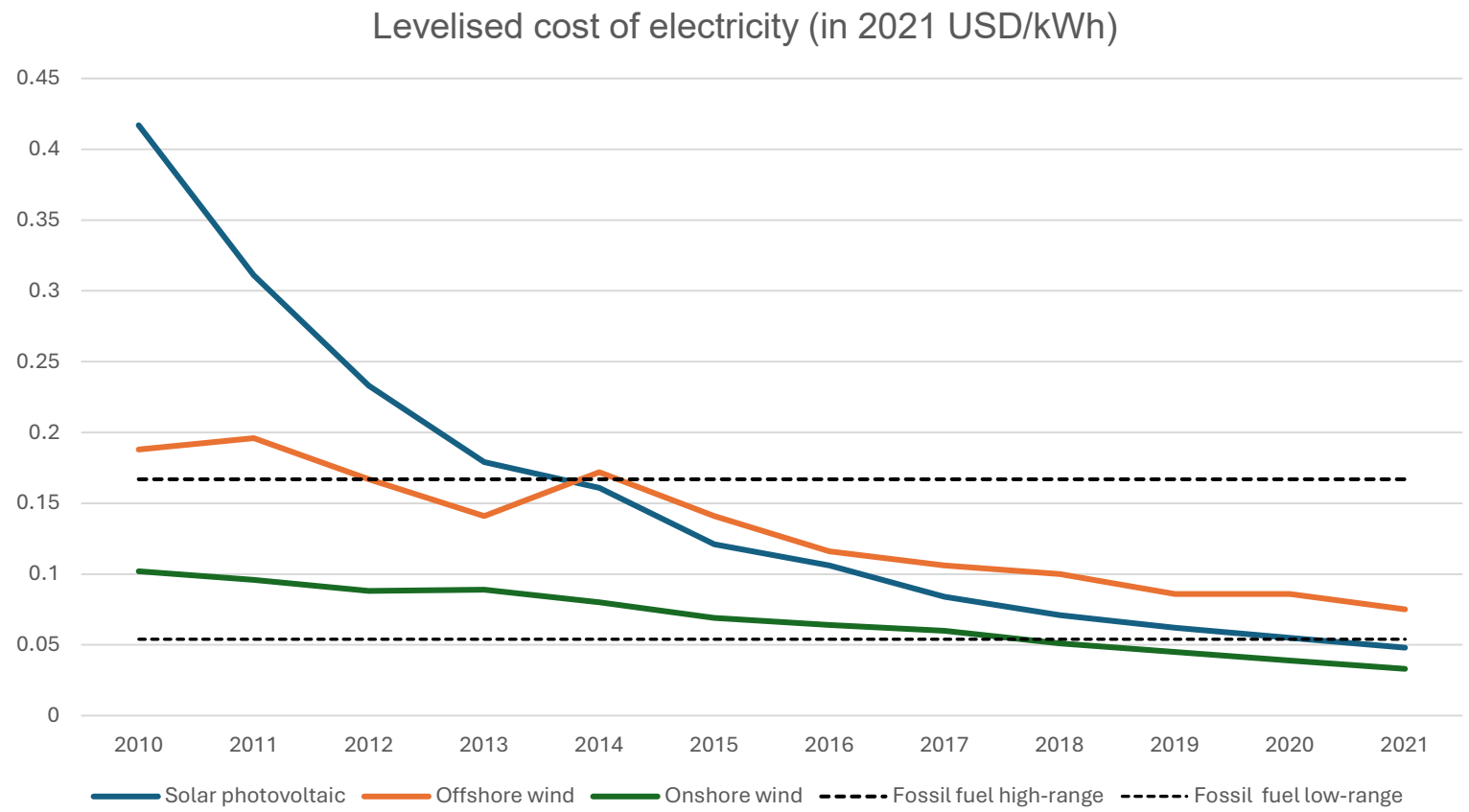


4. Lessons about escaping lock-in

4.1. Drivers of accelerating niche-innovations

- Sustained policy support (FiT, CfD, auctions, capital grants, carbon floor price, R&D subsidies, EV adoption subsidies)
- Changing company perceptions and investment strategies (utilities and automakers)
- Positive public discourses
- **Significant cost reductions (due to *deployment* rather than R&D)**

Cost reductions (2010-2020) made RETs cheaper than fossil fuels in most of the world

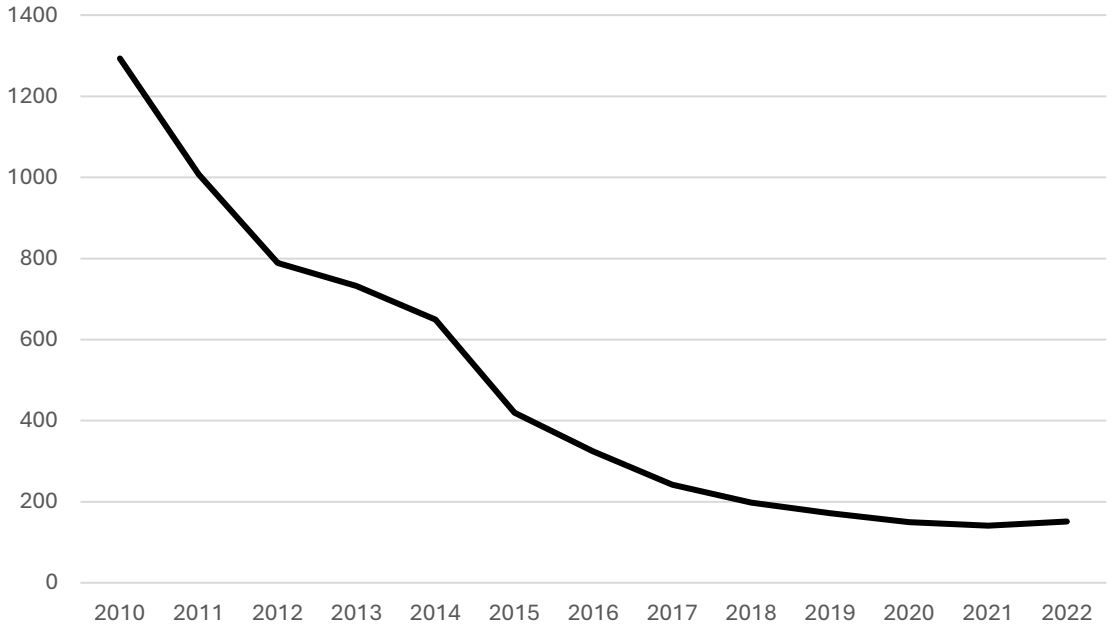


88% for solar-PV
68% for onshore wind
60% for offshore wind

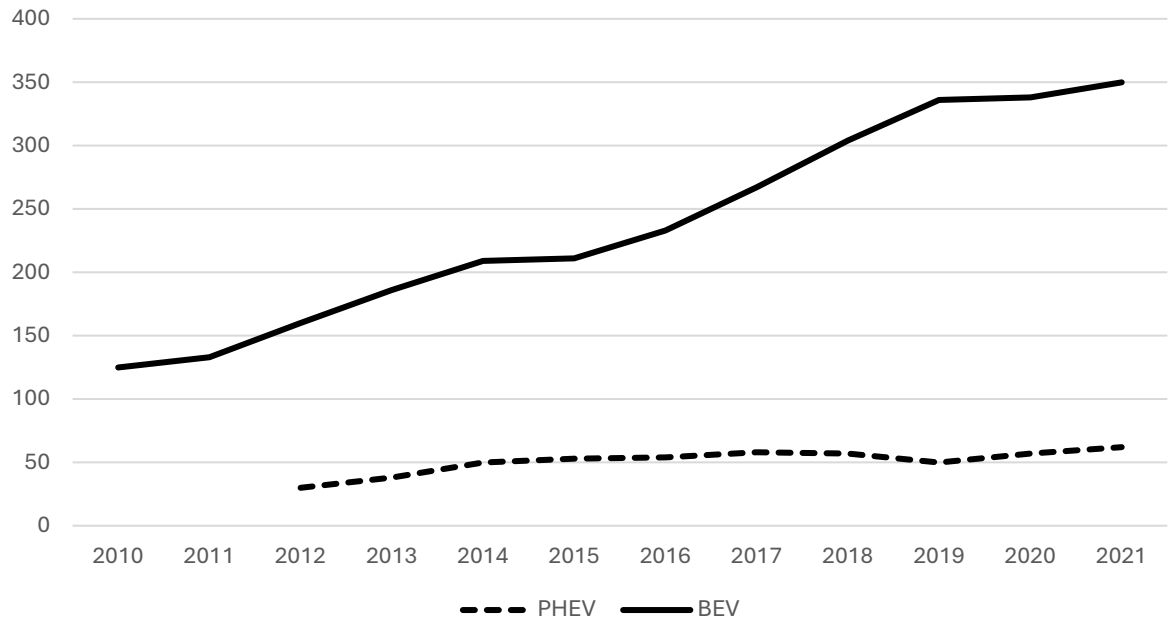
75% of new capacity additions were RETs in 2022
→ 'Unstoppable' (IEA, 2023)

*Global weighted average **levelised cost of electricity** for solar-PV, onshore wind, and offshore wind in 2021 USD/kWh (data from IRENA, 2022)*

BEV cost reductions and performance improvements



Battery pack price in real 2022$/kWh
(data from BNEF, 2022)



Driving range (in km) of BEV and PHEV
(constructed using data from IEA, 2022)

4.2. Landscape shocks and drivers

1. Shift in (macro) policy paradigm: away from neoliberalism towards more interventionist role of state (to support economy during COVID, support households during 2022 gas crisis, drive energy transition)

2. Putins war and EU policy push to reduce Russian gas dependence and accelerate low-carbon transition (REPower EU, 2022)

3. US Inflation Reduction Act + EU Net Zero Industry Act drive global innovation race (in solar, wind, batteries, EVs, hydrogen, CCS) to:

a) Catch up with China and benefit from green growth **[= macro-economic agenda]**

b) reduce dependence on China **[= security agenda]**, which dominates manufacturing in most low-carbon technologies

4.3. Regime reorientation

- Automakers are since 2015 engaged in EV innovation race (after many years of resistance) + governments try to attract battery/EV plants
- Dieselgate delegitimated diesel cars

- Electric utilities in (Western) countries are also reorienting towards solar-PV and wind
- Stimulated by attractive incentives
- And de-legitimation of coal

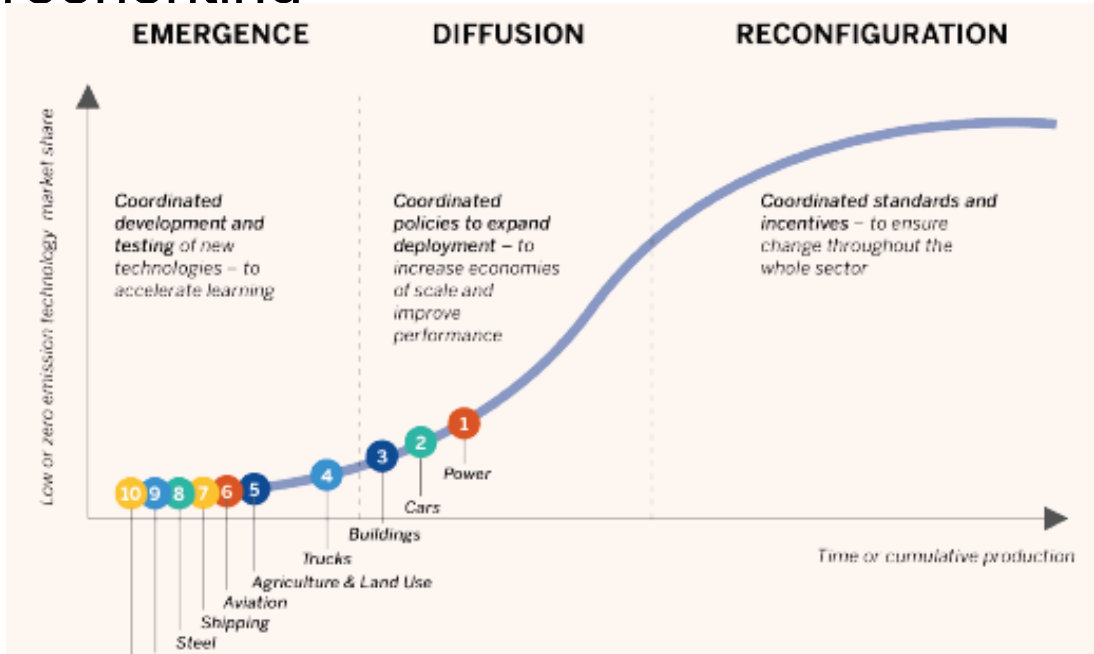
5. Conclusions

- Lock-ins are a (stylised) 'fact of life' and neither 'good' or 'bad' as such
- Accelerating low-carbon transitions require 'unlocking' existing regimes/systems and creating new lock-ins for niche-innovations
- This is beginning to happen in electricity and mobility because of
  a) Increasing momentum (and lock-in) of 'bottom-up' niche-innovations
  b) Significant landscape pressures further supporting niche-innovations
  c) Regime actors 'defecting' and (reluctantly) reorienting

- Other systems are lagging behind

  but there is now a transition playbook

  giving some hope for climate mitigation



Victor, D., Geels, F.W., and Sharpe, S., 2019, *Accelerating the Low Carbon Transition: The Case for Stronger, More Targeted and Coordinated International Action*