Energy Policy and Uncertainty

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Sources of uncertainty

- **Climate uncertainty**
  - How will the climate/weather react to increasing GHG concentrations?
  - Will carbon dioxide removal (CDR) at sufficient scale reduce average global temperature?
- **Energy uncertainty**
  - How much energy will societies demand? What will its characteristics be (e.g. variable/intermittent)? How much will it cost? How secure is it?
- **Technology uncertainty**
  - Will it work? Can it be scaled up? What will it cost?
- **Market uncertainty**
  - What will prices of the product be? Will raw materials be available, at what cost?
  - What are the implications for competitiveness?
- **Policy**
  - Will policies change? Will targets be met? Will the public support net zero policies?
- **People**
  - Will behaviours change?

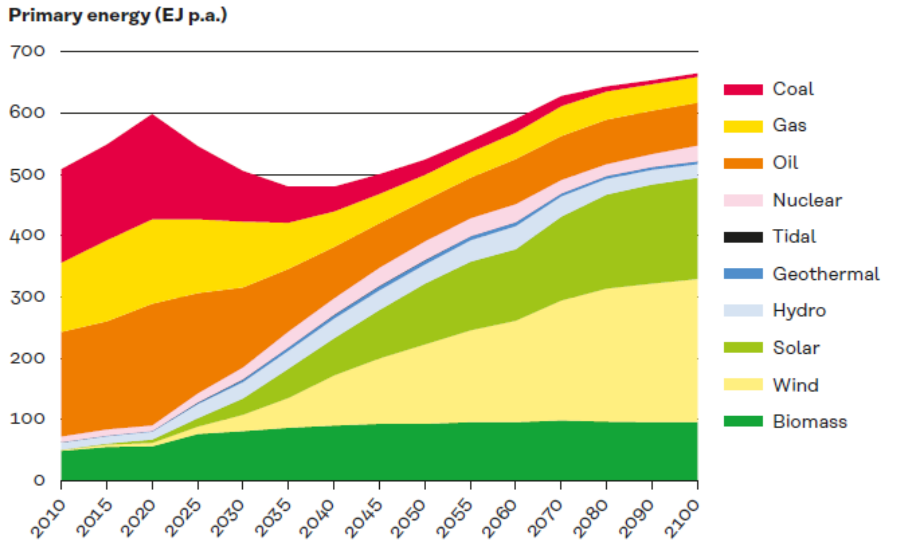
Selected low-carbon energy technologies

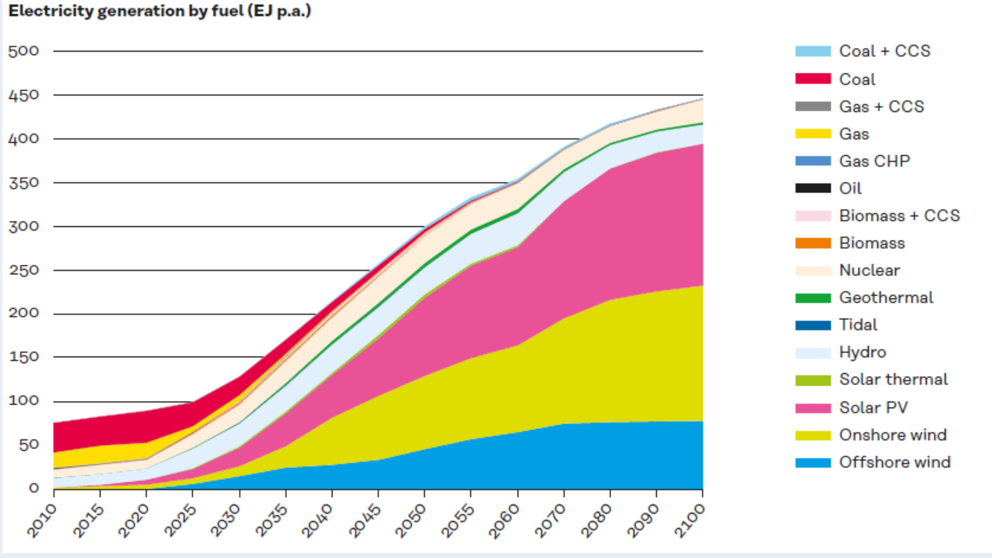
- Energy efficiency: zero-carbon new homes, deep retrofit in existing homes, greater efficiency in industry and transport
- Zero-carbon energy carriers: electricity (renewables, nuclear, CCS), hydrogen (electricity, CCS), biomass, biofuels
- Grid integration and stability: technologies for long-, medium- and short-term storage (batteries, thermal, mechanical, hydrogen, pumped hydro), digitalisation
- Transport: electric vehicles (batteries, fuel cells)
- Heating/cooling: heat pumps, district heating, biomethane, hydrogen
- Industry: hydrogen, carbon capture and storage (CCS)
- Agriculture: reduce food waste, diet shift, transform production
- Change our behaviour: eat less meat, fly/drive less often, live in cooler (warmer) summer (winter) homes

How much energy?

Meeting the 1.5ºC target requires
- No new coal mines or oil and gas wells (IEA 2021)
- Fast coal phase-out
- Large-scale electrification of transport, heat in buildings and industry
- Substantial increase in energy efficiency

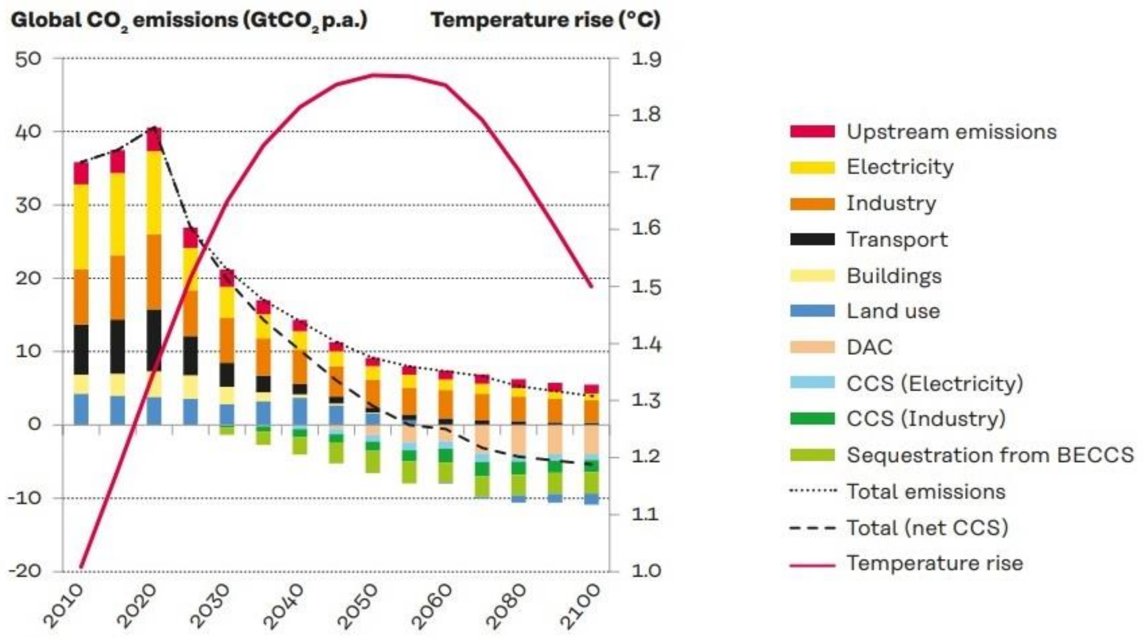
https://www.sitra.fi/en/publications/growth-positive-zero-emission-pathways-to-2050





Which sectors?

- Carbon capture technologies and CDR are important post-2050



(Authors' note: land use includes all CO_2 emissions from agriculture, forestry, land use and land-use change)

Source: Drummond et al. 2021

https://www.sitra.fi/en/publications/growth-positive-zero-emission-pathways-to-2050

What are the uncertainties?

- The 1.5^{o}C target becomes impossible without carbon capture and removal of carbon dioxide from the atmosphere

	Central scenario	Slow coal phase-out	No CCS or NETs	
Coal phase-out rate	5.4% p.a.	2.7% p.a.	5.4% p.a.	2.7% p.a.
Net-zero date	2055	2055	-	-
Offset emissions from CCS, BECCS and DAC (2020-2100)	583 $GtCO_2$	638 $GtCO_2$	0 $GtCO_2$	0 $GtCO_2$
Peak temperature	1.87 °C	1.89 °C	1.89 °C	1.92 °C
Final temperature by 2100	1.5 °C	1.5 °C	**1.74 °C**	**1.79 °C**

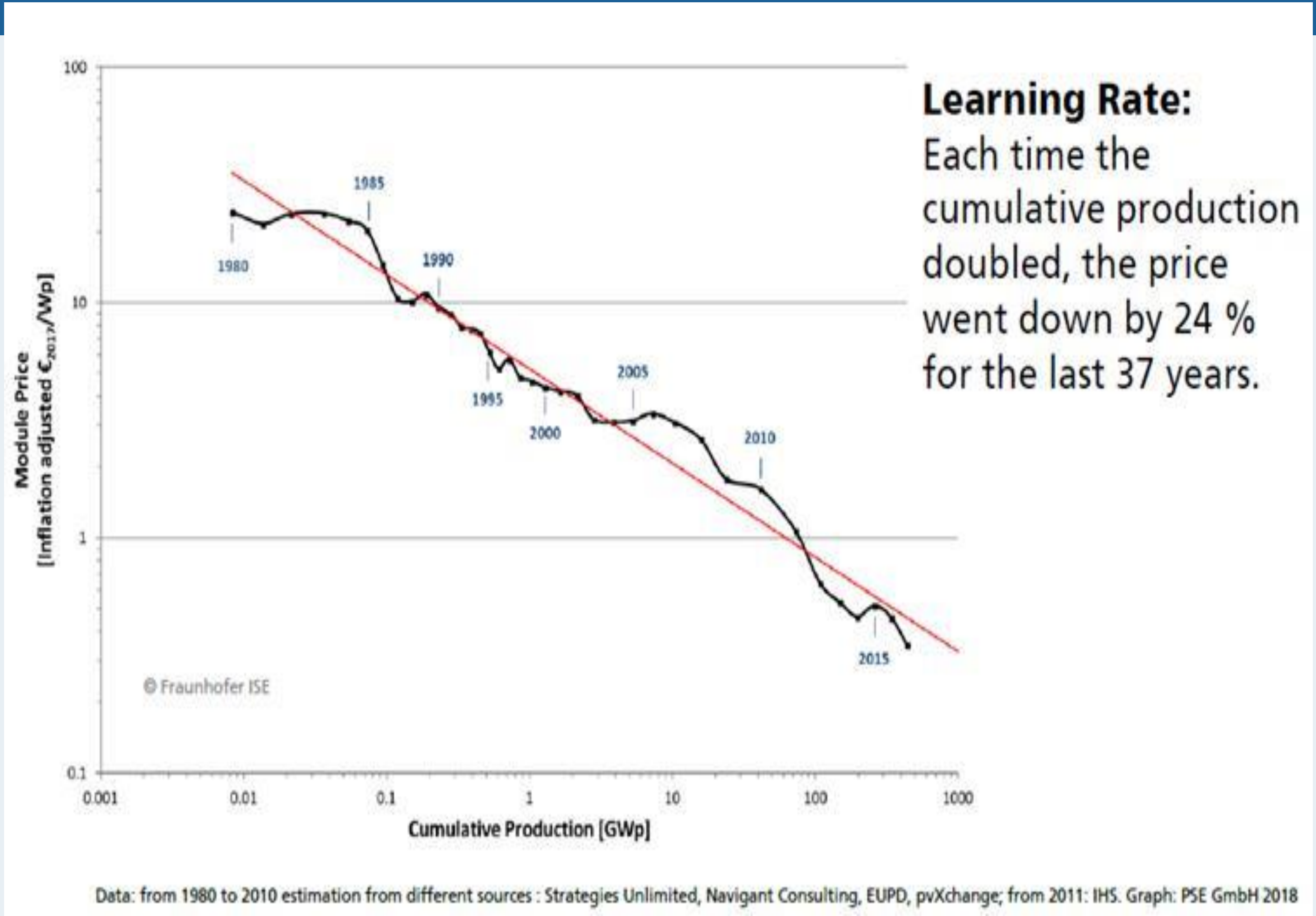
Source: Drummond et al. 2021

https://www.sitra.fi/en/publications/growth-positive-zero-emission-pathways-to-2050

What will it cost?

- Optimists:
  - ‘Costs’ are really investments, can contribute to GDP growth
  - Considerable opportunity for zero-cost mitigation
  - A number of resource-efficient technologies are (nearly) available at low incremental cost over the huge investments in the economic system that need to be made anyway
  - ‘Learning curve’ experience suggests that the costs of new technologies will fall dramatically
  - Resource efficiency policies can spur innovation, new industries, exports and growth
- Pessimists:
  - Constraining resource use is bound to be a serious constraint on growth
  - Cheap, abundant energy and other resources are fundamental to industrial development

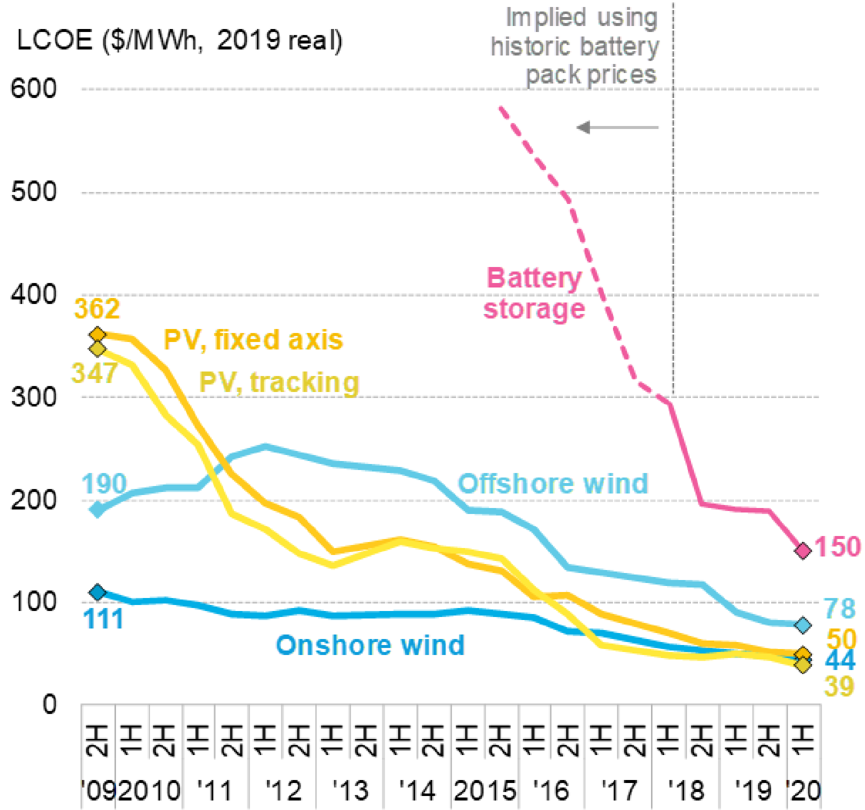
‘Learning’ curves for new tech-nologies



Source: Fraunhofer Institute for Solar Energy Systems, ISE 2018 ‘Photovoltaics Report’, https://www.ise.fraunhofer.de/content/dam/ise/de/documents/publications/studies/Photovoltaics-Report.pdf

1980: €20/Wp, 8MWp
2015: €0.5/Wp, 200GWp

Figure 2: Global LCOE benchmarks – PV, wind and batteries



Source: BloombergNEF. Note: The global benchmark is a country weighted-average using the latest annual capacity additions. The storage LCOE is reflective of utility-scale projects with four-hour duration, it includes charging costs.

Cost evolution for selected technologies

Source: https://about.bnef.com/blog/scale-up-of-solar-and-wind-puts-existing-coal-gas-at-risk/.

NB LCOE in Figure 2 stands for Levelised Cost of Electricity, which is a standard way of comparing the costs of different electricity technologies

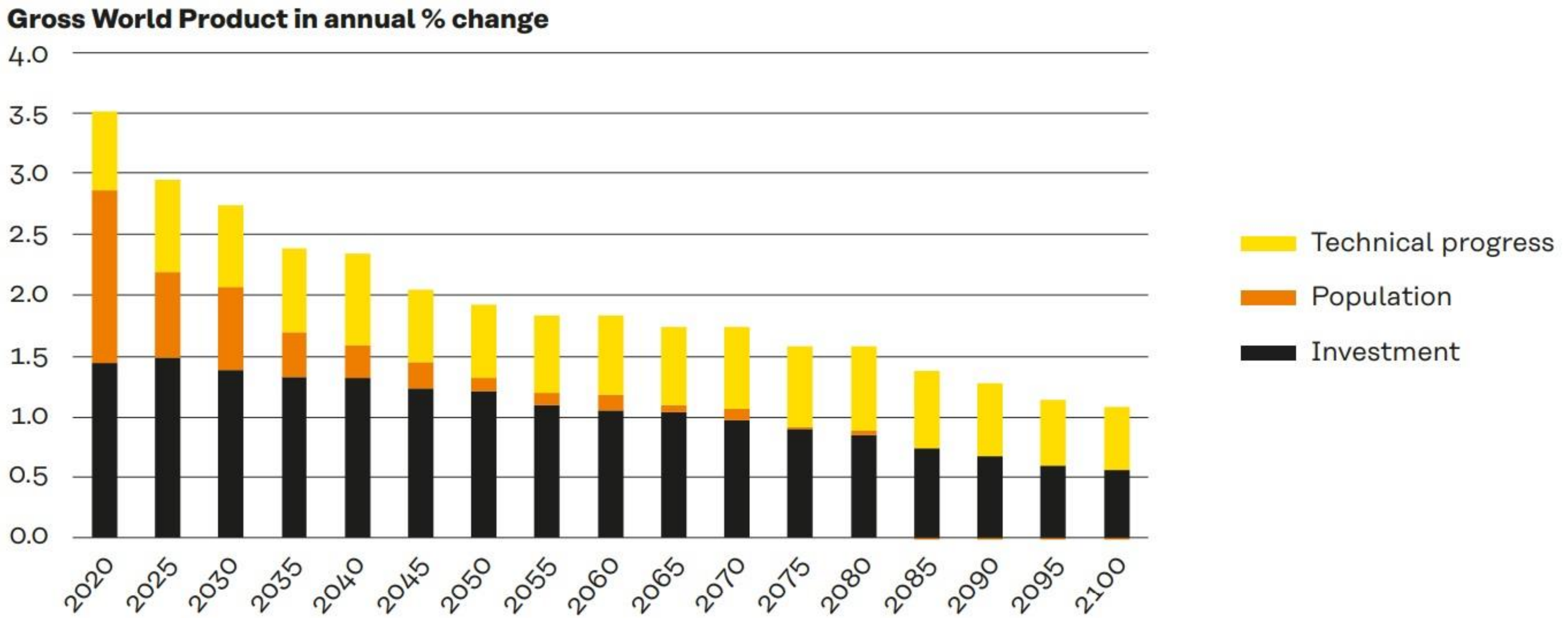
Economic opportunities of emission reduction

- In a decarbonizing world there will be huge investment in new technologies
- Countries that lead in the development and deployment of new technologies will build new industries the products of which will be in demand worldwide
- These industries and technologies can already be identified
- Industrial strategy should be systematically seeking to accelerate their deployment for economic as well as environmental reasons

Macroeconomic impacts of mitigation (1)

- Global economy continues to grow

Source: Drummond et al. 2021
https://www.sitra.fi/en/publications/growth-positive-zero-emission-pathways-to-2050



Macroeconomic impacts of mitigation (2)

- The share of investment in Gross World Product (GWP) increases

Source: Drummond et al. 2021

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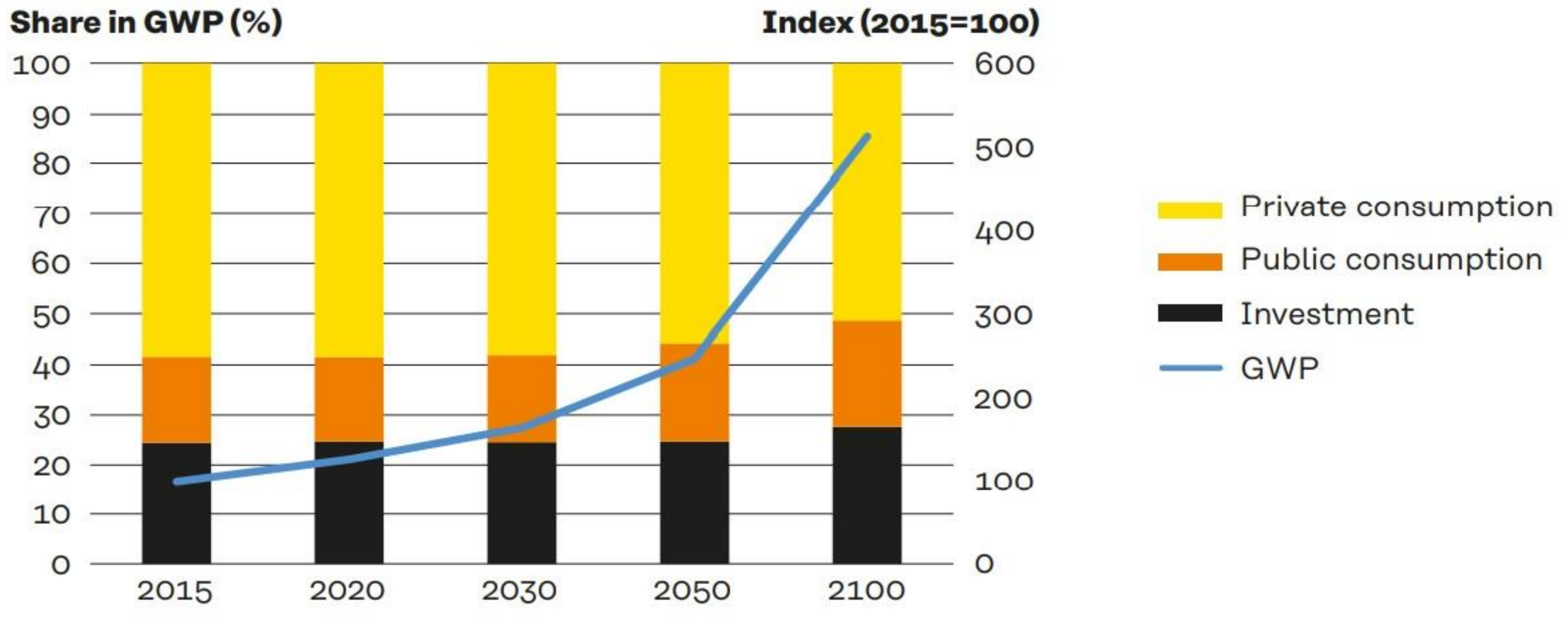
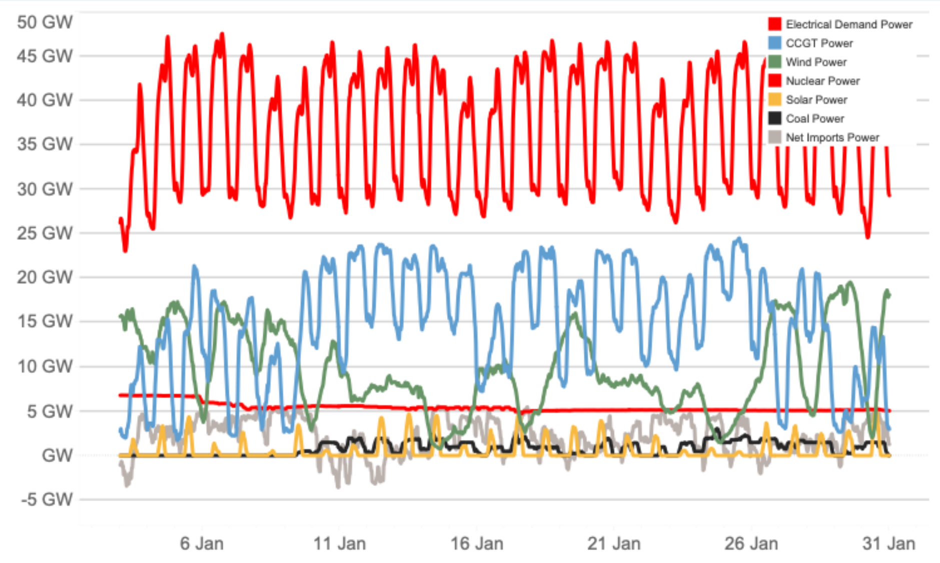


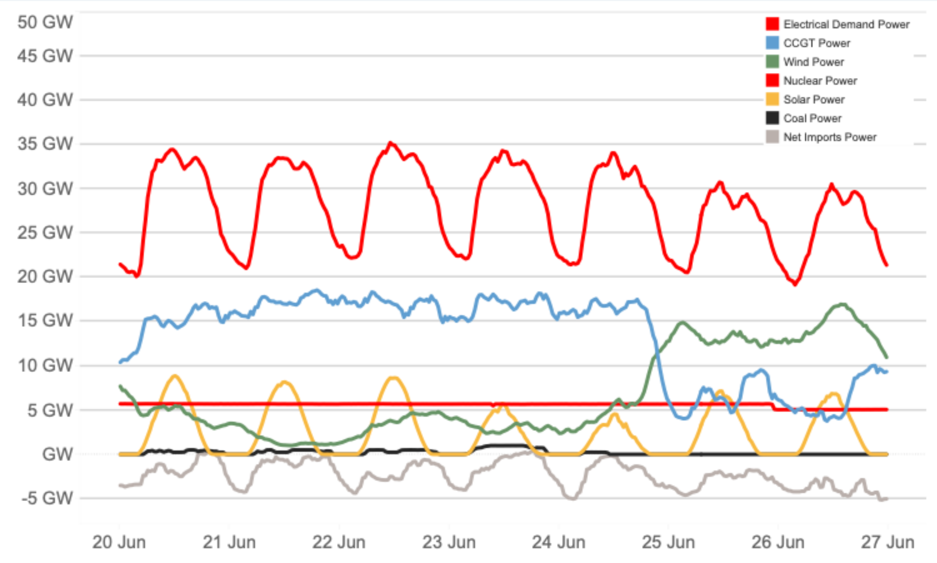
Conclusions on the economics of GHG abatement

- GDP costs of mitigation are, at worst, relatively low (1-4% GDP), and could be negative
- These costs are low compared to expenditures on health and insurance against risk
- With health co-benefits and moves towards a circular economy, there are net benefits from mitigation
- Fossil fuel importing countries with abundant renewables could experience net GDP and employment benefits by 2030
- Fossil fuel importing countries experience energy security benefits
- The development of renewables technologies promises essentially limitless zero marginal cost electricity for the future
- Investment in clean energy could be a major driver of development

The need for of storage: availability of renewables

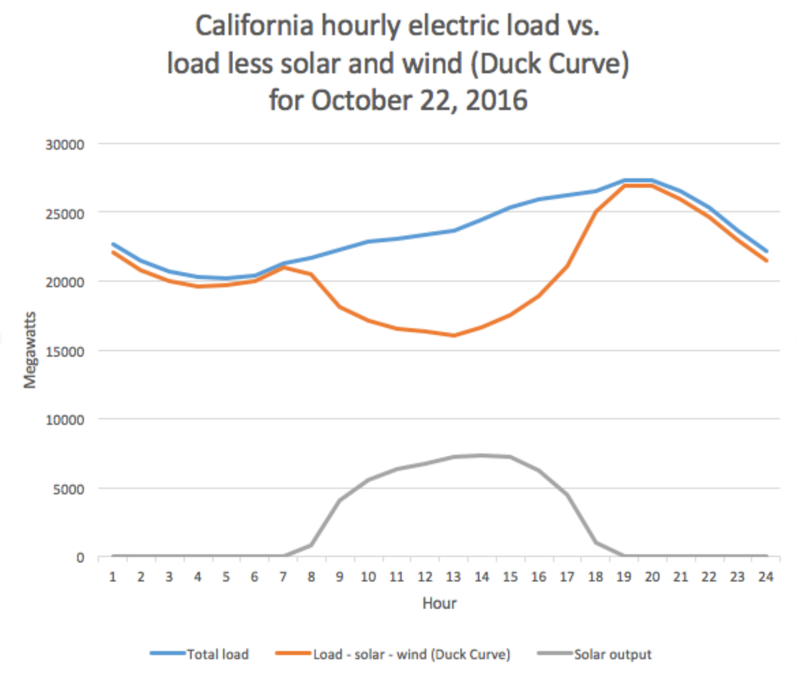
Source: Grant Wilson, University of Birmingham, personal communication, January, June 2022

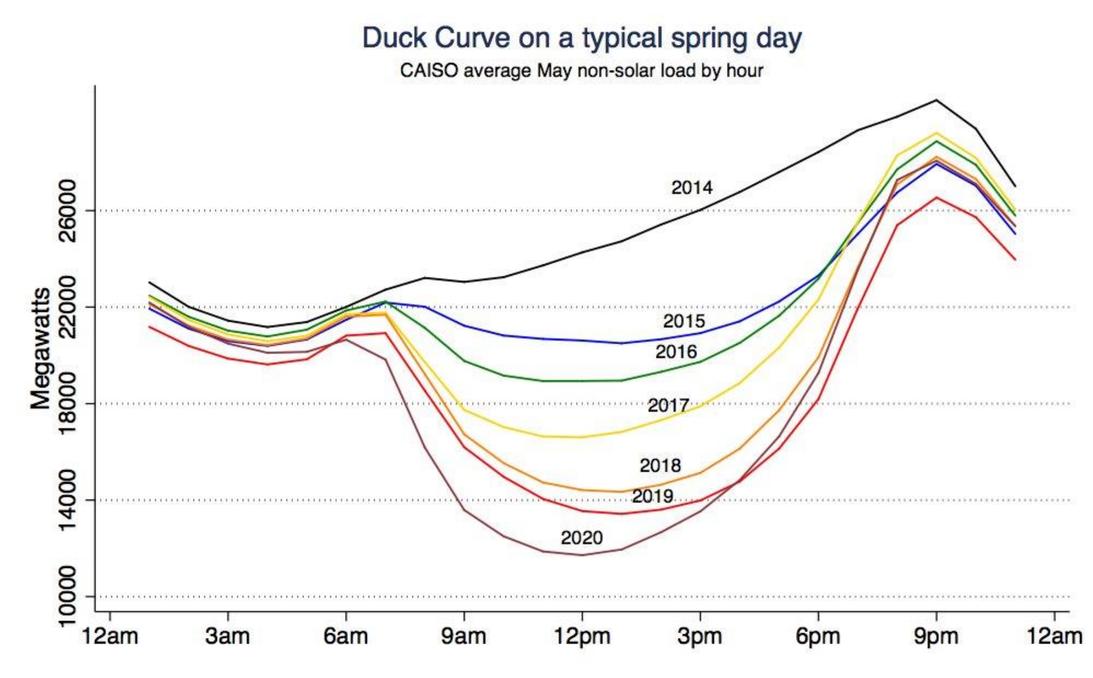




The need for of storage: variability of renewables, the California duck curve

Sources: Wikipedia (left) https://en.wikipedia.org/wiki/Duck_curve;
Zeke Hausfather (right) https://twitter.com/hausfath/status/1278023750110244864/photo/1





	ELECTRICAL		MECHANICAL			ELECTROMECHANICAL			CHEMICAL	THERMAL
	Superca-pacitors	SMES	PHS	CAES	Flywheels	Sodium Sulfur	Lithium Ion	Redox Flow	Hydrogen	Molten Salt
Maturity	Develop-ing	Develop-ing	Mature	Mature	Early commer-cialised	Commer-cialised	Commer-cialised	Early commer-cialised	Demon-stration	Mature
Efficiency	90-95%	95-98%	75-85%	70-89%	93-95%	80-90%	85-95%	60-85%	35-55%	80-90%
Response Time	ms	<100 ms	sec-mins	mins	ms-secs	ms	ms-secs	ms	secs	mins
Lifetime, Years	20+	20+	40-60	20-40	15+	10-15	5-15	5-10	5-30 years	30 years
Charge time	s - hr	min - hr	hr - months	hr - months	s - min	s - hr	min - days	hr - months	hr - months	hr - months
Discharge time	ms - 60 min	ms - 8 s	1 - 24 hs+	1 - 24 hs+	ms - 15 min	s - hr	min - hr	s - hr	1 - 24 hs+	min - hr
Environmen-tal impact	None	Moderate	Large	Large	Almost none	Moderate	Moderate	Moderate	Depend-ent of H2 production method	Moderate

Storage options

Source: World Energy Council 2020

https://www.worldenergy.org/publications/entry/innovation-insights-brief-five-steps-to-energy-storage

	ELECTRICAL		MECHANICAL			ELECTROMECHANICAL			CHEMICAL	THERMAL
	Superca-pacitors	SMES	PHS	CAES	Flywheels	Sodium Sulfur	Lithium Ion	Redox Flow	Hydrogen	Molten Salt
Possible applications by technologies										
Power quality	✓	✓			✓	✓	✓	🤞		
Energy arbitrage			✓	✓	🤞	✓	✓	✓	🤞	✓
RES integration		✓			✓	✓	✓	✓	✓	
Emergency back-up					✓	✓	✓	✓	🤞	
Peak shaving			✓	✓		✓	✓	🤞	🤞	🤞
Time shifting			✓	✓		✓	✓	🤞	🤞	🤞
Load leveling			✓	✓		✓	✓	🤞	🤞	🤞
Black start						✓	✓	✓	🤞	🤞
Seasonal storage			🤞	✨					🤞	🤞
Spinning reserve		🤞			🤞	✓	✓	🤞	🤞	
Network expansion			✓	🤞		✓	✓	🤞	🤞	🤞
Network stabilisation	🤞	✓			🤞	✓	✓	🤞		
Voltage regultation	🤞	🤞			🤞	✓	✓	✓		
End-user services	🤞	🤞			🤞	✓	✓	🤞		

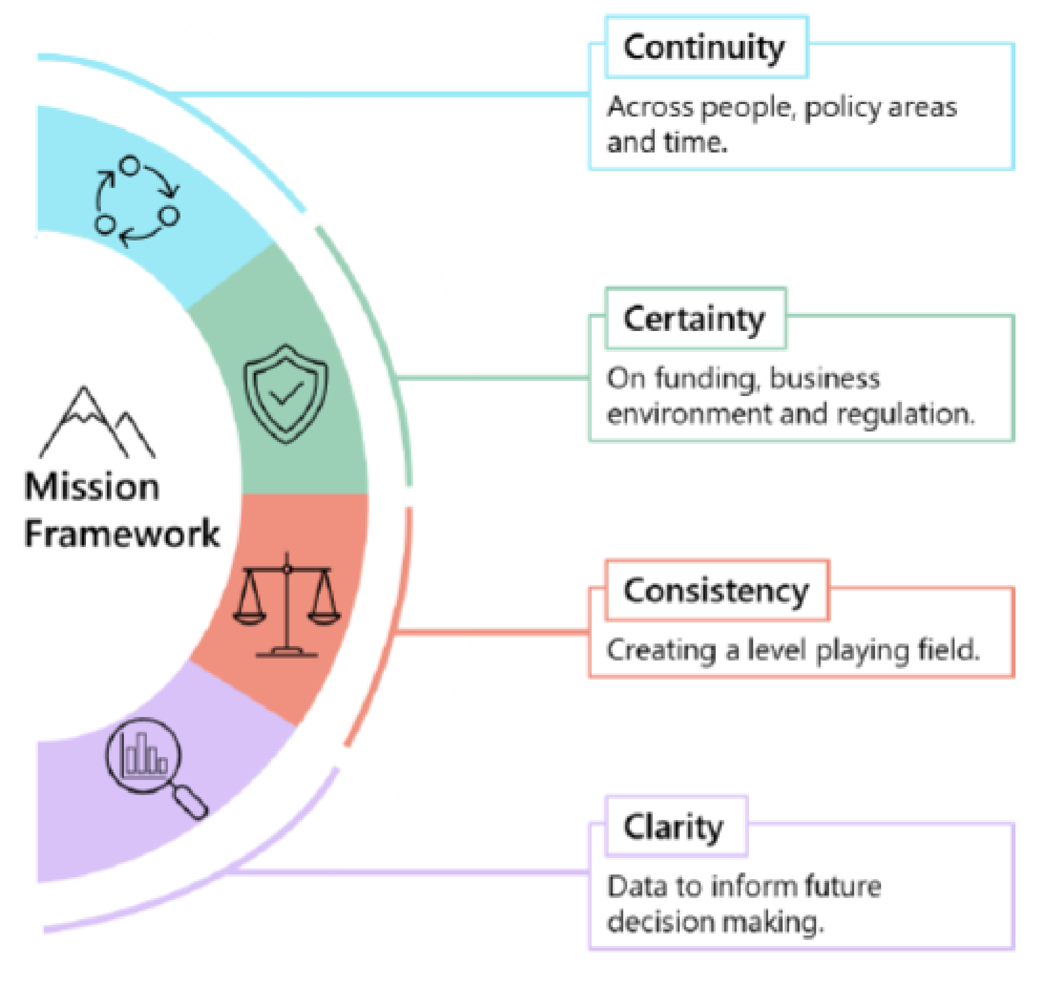
The roles of storage

Source: World Energy Council
2020

https://www.worldenergy.org/publications/entry/innovation-insights-brief-five-steps-to-energy-storage

Policies of all kinds will be needed in policy mixes

- *Market/incentive-based (also called economic) instruments*: include emissions trading, environmental taxes and levies, feed-in tariffs, deposit-refund systems, subsidies (including the removal of perverse subsidies), power purchasing, and liability and compensation.
- *Regulation instruments*, which seek to define legal standards in relation to technologies, environmental performance, pressures or outcomes. Can also include imposition of obligations, e.g. renewable and energy efficiency obligations.
- *Voluntary/self-regulation (also called negotiated) agreements* between governments and producing organisations. Economic actors may enter into these in order to forestall the introduction of market-based instruments or regulation.
- *Information/education-based instruments* e.g. Eco-labels, ‘smart’ meters, may be mandatory or voluntary.
- *Innovation instruments*: R&D budgets, capital allowances for investment, public/private partnerships for demonstrations, long-term contracts
- *Trade measures*: Carbon Border Adjustment Mechanism

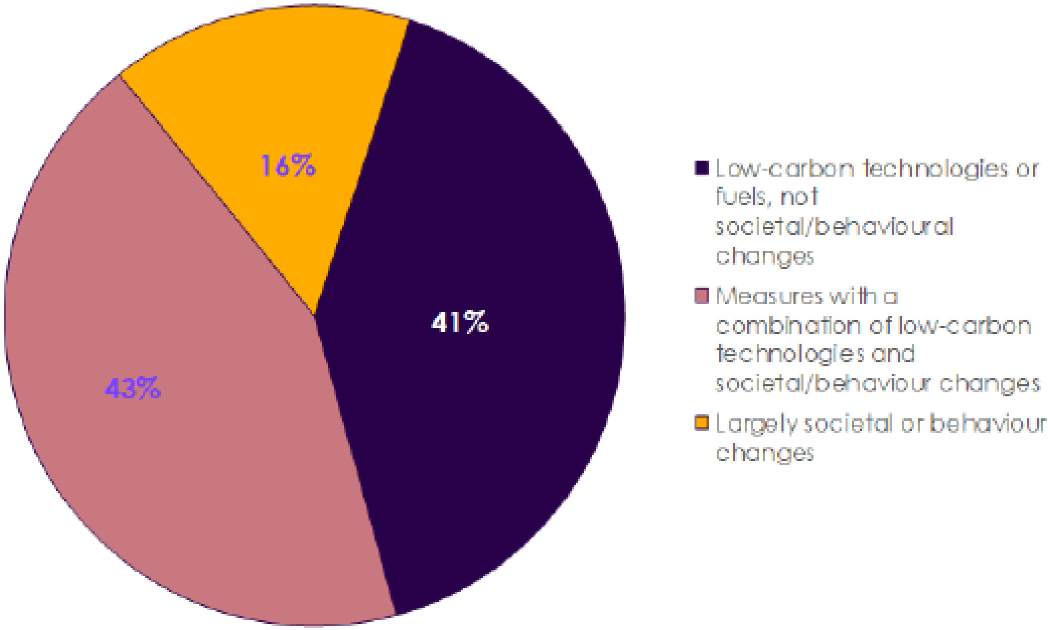


Desirable policy characteristics to reduce uncertainty

Source: Skidmore Review 2023
https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1128689/mission-zero-independent-review.pdf

- Credibility: businesses and people must believe the government is serious about the targets and will do what is necessary to meet them
- Flexibility: policies must be able to be changed in light of experience

Figure B2.2 Role of societal and behavioural changes in the Balanced Net Zero Pathway (2035)



Source: CCC analysis.

How much will people change their behaviour?

"Shifting quickly towards healthier diets, reducing growth in aviation demand and choosing products that last longer and therefore improve resource efficiency are all key."

Source: Climate Change Committee 2020
Balanced Pathway, Sixth Carbon Budget

Conclusions

Uncertainties for policy makers:

- Which technologies should be supported?
- What infrastructures will be needed?
- How will we balance the grid (essential role for storage)?
- Will the costs of key technologies come down?
- Will we get green growth?

Uncertainties for businesses:

- Do policy makers really mean Net Zero?
- Are the policies credible?
- Will the policies be clear, consistent, certain and continuing?
- Shall I make the investments in clean technologies
- Shall I (re)train my staff?

If the answers to any of the businesses' questions are 'No', Net Zero will not be attained

Thank you

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www.bartlett.ucl.ac.uk/sustainable