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The 'uncertain middle': the role of demonstration projects and trials in influencing innovation success in renewable energy systems

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Project objectives

1. To evaluate the impact of demonstration projects and field trials in accelerating innovation in renewable energy technologies [for stationary power].

2. To evaluate the external factors affecting success, including the larger context of policy measures and follow-on activities necessary for maximising success.

3. To evaluate the impact of demonstration projects and field trials in accelerating innovation within firms.

4. To evaluate factors internal to the firm, which affect their ability to manage and exploit the opportunities presented by demonstration projects and trials.

5. To develop a clearer theoretical specification of demonstrations and trials within the innovation process, to guide policy makers in their effective use.

What is a demonstration project?

Government-funded

Specific technical, operational, economic, commercial, and social objectives

An overall budget and duration

Invites bids with a clear specification of goals

Evaluates projects against these

Has a formal management structure

Provides ongoing customer/user support from the manufacturer or operator

Not a ‘demand-pull’ investment subsidy, but …

Aims of this paper

Highlight the importance of DTs in the innovation process for renewable energy technologies in stationary power

Set out a theoretical framework for assessing their contribution

Apply it to a preliminary analysis of DTs in advancing the commercialisation of wind, PV and fuel cell technologies (using public records)

The role of demonstrations and trials in Energy RDD&D

R&D → Pre-commercial → Commercialisation/diffusion

"fuzzy front end"
"probe & learn"
(Lynn et al, 1996)

prototyping, consumer trials

'market failure' in energy innovation
- time-scale, cost, returns, system complexity (technical)
- climate externalities, energy security (public interest)

"uncertain middle"
↓

public R&D

demonstrations & field trials

subsidies, incentives
regulatory change
skills & standards
public procurement

Practical value of demonstration projects and trials

1. Improve technology and its match to market opportunities (‘co-evolution’)

2. Develop supply chain capabilities

3. Build customer awareness, experience, and socio-political support

4. Give (subsidized) quasi-revenues to firms

Theorizing the impact of DTs on innovation

public R&D

demonstrations & field trials

subsidies, incentives

search ← **learning** → manufacture & use

make, operate, interact

increase knowledge stock

innovation output

more than
just reducing uncertainty

cumulative installations

declining costs
experience curve/
progress ratio

develop a dominant design

competitive applications, application/system-specific costs,
economies of scope, match to industrial system

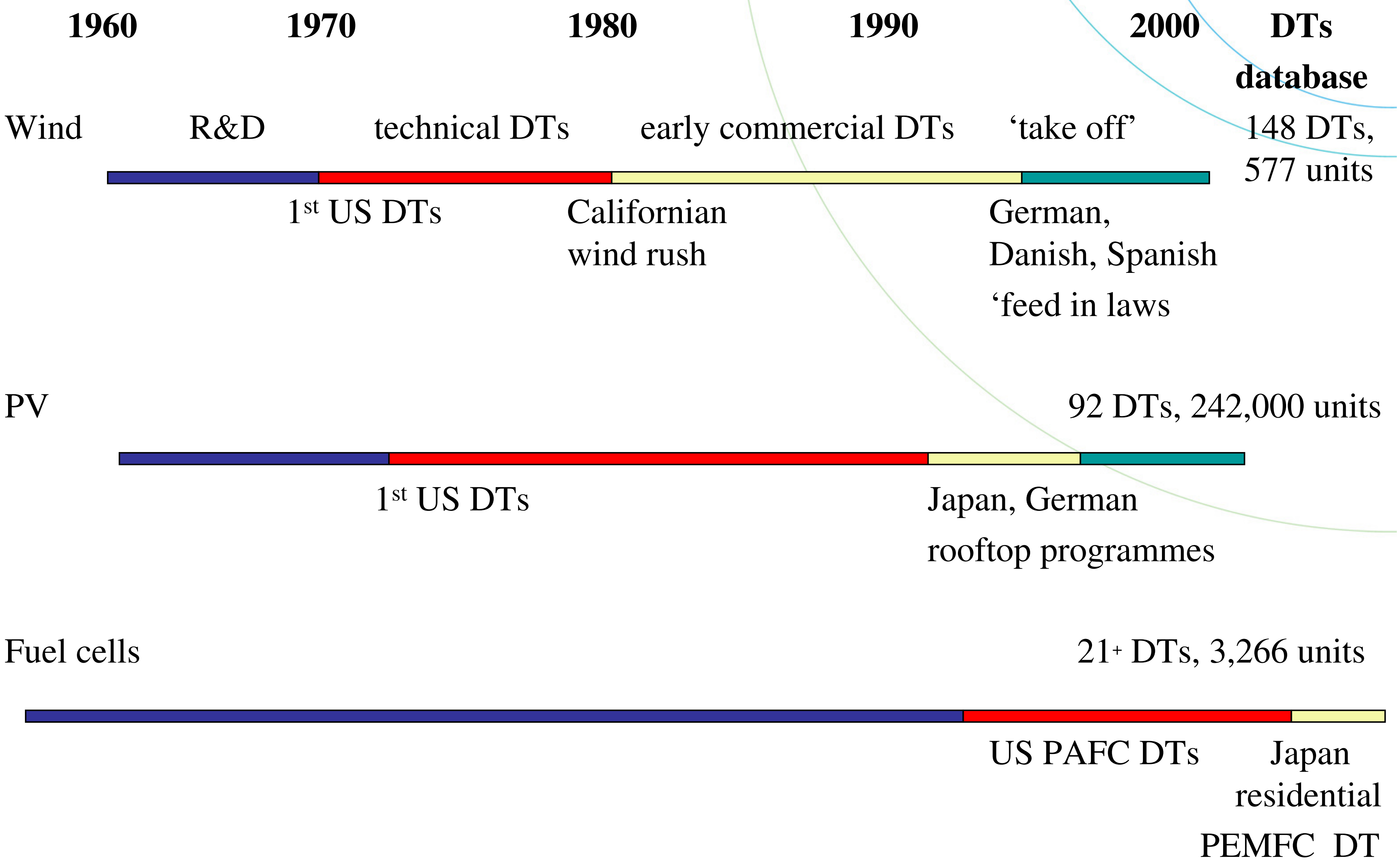
support socio-technical change

increase variety, new knowledge, aid direction of search
build industrial system (entry of new firms, supply chain, resources)
institutional change (form markets, increase linkages, catalyse coalitions)

complicated by knowledge spillovers

international participation in DTs, acquisitions

Wind, PV and fuel cells: R&D to commercialisation



DTs'contribution to dominant design and socio-tech system in wind

Progression to larger turbines .. but EU DTs still tested

- wide range of power outputs (<100kW to >500kW)
- 1, 2, 3 blades
- downwind & upwind
- horizontal axis & vertical axis designs
- different materials for blades

: pre-dominant, not dominant design

EU DTs keeping open design options for different conditions across Europe?

US/California market creation premature, but helped Danish/German manufacturers

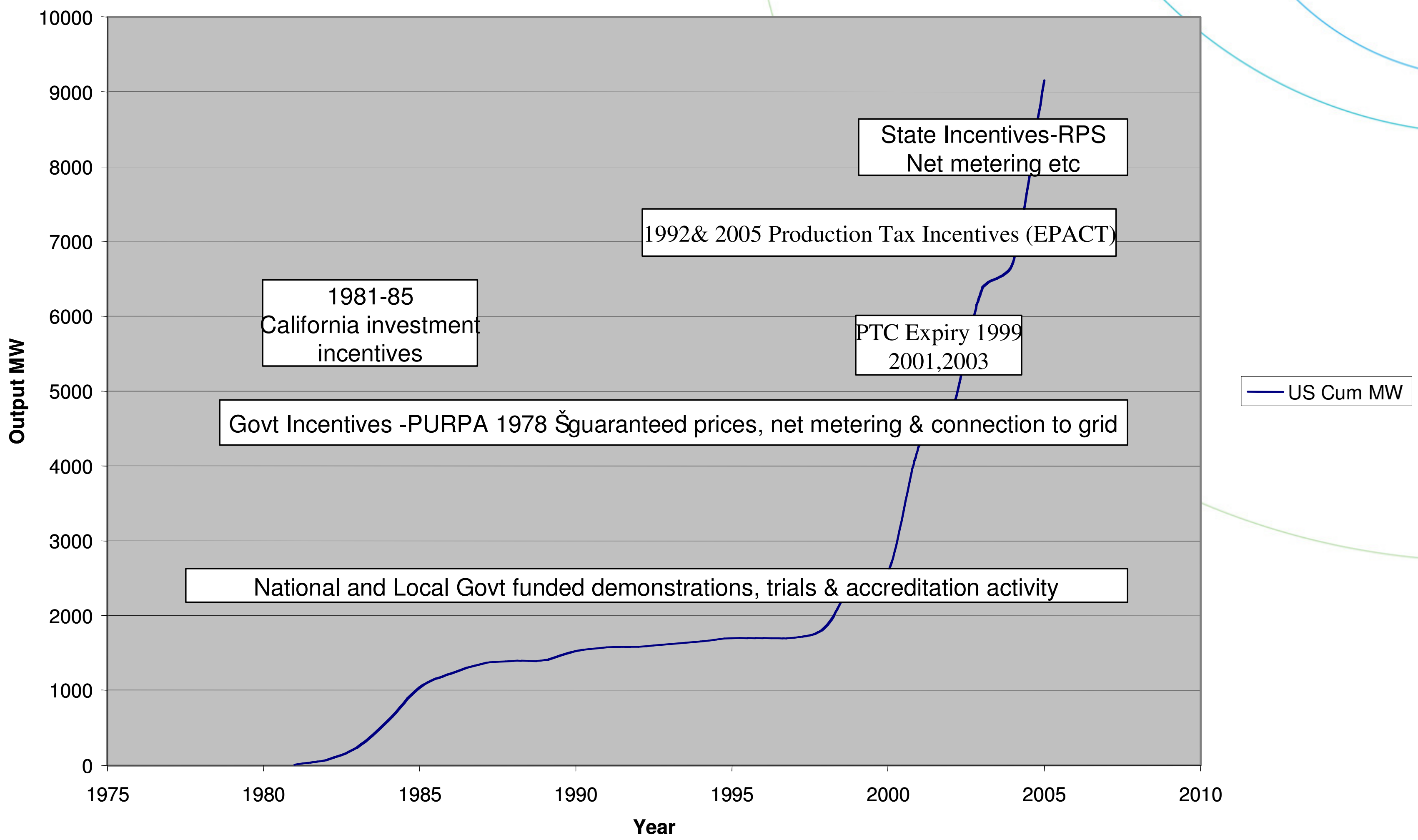
.. 8 of top 10 firms are European

But lead firms no more involved in DTs than smaller, less successful firms

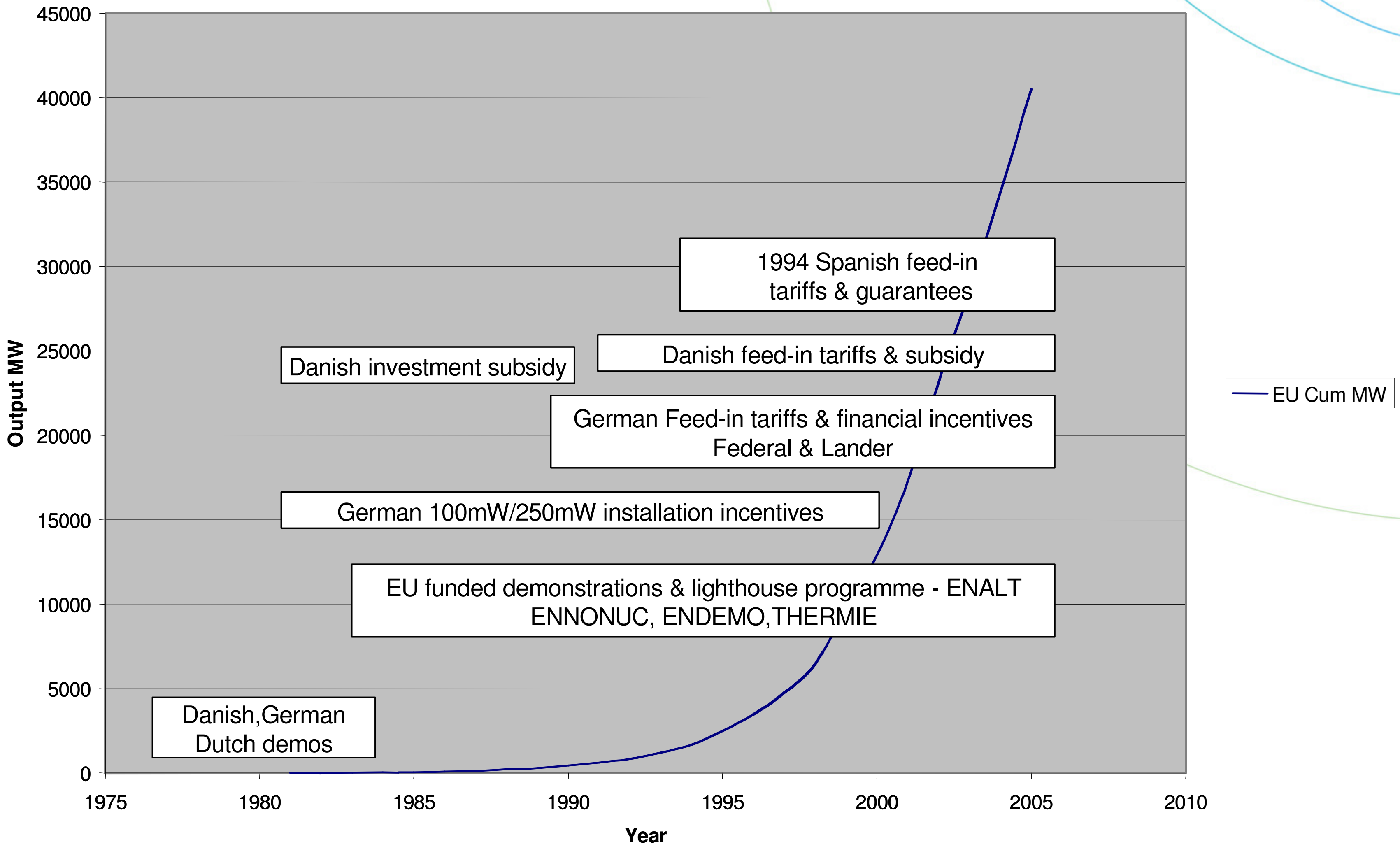
Lead partners in US & Japan most frequently utility or local authority .. in EU, manufacturer or developer

Development owes more to national R&D, strategy & policies in Denmark, Germany

US wind installations, DTs and market incentives



European wind installations, DTs and market incentives



EU funded wind DTs by member states - Stimulating national industries and diffusion?

Period	Ger	Italy	Ire	Fr	Dk	Gr	Pol	Lux	Ne	Be	Swe	UK	Spain	Total
1970-74														
1975-79					2									2
1980-84	10	7		7	7	6			9	4	3	11		64
1985-89	9	12	3	10	12	14			14	2		13	8	97
1990-94	6	5	4	6	2	3	2		2			13	3	46
1995-99	2	1	6	7	5	3	1	1	2		1	6	4	39
2000-05											2			2
Totals	**27**	**25**	**13**	**30**	**28**	**26**	**3**	**1**	**27**	**6**	**6**	**43**	**15**	**250**

DTs' contribution to dominant design and socio-tech system in PV

More market alternatives .. more complex systems

Off-grid dominated until late 1990s (especially USA)

Japanese 'grid-connected rooftop systems' strategy .. testing grid-connection from 1986

Japanese & German rooftop DTs, then rapid national roll-out

EU & Germany testing wider range of applications .. large-scale and 2nd generation 'building-integrated PV'

: winning technology/design still evolving

German research-industry-public coalition created .. rooftop programmes to support lead manufacturers

Rooftop programmes built on existing industrial base + stimulated new firms upstream & downstream

Japan/German development of standards & training for rooftop PV grid-connection

US DTs unfocused .. fragmented providers, resistant to grid-connection

EU firms acquired US firms & knowledge ('spillovers')

EU states benefiting?

DTs' contribution to dominant design and socio-tech system in FCs

Complex mechanical/electrical/chemical/material systems .. 4 competing types

Many market segments .. but 'combined heat and power' (CHP) attractive

Technology-market co-evolution in PAFC

USA & Japan 2-5 years ahead of EU

: Dominant design & commercialisation a long way off

USA has strong strategic focus (residential use at military scale, developing US industry), led by DOD

Japanese grid-connected residential strategy, methodically unfolding (2001-05-10-)

Japan 'convened' industry coalition to develop & implement residential PEMFC CHP

US PAFC programmes → early revenues, clarified markets, confidence to invest in FCs .. but lack of variety & new knowledge from new entrants

But PEMFC has mobilised whole value chain through partnering, helped by DTs

US/Japan DTs own firms only .. EU DTs include US & Japanese technology leaders

Supporting socio-technical change in Japanese fuel cells

(Jacobsson and Bergek, 2004)

- Stimulate and guide learning (influence the direction of search)
- Build the industrial system (draw in new firms, build the supply chain, supply resources)
- Stimulate institutional change (form markets, create linkages, catalyse coalitions)

Moonlight Project (1978) → New Sunshine Project (1993) → Millenium Project (2000) & Groundwork Project for Diffusion of Fuel Cells (2000) → Fuel Cell Commercialization Conference (2001) → regional grid & residential DTs (2003-07; 2005-08)

Lessons (for FP7 470 million euros H2&FC JTI)

Increasing sophistication in bringing renewable energy technologies on stream

1. National targets & roadmaps
2. More programmatic approach to timing and coordination of R&D, DTs and market incentives
   - → ensure technology-readiness, complementary activities & follow-on measures
   - → focus vs. flexibility in DTs (cost reduction from focussed market applications vs. maintaining variety until design future clear)
3. Wider range of objectives for DTs being set
   - → need to remain mindful of wider socio-industrial possibilities from DTs (especially UK!)