Energy Storage and Renewable Energy Deployment: Empirical Evidence from the OECD countries

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Motivation

- The main disadvantage of high penetration of renewable energy is the intermittency caused by renewable energy sources which makes balancing of an energy system challenging (negative externality of renewable energy).

- Most energy storage technologies are immature and require investments in R&D in order to improve performance, safety and reduce cost.

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Wind farms paid £1m a week to switch off

New figures show £53m was given to the wind industry last year to keep turbines switched off to regulate electricity supplied to National Grid

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GERMANY PAID WIND TURBINES $548 MILLION TO SIT IDLE

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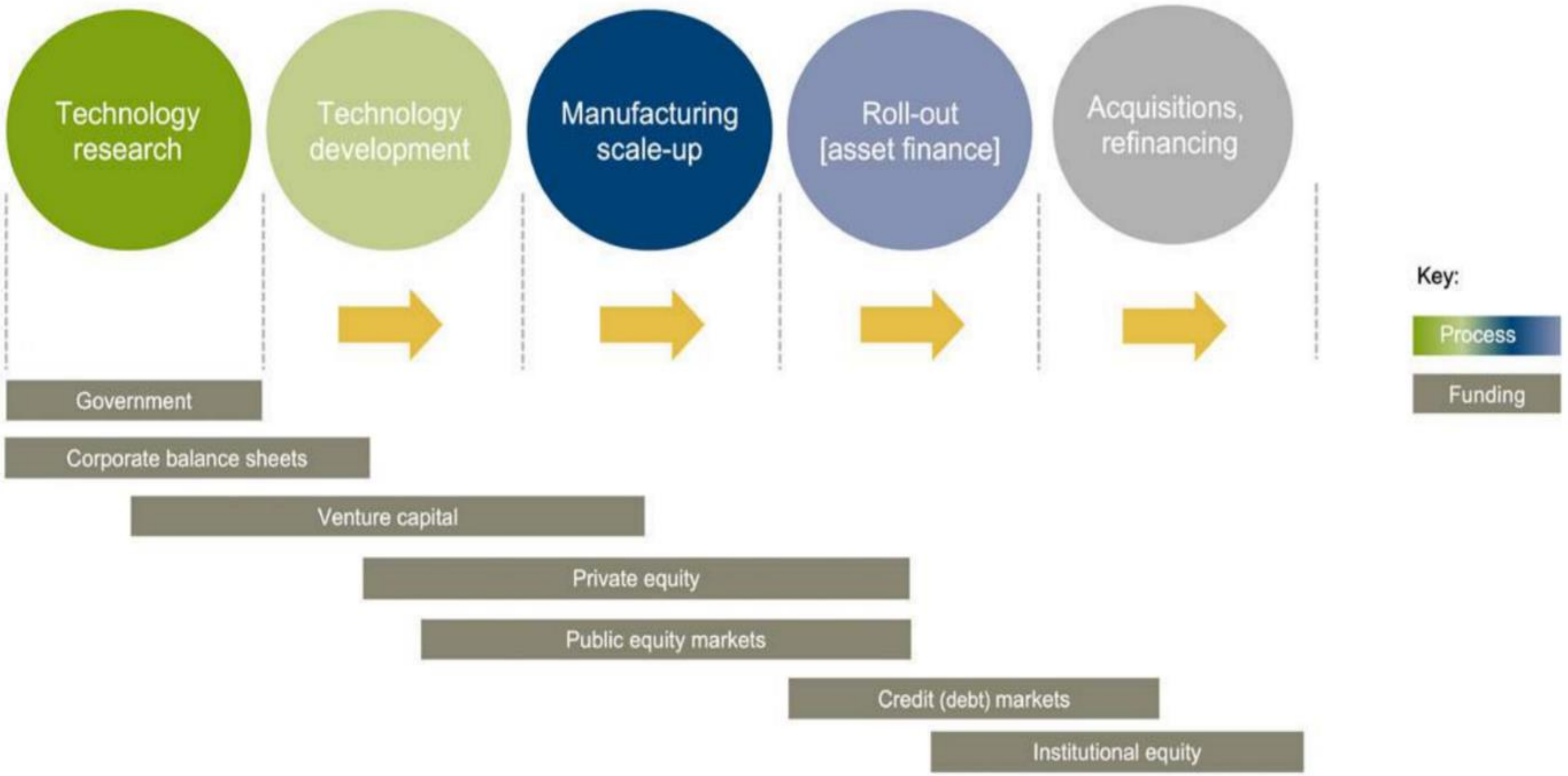
Wind farms paid £43m to switch off

SCIENCE | March 4. 2013. 18:00

Why windfarms get paid to switch off

A headline in the Times today claims windfarms get “paid Â£10,000 a day to sit idle”, leading consumer group

Investments in Energy Storage R&D



Source: Frankfurt School-UNEP Centre/BNEF (2020)

Research question

- "Which policies incentivize investments in energy storage?"

Data

- Using annual panel data from 29 OECD countries over the period 1985-2016 this paper provides an empirical evidence on the role of policies on investments in energy storage.

Dependent variable: Energy storage R&D

Investments in R&D of energy storage technologies (in nominal national currency):

- hydrogen and fuel cells
- other power and storage technologies
- other cross-cutting technologies and research

Independent variables: Policies

- Energy Storage Policy instruments: fiscal (taxes & grants), financial (loans), public investment (RD&D), grants, etc. (binary)

- Environmental tax (share of GDP)

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Control variables

- *Environmental patents*

The patent is counted if it was filed in at least one of the five largest patent authorities in the world, i.e., China, the US, the European Patent office, Japan, and South Korea. (count)

- *Energy intensity*

of primary energy (amount of primary energy (in TJ) per unit of GDP (in 2011 PPP US dollars).

- *Fossil fuel*

consumption (share in total energy consumption.)

Variable	Obs.	Mean	Std. Dev.	Min	Max
Log(energy storage R&D share)	846	-11.05	1.55	-16.69	-6.61
Log(energy intensity)	559	1.57	0.322	0.66	2.35
Log(share of fossil fuels)	801	4.31	0.27	2.56	4.60
Energy storage policy	846	0.22	0.41	0	1
Log(energy tax share)	513	0.43	0.39	-0.82	1.17
Log(environmental tax share)	512	0.81	0.39	-1.99	1.68
Log(environmental patent share)	659	-2.508	0.40	-4.25	-0.89
Log(R&D expenditure share)	678	-17.96	0.55	-20.45	-16.96

$$\ln RD_{i,t} = a_0 + a_1 \ln EI_{i,t} + a_2 \ln EP_{i,t} + a_3 \ln EPAT_{i,t} + a_4 \ln RD\_EXP_{i,t-1} + a_5 \ln FS_{i,t} + a_6 \ln ERS_{i,t} + u_i + \varepsilon_{i,t}$$

- $RD_{i,t}$ - energy storage R&D (share of budget in GDP)
- $EI_{i,t}$ - energy intensity (primary energy (in TJ) per unit of GDP (in 2011 PPP USD)
- $EP_{i,t}$ - energy storage policy (binary)
- $EPAT_{i,t}$ - patents in environmental or low carbon technologies
- $FS_{i,t}$ - fossil fuels consumption (share in total energy use).
- $ERS_{i,t}$ - environmental tax and energy tax (share in GDP).
- u_i - captures the fixed-effect that corresponds to country i. Note that u_i captures the time-invariant and economy-specific effects.
- $\varepsilon_{i,t}$ is the error term.

	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Energy intensity, log	-1.99***			-2.14***		-2.08**
Energy storage policy, binary	0.50*	0.74***	0.63**	0.35	0.65**	0.38*
Environmental patent share, log	0.37*	0.47**	0.14	0.09	0.17	0.11
R&D expenditure share, lag of log	1.04**	0.35	1.36***	1.30**	1.35**	1.27**
Fossil fuel share, log		-2.89**	-2.87**		-2.54*	
Energy tax share, lag of log			-1.93***	-1.81***		
Environmental tax share, lag of log					-1.92**	-1.84***
Constant	11.63	8.836	26.84***	16.76*	26.11***	16.78*
Obs.	432	490	372	372	373	373
R-squared	0.34	0.23	0.38	0.39	0.37	0.38

Results I: Policy

- Energy storage policies are effective in promoting investments.

- Implementation of energy storage policies increases investments in R&D of energy storage by 0.5-0.6 percent.

- The results failed to provide the effectiveness of energy tax and environmental tax on investments in R&D of energy storage.

Results II: Innovation in low carbon technologies

- Innovation capability in low carbon technologies increases investments in energy storage.

- A one percent increase in environmental patent share in total patents is associated with an increase in investments in R&D in energy storage by 0.4-0.5 percent.

Results III: Fossil fuels

- Fossil fuels have a negative effect on energy storage R&D budget. This means that countries with greater share of renewable/clean energy in their energy use structures invest more in R&D in energy storage. Renewable energy in the energy structure use increases then need to invest in energy storage grows.

Policy recommendations for promoting investment in energy storage

Large impact

- The major determinant of investments in R&D of energy storage is the share of **fossil fuel** in energy use structure. Countries with low, but growing, share of renewable energy need to provide more incentives to promote investments in energy storage.
- **Innovations** in low carbon technologies promote investments in energy storage.
- Energy storage **policies** are effective in promoting investments in energy storage; however the impact is small.
- We could not provide an evidence on the effectiveness of energy tax and environmental **tax** in promoting investments in energy storage.

No impact