ORGANISATION FOR ECONOMIC CO-OPERATION AND DEVELOPMENT

The Benefits of Fostering Innovation in Storage and Grid Management Technologies under Imperfect Information

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Technology Neutrality vs. Directed Technological Change (1)

- Strong theoretical and reasonable empirical case for technology-neutrality of ‘environmental’ policies
  - Information asymmetries between regulator and regulated
  - Danger of ‘lock in’ – particularly in sectors with long-lived capital and network externalities
- General conclusion => gov’ts should focus on basic research > applied; and if applied, invest in diverse portfolio

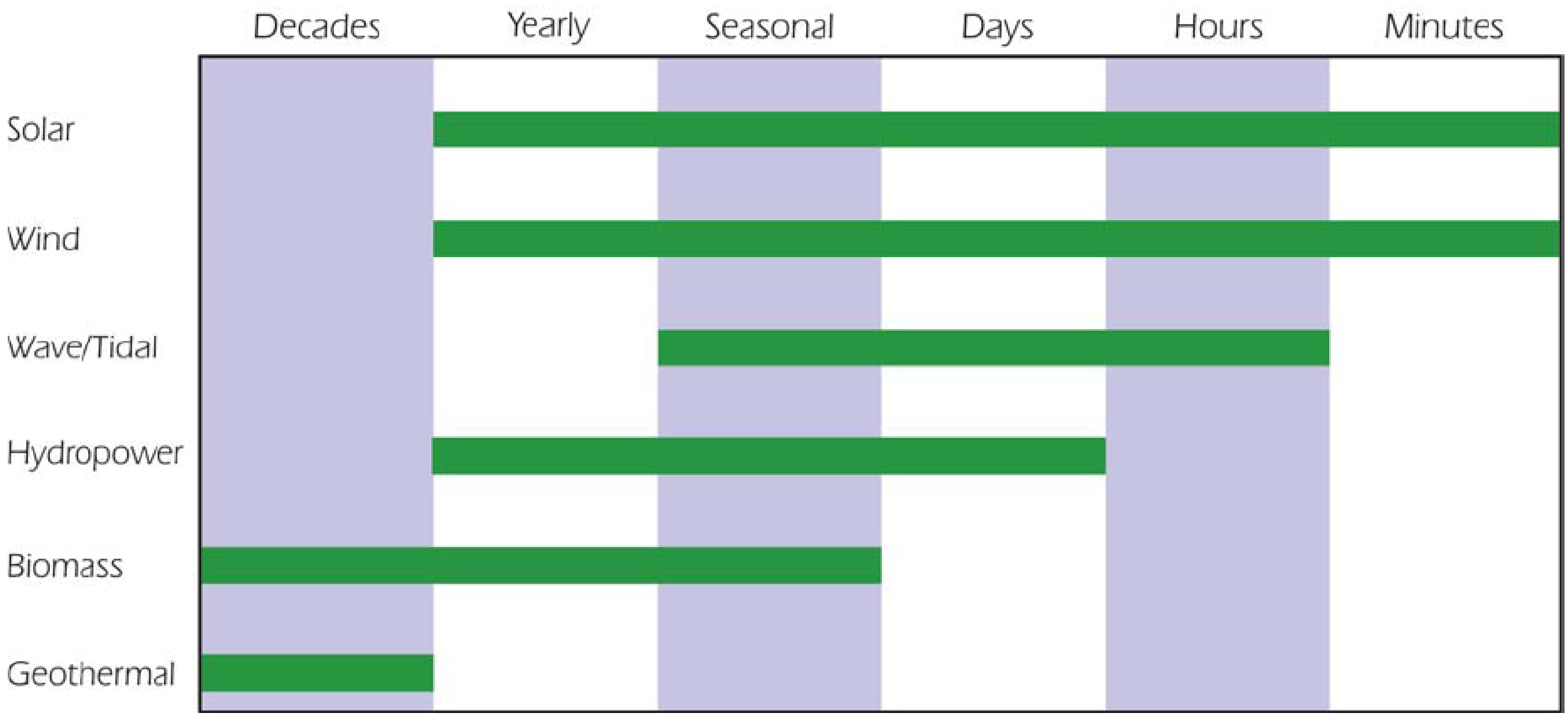
Technology Neutrality vs. Directed Technological Change (2)

- However, in practice governments frequently seek to 'bend' trajectory of technological change in environmentally-benign direction
- Recent work (e.g. Acemoglu et al. 2009, Bosetti et. al. 2010) has started to provide a theoretical and empirical basis for doing so in context of climate change mitigation
- Some reasons apply to all areas, but why might the case be stronger for CCM?
  - Appropriability issues related to public goods
  - Credibility of negative (price/quantity) incentive
  - Entry barriers in some of the main emitting sectors
- However – literature is not yet able to provide precise policy guidance on how to do so in a manner which is directly applicable for policymakers. Attempt to do so in context of renewable energy.

Challenge of Increased Penetration of Renewables

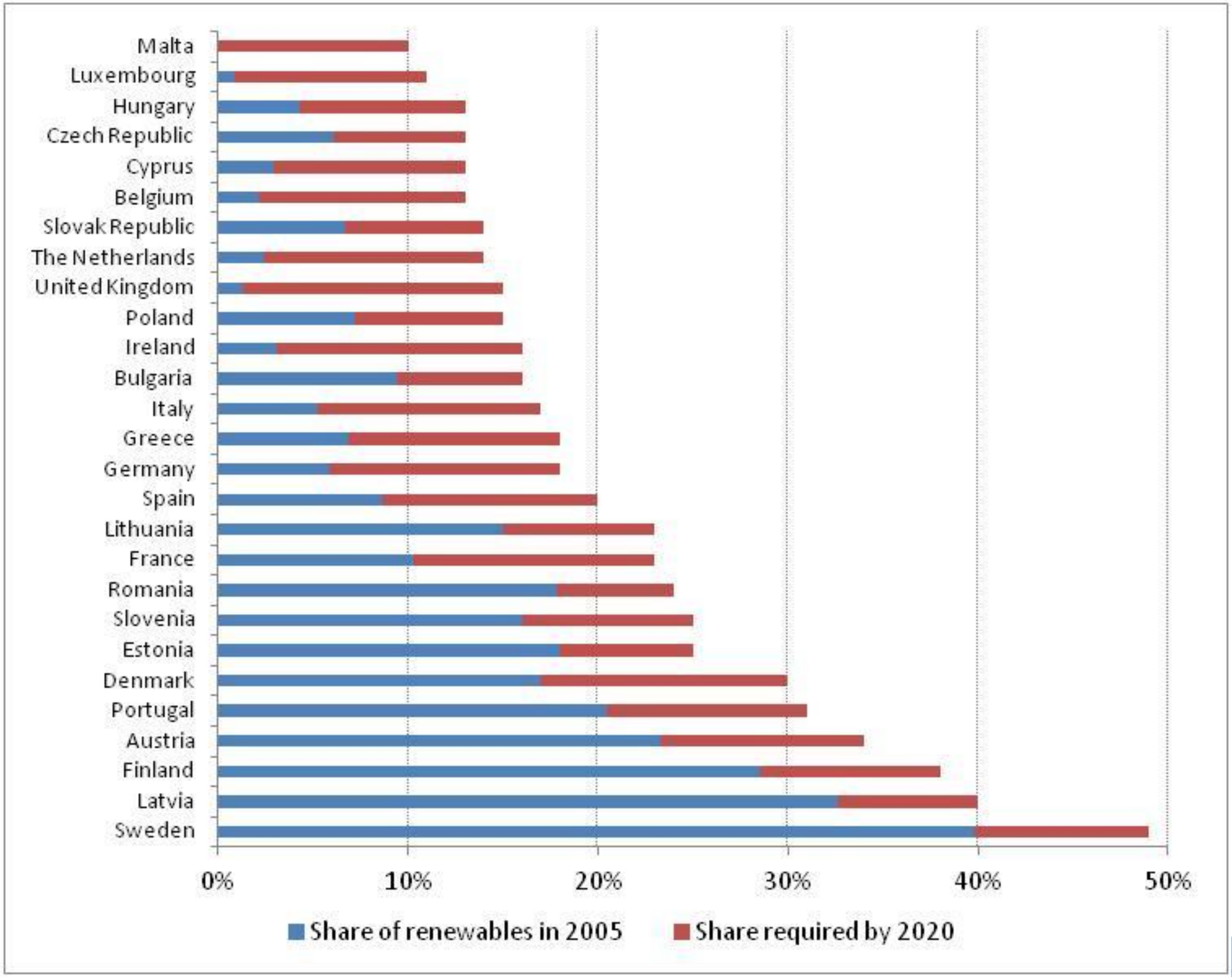
- The most important renewable energy sources (wind, solar, ocean/tide) are 'intermittent'
- Generation potential is subject to significant temporal variation (minutes, hours, days, seasons), which is uncertain and often correlated, and negatively correlated with peak demand (in some cases)
- This means that increased capacity of renewable energy generation is not a perfect substitute for 'dispatchable' generation capacity (e.g. fossil fuels)
- Challenge of LOLP becomes greater as share rises – note that some countries have targets > 40%, where capacity credit starts to converge to zero

Timescale of Natural Cycles of Variability



http://www.iea.org/papers/2005/variability.pdf

Renewable Energy Targets (Europe)



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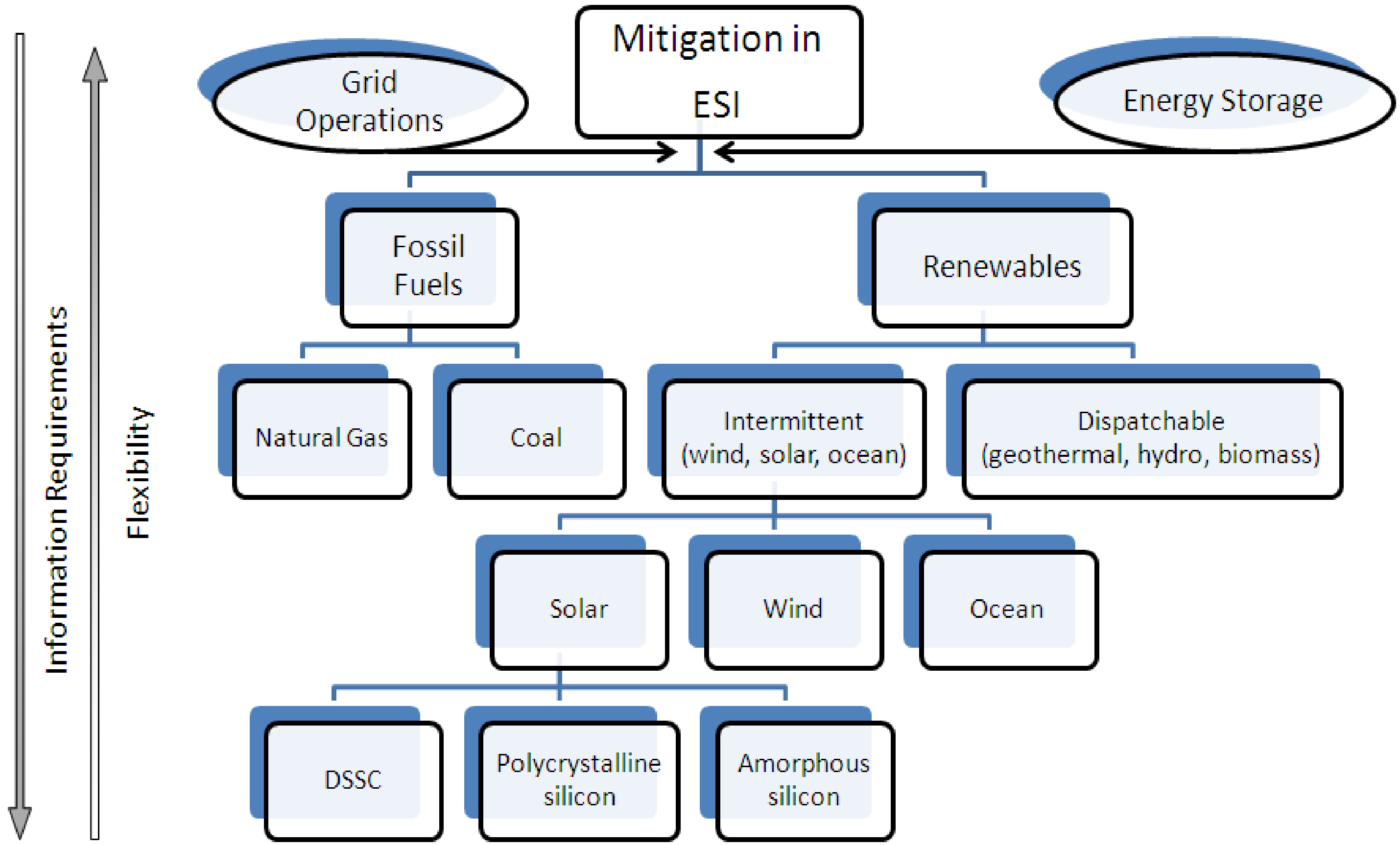
Means of Overcoming Intermittency

- Reduce correlation of variation in intermittent sources and/or allow for ex ante/ex post adjustment. How?
  - Improved weather forecasting
  - Spatial dispersion of sources (within type)
  - Diversity of sources (across types)
  - Trade in electricity services (states, countries)
  - Improvements in **load mngmt and distribution**
  - Investment in **energy storage**
- Focus on innovation in latter two as enabling or ‘local’ general purpose technologies

Intermittency and Targeting of Incentives

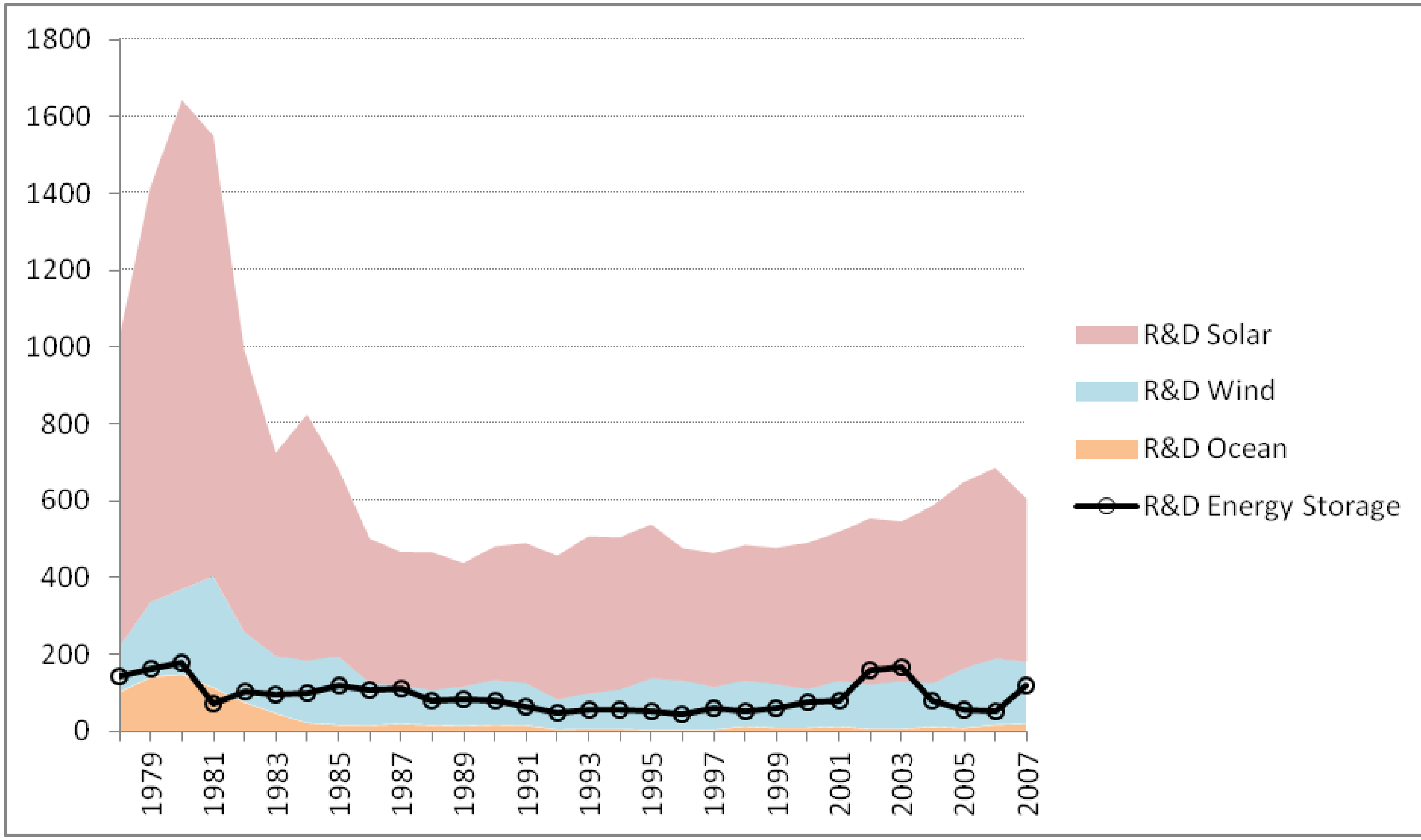


Hypothesis

- Price on carbon as necessary but not sufficient. How to target the 'technology' arm of the policy mix?
- In case of renewables the risk averse strategy would be to target support at energy storage (or *grid management and distribution*) rather than at the generating technologies themselves.
  - Storage as complement to portfolio of generating technologies with different (but unknown) long-run potential
  - Reduces the information requirements of policymakers and increases the flexibility of the system
- Tested (partially) by assessing the return (in terms of generating patents per unit public R&D) when support is targeted at storage technologies on one hand and generating technologies themselves on other hand

Targets of Public R&D Support

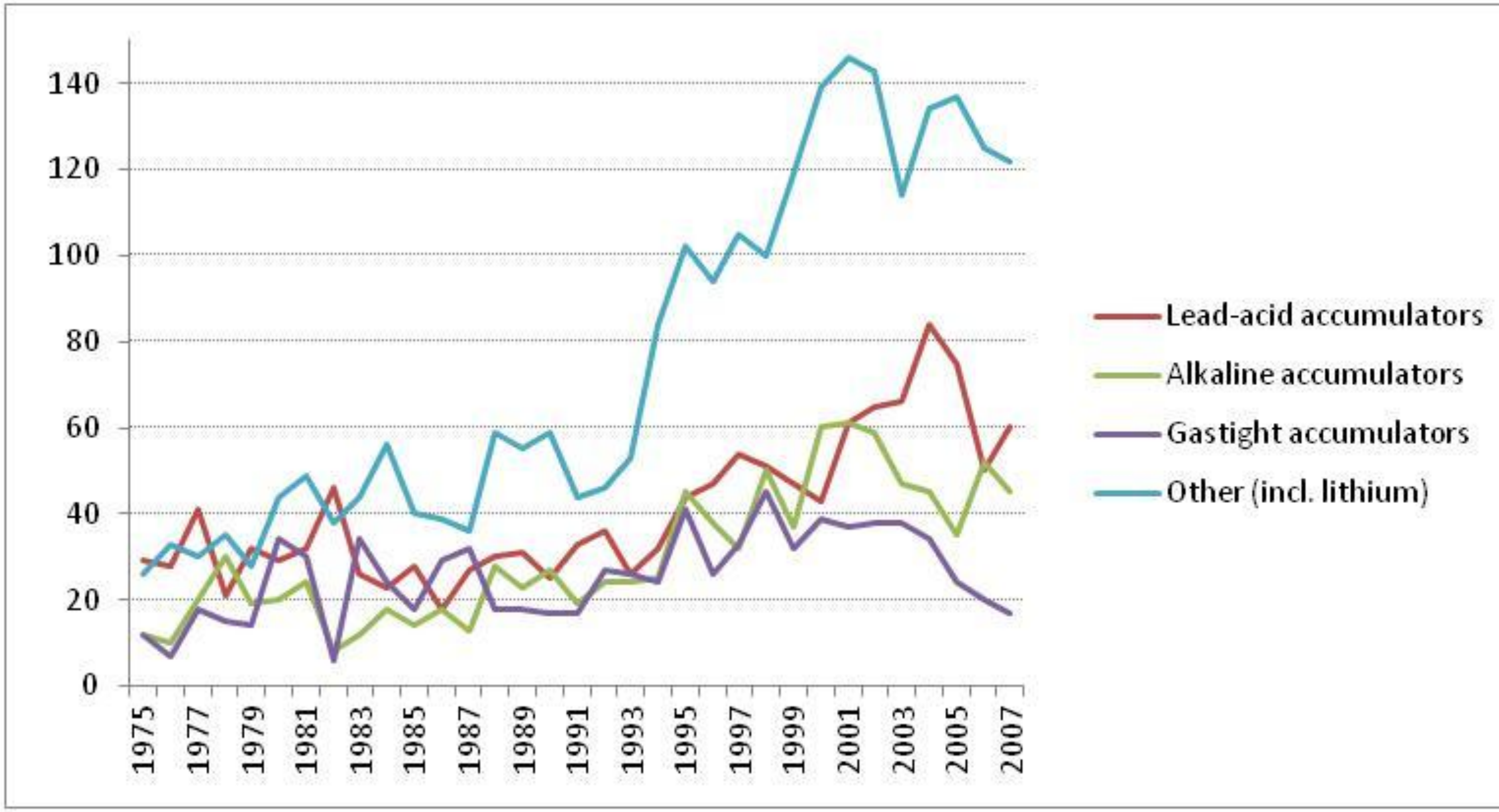
(million USD – 2009 prices and PPP)



Source: IEA Energy Technology R&D Budgets

Patented Inventions in Energy Storage

(All patents filed (globally) – singulars and claimed priorities)



Source: Extraction from EPO World Patent Statistics Database. All patents filed (globally) – singulars and claimed priorities.

Modelling Strategy (1)

- Panel of 28 countries (most of the IEA) over 34 years (1974-2007)
- First estimate patented storage invention using count data models

$$PAT\_STORE_{it} = f\,(R\&D\_STORE_{it}\ ,\ INTR\_PERC_{it}\ ,\ INTR\_VAR_{it}\ ,\ ELEC\_TRADE_{it}\ ,\ PAT\_TOTAL_{it}\ ,\ \omega_i\ ,\ \varepsilon_{it})$$

- Then, create a ‘storage’ knowledge stock variable from predicted patents using perpetual inventory method (Popp 2003) with 15% discount rate.

Modelling Strategy (2)

- Then estimate patented generation (wind, solar, ocean/tide) with knowledge stock variable as explanatory variable

$$PAT\_GEN_{it} = f\,(KS\_STORE_{t}\ ,\ ELEC\_PRICE_{it}\ ,\ R\&D\_GEN_{it}\ ,\ GEN\_POLICY_{it}\ ,\ PAT\_TOTAL_{it}\ ,\ \omega_{i}\ ,\ \varepsilon_{it})$$

- Simulate effects of 10% increase in public R&D targeted at storage and at generation (under different assumed allocations of expenditures)

- Robustness: discount factor on KS, continuous policy variables (FITs and RECs), lags in R&D and policy variables, sample (without US, most recent period)

Elasticities from First-Stage

	Zero-inflated neg. binomial (ZINB)	Negative binomial (NB)	Cond'l fixed-eff. NB	Random -effects NB	Zero-inflated Poisson (ZIP)	Cond'l fixed-eff. Poisson
	(1)	(2)	(3)	(4)	(5)	(6)
R&D exp. on energy storage	**0.0397**	0.0454	0.1036	0.1580	0.0676	0.0153
% intermittent sources	**0.1818**	0.1981	1.1506	1.7408	0.0390	0.0371
Diversity in intermittent sources	**-0.0755**	-0.0809	-0.5176	-0.7804	-0.0146	-0.0132
Trade in electricity	**0.0604**	0.0604	1.0889	0.9480	0.9319	0.8035
Total patents	**0.2907**	0.3316	0.8201	1.2401	0.1703	0.1573

Elasticities Second Second-Stage (ZINB)

	Wind	Solar	Ocean	**All intermittent**	**All dispatchable**
	(7)	(8)	(9)	**(10)**	**(14)**
Knowledge stock	0.3011	0.3323	0.3955	**0.3345**	**0.1946**
Electricity price	-0.0441	-0.4331	-0.5213	**-0.2713**	**-0.0706**
Total patents	0.1169	0.0828	0.0309	**0.1012**	**0.0845**
Specific R&D exp.	0.1237	0.0610	0.0616	**0.0703**	**0.0338**
Renewables policies	0.4499	0.1904	0.2302	**0.3102**	**0.5672**

Simulation Scenarios – 10% increase in R&D

- Risk minimisation – Allocating the increase to energy storage technologies, i.e. our hypothesised strategy;

- Business-as-usual – Allocating the increase to intermittent generating technologies in a manner proportional to actual portfolio of expenditures by country and by year; and,

- Perfect information – Allocating the increase to intermittent generating technologies according to which yielded the highest return (patents per dollar) by country and by year.

Simulated change in patenting from a 10% increase in targeted R&D