C.I.R.E.D.
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To design an Energy Technology Innovation Policy

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Introduction
Main challenges of RD and innovation policy for energy transition

IEA (2012) argues that, for reaching reduction of CO_2 emissions target, investment in RD&D to be raised by 25% by 2020 and 50% by 2030

The complex nature of energy technology innovation policies to be recognized

It is not only an issue of public money, but also a combination of issues

- To act in a context of a highly liberalised business context
- Variety of technologies and states of development
- Evolving supports along long innovation chain
- Organisational networks (public -private partnership, developers-consumers ,etc.)
- Mode of technology selections

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1. Changing Context of Energy technology innovation policy

Recent recovery of RD and innovation budgets in highly liberalised business context

When low priorities of policy objectives (SoS, competitivness, business development) : low public RD effort

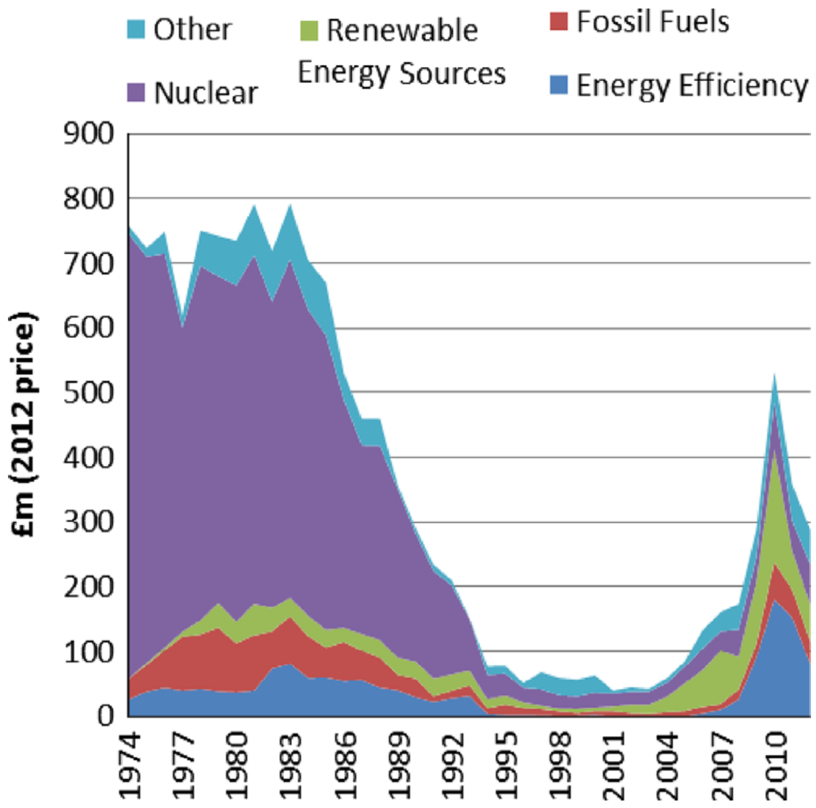
After countershock and liberalisation of utilities industries, decrease of the RD of energy companies

Under new priority to decarbonisation and transition

First stage of decentralised and fragmented public RD effort when effort recovery

Second stage of coordinated approach

The extreme case of the UK 's RD energy budget



Firms tend to invest :

- in incremental innovation in fossil fuel (extraction, transformation, clean coal, etc.) & centralised generation (nuclear)
- rather than low carbon and renewables

2012 $ Billion	Total	Alternative energies	Oil & gas	Other (Fossil Nuclear, etc)
Public RD effort (US-EU-J)	13.4	3.9	na	11.5
Private RD effort in OECD (1000 RD top companies)	14.6	0.8	9.0	4.7

Source (Rhodes , Skea, Hannon, 2014)

2. RD and innovation policies : to cover all the innovation chains

To challenge the « libertarian » view: the technology-neutral view

- Governments should provide funding for general early-stage R&D,
- with the private sector better placed to identify promising technologies and develop these further [Helm, 2006, 2013).
- A tax on carbon emissions wold be an example of a technology-neutral policy).

2.1. Charactersof energy technology innovation

The specific characters compared to knowledge sectors technologies

Firms' RD intensity much less important than in other sectors (Rhodes , Skea, Hannon, 2014)

Average	Oil & Gas producers	Electricity firms	Equipement suppliers	Pharmaceutals biotechnology	Computer services/ software
3.2%	0.3%	0.5%	Na	14%	10%

Explanation:

- In ITC and pharmaceutals /biotech
  - product turnover is quite fast and product developement relatively cheap.
  - New products are associated to new services

  Technology push is not that hard , but « natural » market pull is enormous.

- In energy and transport use
  - Low carbon technologies traverse a very long, expensive and risky chain of innovation to move from idea to the market
  - Expensiveness of the process up to the adoption
  - The product is basically the same.

The market pull and the technologuy push are both quite weak

Difference of characters of energy technologies/ difference of innovation system-governance

Complex large sized technology systems

- CCS, new nuclear reactors, hydrogen system-distribution-fuel cell, off-shore wind, etc.
- very large uncertainty, long lead time,
- need of strong governance and planning

In the mid-range,

- mid-sized/small sized renewables plants (long lead times, need of support in deployment stage)
- equipment goods (with breakthrough on some components as electrical vehicles)

Besides,

- Fertilization of grid technologies and consumers technologies by ICT (smart grids, virtual power plants, connectivity, digitalisation, etc.)

Field of actions of entrants and energy companies (partnership, incubators, etc.)

To understand consumers' need and modes of integration of decentralised/individual plants

2.2.Intergated approach to cover all the innovation chain

Because Importance of the Valley of death

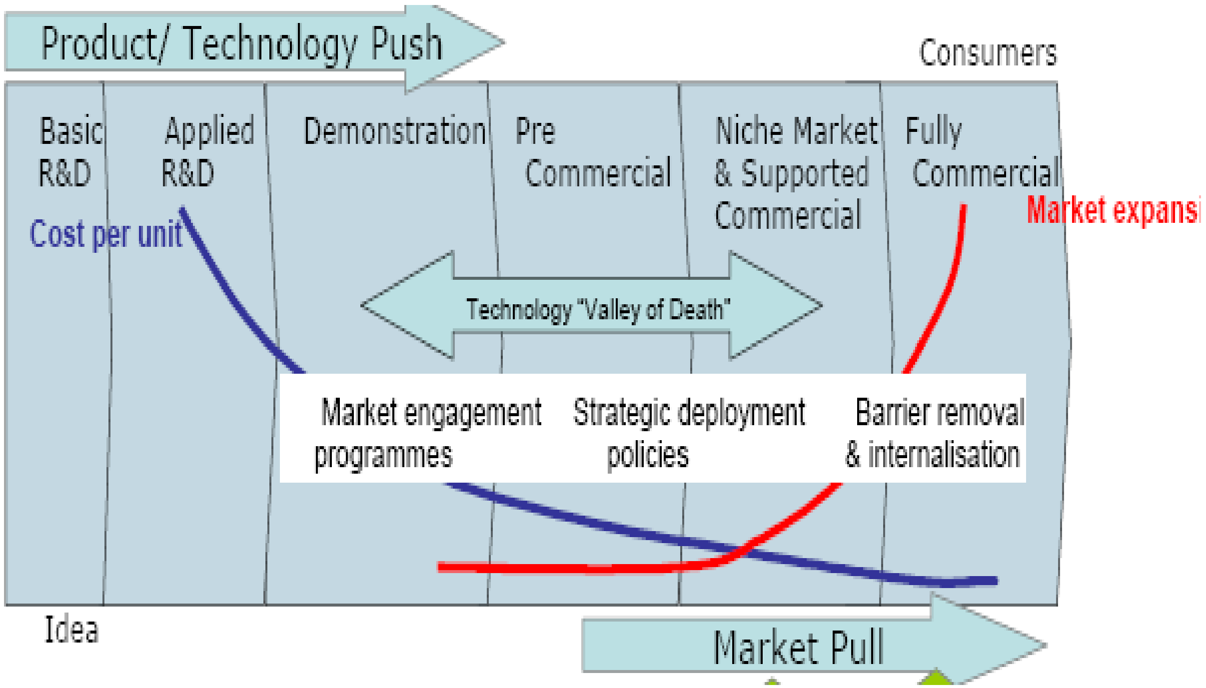
Barriers to post demonstration and pre-commercial deployment

- long lead times from basic research to deployment,
- high capital costs
- long payback periods for investors of many new energy technologies.

Insufficient private finance to continue commercialisation after demo stage

To adopt an integrated view of the innovation chain

Need of market pull
Incentives
after techology push



2.3 Technology push policy
One side of the bridge

- RD public investment by public agency, eventually with private partnership

e.g. nuclear projects in France and Japan at the stage of pre-demo and demo plants

- Public-private partnerships

e.g. The government picking up part of the costs/risks, : in the UK, the Carbon Trust technology accelerators

- Government market engagement

Government funded demonstration projects or deployment programmes, e.g. in Denmark for wind power, in the UK for capture projects

- Incubators and technology transfer services:

Offers start-up companies connection between funding sources and research institutes.
e.g. Specific public funds with angel/venture capital investors

NB . Important sources of techno push for the hybridisation of energy efficiency technologies by the ITCs

2.4. Demand pull in the low carbon context :
The other side of the bridge

Under the promise that diffusion would yield
enough cost reductions by learning, scaling up effects and network externalities
to make technologies competitive, the creation of a market is crucial from the start.

- Niches creation by public procurement
- Capital cost subsidies
- Production subsidies (combined with long term risk sharing arrangements) or CfDs

    Feed-in tariffs and CfDs.
    Subsidies to be paid by the consumers
    Ensures a specific price given to RES and low carbon techno, can be fixed or re-adjusted

- Clean energy or Renewable obligations

    In fine subsidization by the obliged suppliers' customers of the obliged suppliers
    Association with certificates exchanges (but increased risks to invest in the power markets)

Carbon pricing, emissions taxes, standards on new emitting technologies

    Literature shows the importance to combine regulation and taxes in matter of technology pull
    To shape the environment of selection
    Importance of the foreseeability of the pricing

3. How to structure and assess an Energy Technology Innovation policy?

Highlights by the Technology System Innovation approach :

- organisations (agencies, firms, etc),
- Traits of innovation policies
- Rules (regulation, market rules),
- social values

How to structure the RD Innovation policy?

- **Striking a balance between basic and applied research :**
  - Difficulties on budget setting on basic research
  - For budget setting, a way to proceed is to define energy system scenario for applied research (Wickens, 2014)

To realise an efficient adaptation of supports along the innovation chain

- Need of tailored and steady support to each technology as it move from one stage to the next stage
- Design of instruments to be relevant to the maturity of technology

  (examples of PV : investment subsidy, then feed-in tariffs)
- Need to debate how far processes of priority-setting should go
  - The process be extended to deployment support

  My opinion: this appears to be crucial in the power sector and biofuels

- For each use with new different technologies (power generation):
  - No technology neutrality at the first stages
  - Instruments which do not add risks (CfDs, FIT versus renewable obligation)

To select and to assess the innovation policy

- Need of clear process by which government can make choices on support to different technology options
  - To define different scenarios of competition between technologies
  - Define key milestones
  - Standard assessment methods
    - Innovation priorities : social benefits (political objectives)
    - estimated value of cutting costs and risks,
    - identify the case for public intervention,
    - export opportunities
    - Adequacy to social acceptance

- How to select in order to avoid too great dispersion?
  - Which influence of local conditions (natural resoources as wind potential) and technology resources of national firms (as for nuclear or carbon capture technologies) ?
  - **Regular assessment** to integrate informations of recent internal and internaional developments
  - Transparent process to manage the competition between constituencies/ interest goups
  - To keep freedom of choice to stop programs when results are more and more gloomy

Which governance structure ?

-Involvement of industrial mangers in the design of programs,

but risks of regulatory capture

- Overestimation of the promise and benefits of a technology by its promotors,
- Hiding difficulties to suppress technical bottlenecks, e.g. hydrogen, fuel cells, battery,
- Example of the present narrative of the Paradigm Change
  - (decentralised technologies, ITCs, renewables, prosumers, digitalisation
- Need of independent expertise

- **Complement of a centralized administrative structure for coordination among ministries and arms length agency:**
  - setting broad priorities,
  - monitoring overall progress (progress assessment)
  - evaluating performance

3. Conclusion

- To recognize that we are seeking radical innovations , more than incremental in some of the least innovative sectors

- To adopt an integrated approach of the innovation chain to the overcoming of the obstacle of the Death Valley

- Technology-neutral approach is not relevant
  - because the learning and the scaling up effects of the post demo stage
  - because the differences of technology regimes of innovation

- Need of coordination and strong governance in mission-oriented RD programs as decarbonisation program
  - Quite similar to central planning, in electricity markets
  - Suppression of the market function for long term coordination