

Comparing nuclear trajectories of Germany and the UK: exploring drivers behind socio-technical transitions and discontinuities

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Introducing Governance of Discontinuity in Technological Systems (DiscGO)



DDT led by Pierre Benoit-Jolie
INRS, Paris



Combustion engines, Sebastien Hoffman,
Dortmund.



Incandescent light bulbs,
Stefan Kulmann, Peter
Stegmaier @ Twente



Nukes –Stirling, Johnstone
(SPRU), Geels (Manchester)

Research puzzle: comparative approach. Germany and the UK the most divergent nuclear policies in Western Europe but what are some of the drivers to these radially differing technological trajectories?

Germany: attempted discontinuation of nuclear power by 2022 (with 9 reactors still to close)

UK: The most ambitious nuclear new build programme (16GW) in Europe, if not the developed world as a whole.

Comparing 9 criteria based around literatures from ‘innovation theories’ broadly understood, and nuclear-specific factors.

Exploring **qualities of democracy, incumbency**, and more recent anomalies in UK energy policy

Perspectives from innovation theory and transitions: defining the 'focal regime configuration'

Background literatures adopt distinct overlapping frameworks:

innovation dynamics (Freeman, Dosi); innovation journeys (Scot, Geels); transition studies (Rip, Schot, Kemp, Geels), functions (Hekkert, Jacobsson); STS (Bijker; Feenberg; Jasanoff, Wynne, Williams); destabilisation (Turnheim, Penna, Geels); discontinuity (Stegmaier, Kuhlmann); discursive struggles (Hajer, Kern, Geels); political contestation (Meadowcroft, Berkhout, Smith, Stirling)

Emergent processes many mechanisms entrench pathways:

autonomy (Winner); lock in (Arthur); path dependency (David); lock-out (Unruh); entrapment (Walker); obduracy (Hommels); imaginaries (Jasanoff); expectations (van Lente); shaping (Bijker); framing (Benford, Snow); civic epistemologies (Miller); increasing returns (Cowan), learning by doing (Rosenberg), scale / scope economies, sunk investments (MacKerron); research infrastructures (ESFRI); advocacy coalitions (Sabatier)

Deliberate social agency further reinforces trajectories:

incumbent strategies (Geels, Hekkert); regulatory capture (Sabatier)

Developing Core Criteria: internal/ external

Specific analysis of dynamics of nuclear incumbency

Attention to climate; energy security and policy; public opinion.

- Much earlier literature on nuclear vested interests (Blowers, Hoffman, Kitschelt, Massey, O'Riordan, Purdue, Schrader-Frechette, Wynne, Grove White, Walker).
- But rather little recent analysis of specific dynamics (Sovacool, 2011)

Potentially related performance criteria

'actual sustainability' (Verbruggen); energy security (Jewell, Cherp); acceptability (Pidgeon); dimensions (Hultman; Sovacool); ordinary asset (Kahn, MacKerron, Bradford).

Other areas of analysis relevant to broader criteria

negative learning experience (Grubler); renewable revolution (Mitchell, Rifkin, Gonzalez); military nuclear complex (Hecht, Cowan, Arnold, Barnaby, Elbaradei, Hultman); political opportunities (Kitschelt); tools of democracy (Asdal); social movement studies

- *1:0 General Market Conditions In The Two Countries*
- *2:0 Degree of penetration of nuclear in the electricity generating mix*
- *3.0: the relative strengths of the nuclear engineering sector in terms of performance in manufacturing and operational equipment supply and associated industrial lobbies*
- *4.0: Relative magnitudes and costs of available national renewable resource potentials*
- *5.0: The scale of national industrial capacities and interests to address renewable energy supply*
- *6.0 relative scales of military-related nuclear activities and associated industrial interests*
- *7.0: Relevant characteristics of general national political institutions and elite cultures*
- *8.0: Broader Presence and activity levels of relevant social movements*
- *9.0 Qualities of democracy*

- ***1:0 General Market Conditions In The Two Countries***
- *1:1 Market coordination*
- *1.2: General public spending*

- ***2:0 Degree of penetration of nuclear in the electricity generating mix***
- *2.1: Top ten nuclear generating countries*
- *2.2: Dependency on Nuclear power*

- ***3.0: the relative strengths of the nuclear engineering sector in terms of performance in manufacturing and operational equipment supply and associated industrial lobbies***
- *3.1: Performance of plants*
- *3.2: Comparison of constitution of respective nuclear industries in Germany and the UK*
- *3.3: Research and Development in nuclear power*
- *3.4 Share of global nuclear Patents (national aggregate and by company)*
- ***4.0: Relative magnitudes and costs of available national renewable resource potentials***
- *4.1 Overall renewable Resource*

- ***5.0: The scale of national industrial capacities and interests to address renewable energy supply***
- *5.1: Overview of renewables growth in Germany and the UK*
- *5.2: Research and development*
- *5.3: General Narratives of renewables policy*
- *5.4: Industrial strength – equipment supply industries*
- ***6.0 relative scales of military-related nuclear activities and associated industrial interests***
- *6.1 nuclear weapons capabilities*
- *6.2 Nuclear Ballistic Missile Infrastructure*
- *6.3 Nuclear propelled submarines*
- *6.4 Military-related equipment supply industries*
- *6.5 Stated future plans for military renewal*

- **7.0: Relevant characteristics of general national political institutions and elite cultures**
- 7.1: centralisation ' hierachy / consensual, decentralised
- 7.2: Prominence of Green Party
- 7.3: prominence of consensus/deliberative-style politics

- **8.0: Broader Presence and activity levels of relevant social movements**
- 8.1: generalised public opinion on nuclear power
- 8.2: Baseline in public attitudes on nuclear: confidence in nuclear industry
- 8.3 Baseline in public attitudes on nuclear: perception of nuclear risk
- 8.4 Maximal Scale of protests
- 8.5 intensity of public debate including media mentions

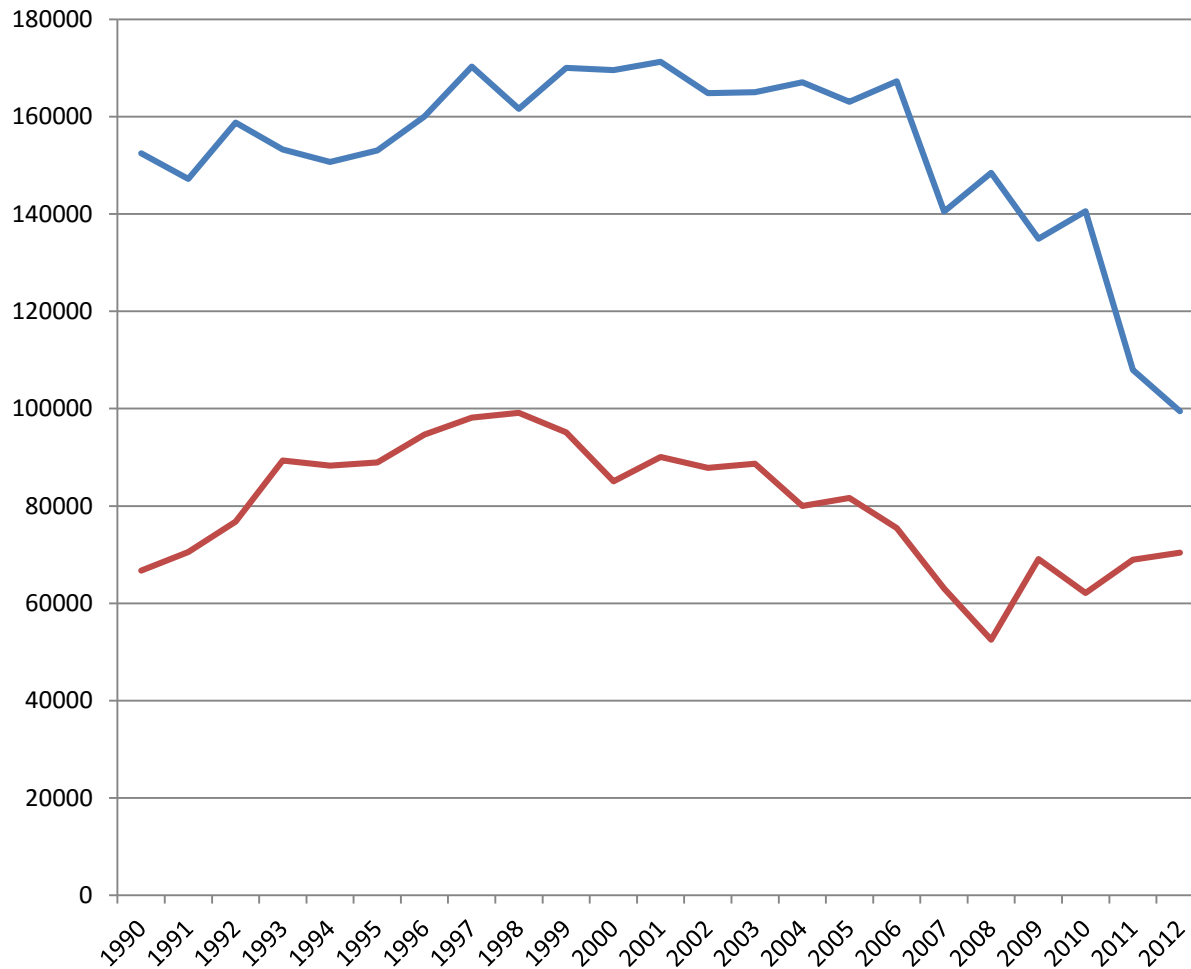
- **9.0 Qualities of democracy**
- 9.1 consensus vs majoritarian
- 9.2 Proportional representation vs winner takes all
- 9.3 rankings in qualities of democracy indexes

Summary of Key Patterns

<div> <div> criterion</div> <div>case</div> </div>	GENERAL MARKET CONDITIONS (GMC)
- Germany	<ul style="list-style-type: none"> - ‘coordinated economy’ - more state intervention - higher public spending
- UK	<ul style="list-style-type: none"> - ‘market economy’ neoliberalism - less public spending
criterion	GMC
locus drivers / regime	in
proposition: discontinuity more likely?	UK

criterion

DEPENDENCY ON NUCLEAR ELECTRICITY (DNE)



**Production:
GWh**

Summary of Key Patterns

criterion **DEPENDENCY ON NUCLEAR ELECTRICITY
(DNE)**

Top 10 Nuclear Generating Countries

2013, Billion kWh



critterion

DEPENDENCY ON NUCLEAR ELECTRICITY (DNE)

	GERMANY	UK
World ranking in nuclear electricity production (2010)	5 th	9 th
Total nuclear capacity MWe (2010)	20,339 MW	10,038 MW
Historic maximum nuclear production in one year (GWh)	171,305 (in 2001)	99,486 (in 1998)
% share of electricity generation in overall mix (2010)	22.2%	16.27%
Historic maximum % share of nuclear in generation mix	31%	28%
Number of reactors in 2010	17	16
Average size of individual reactors (MW)	1048 MW	581 MW

Summary of Key Patterns

<div> <div> criterion</div> <div>case</div> </div>	DEPENDENCY ON NUCLEAR ELECTRICITY (DNE)
- Germany	<ul style="list-style-type: none"> - higher proportion of electricity generated (25%) - greater total amount of nuclear electricity - home based dedicated nuclear utilities
- UK	<ul style="list-style-type: none"> - lower proportion of electricity generated (19%) - half as much nuclear power as in Germany - foreign-based nuclear utility

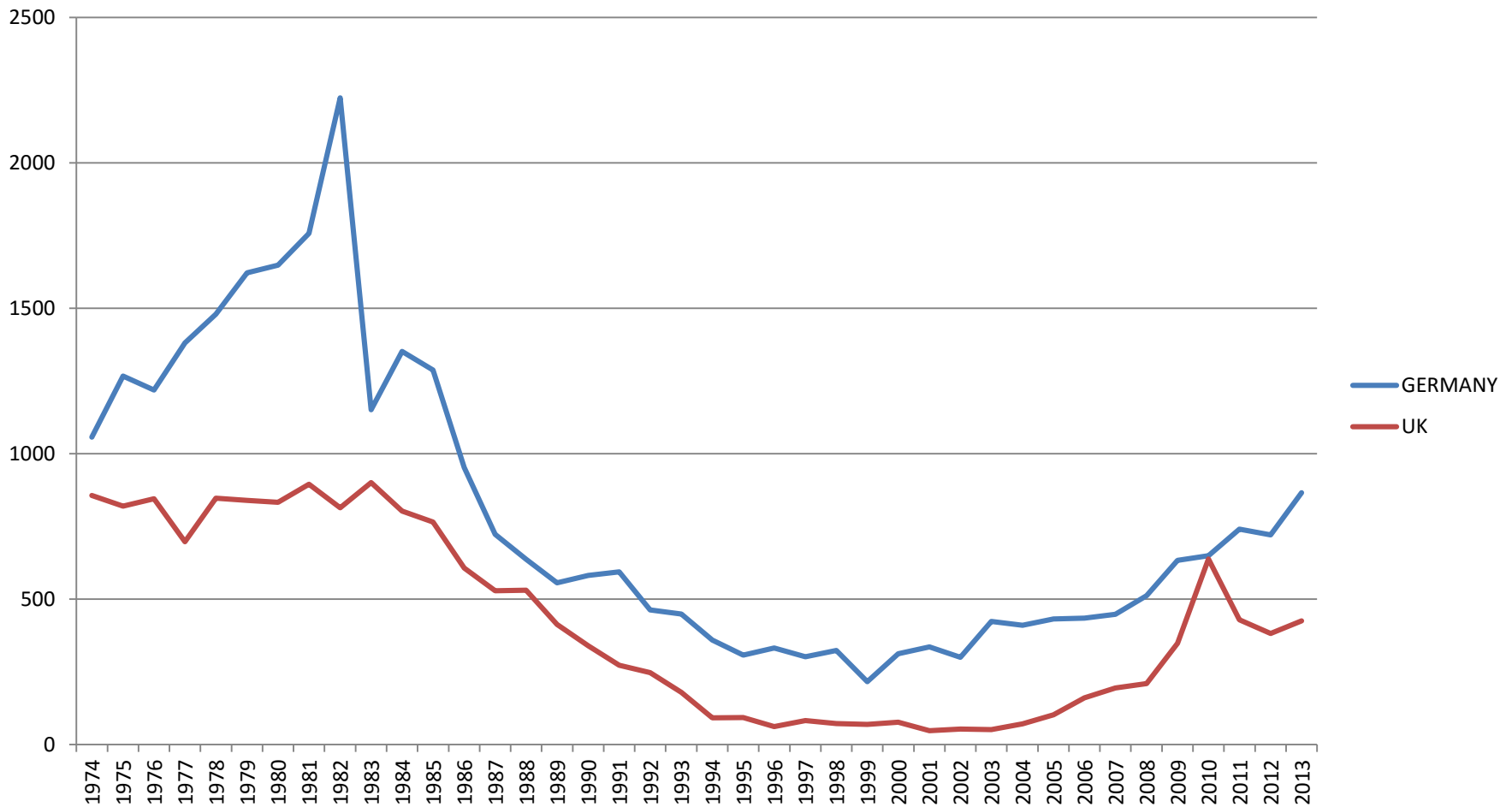
crit	GMC	DNE
locus drivers / regime	in	in
proposition: discontinuity more likely?	UK	UK

critterion

STATUS: NUCLEAR ENGINEERING INDUSTRY (SNI)

case

R and D spend on civilian nuclear power (Million Euro)

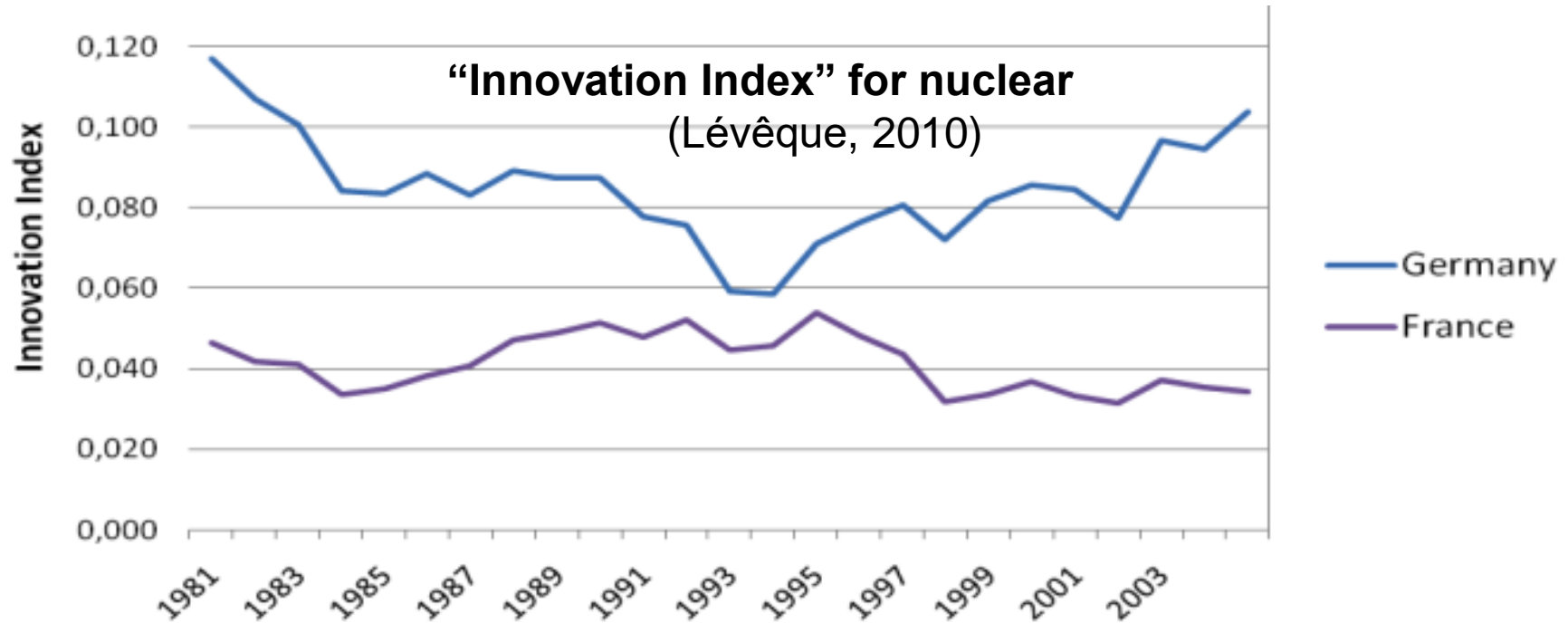


Summary of Key Patterns

criterion

**STATUS: NUCLEAR ENGINEERING INDUSTRY
(SNI)**

case



“Despite this decision [to phase out nuclear power], Germany seems to innovate more in nuclear technology than France. It has a better innovation index (as defined as the number of yearly national patent applications in nuclear technology divided by the number of yearly national patent applications in all technological fields) than France.” (Lévêque, 2010).

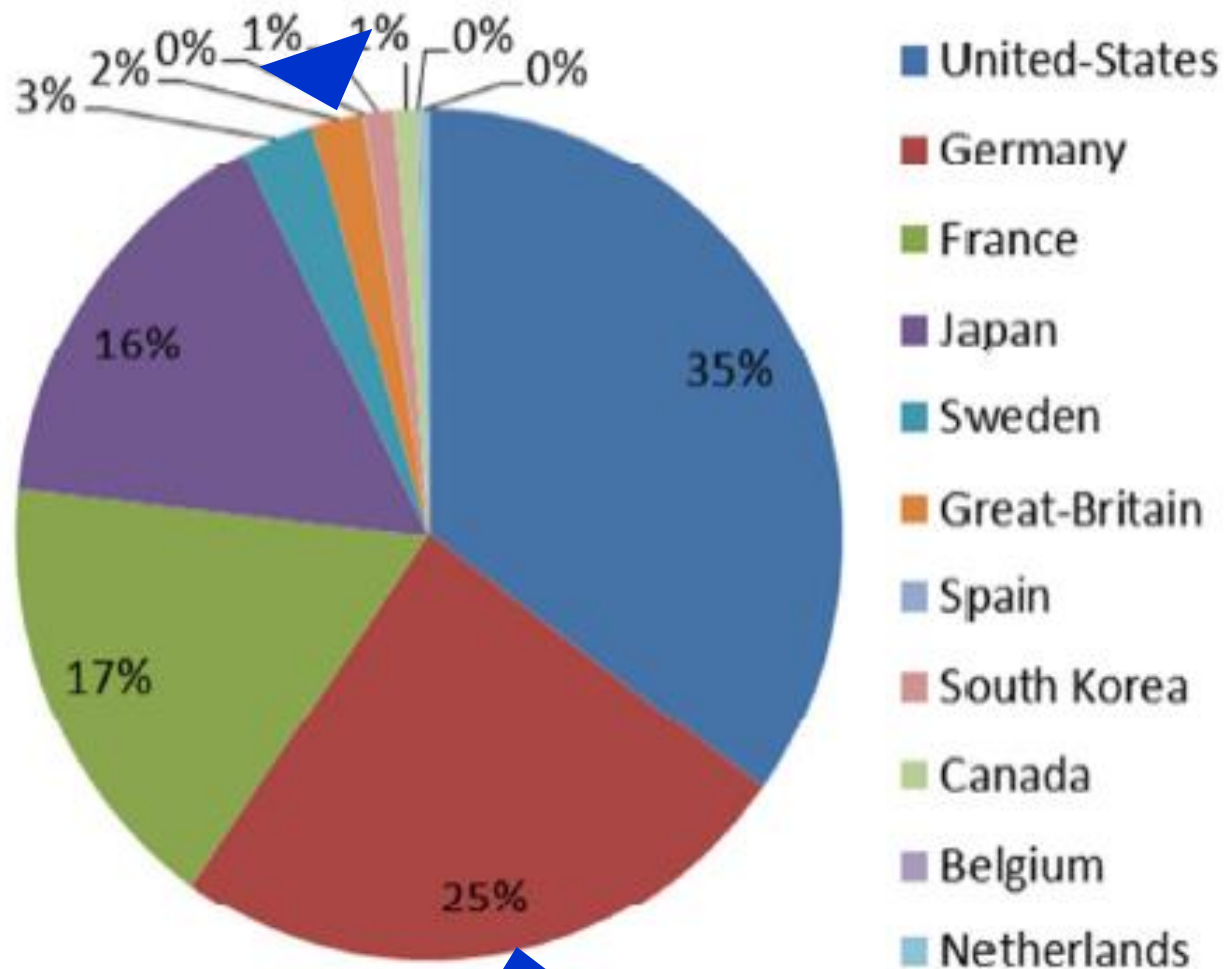
Summary of Key Patterns

critterion

**STATUS: NUCLEAR ENGINEERING INDUSTRY
(SNI)**

case

**Share of Global
Nuclear Patents
1970-2010**
(Berthélemy, 2012)

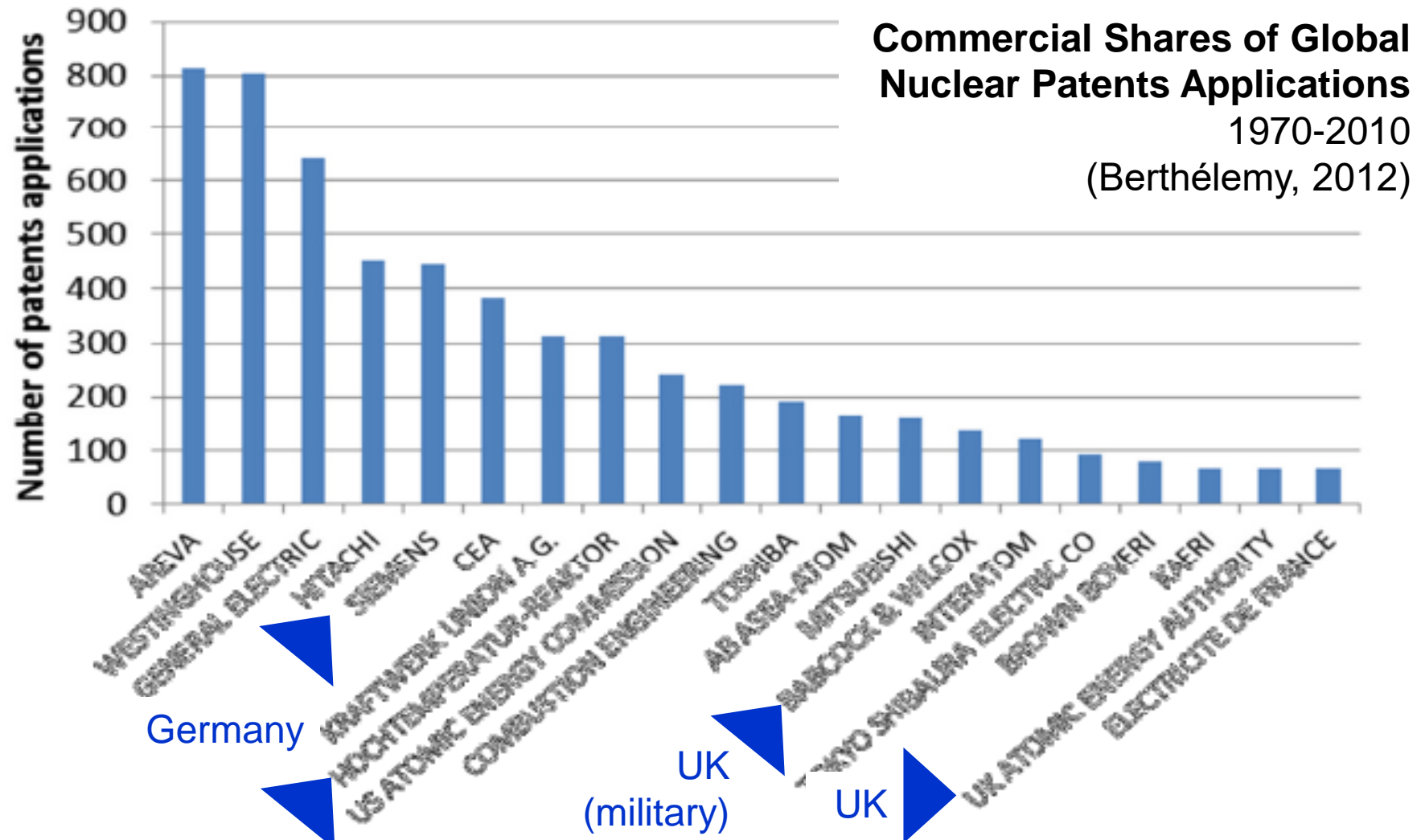


Summary of Key Patterns

criterion

**STATUS: NUCLEAR ENGINEERING INDUSTRY
(SNI)**

case



crit
case

crit
case

STATUS: NUCLEAR ENGINEERING INDUSTRY (SNI)

	Germany	UK
Total R and D spent on civilian nuclear 1974-2012	€31.4 Billion	€16.6 Billion
% of total Energy R&D expenditure dedicated to civilian nuclear power, 1974-2013	47%	51%
Amount spent on nuclear R&D in 2010	€11.7 million	€3.4 million
% of overall expenditure of Energy related R&D in 2010	11.5%	3.4%
Approximate number of patent applications 1974-2008	1050	250
% total of civilian nuclear patent applications 1974-2008	25%	2%

Summary of Key Patterns

<div>crit case</div>	<div>STATUS: NUCLEAR ENGINEERING INDUSTRY (SNI)</div>
<div>- Germany</div>	<div><div>- best performing industry in the world;</div><div>- best load factor, economies of scale,</div><div>- industry world leaders across supply chain,</div><div>- higher share of energy R&D expenditure (7.3%)</div></div>
<div>- UK</div>	<div><div>- scores badly on most indicators</div><div>- low load factor, absent in much of supply chain</div><div>- low share of energy R&D expenditure (1.8%)</div></div>

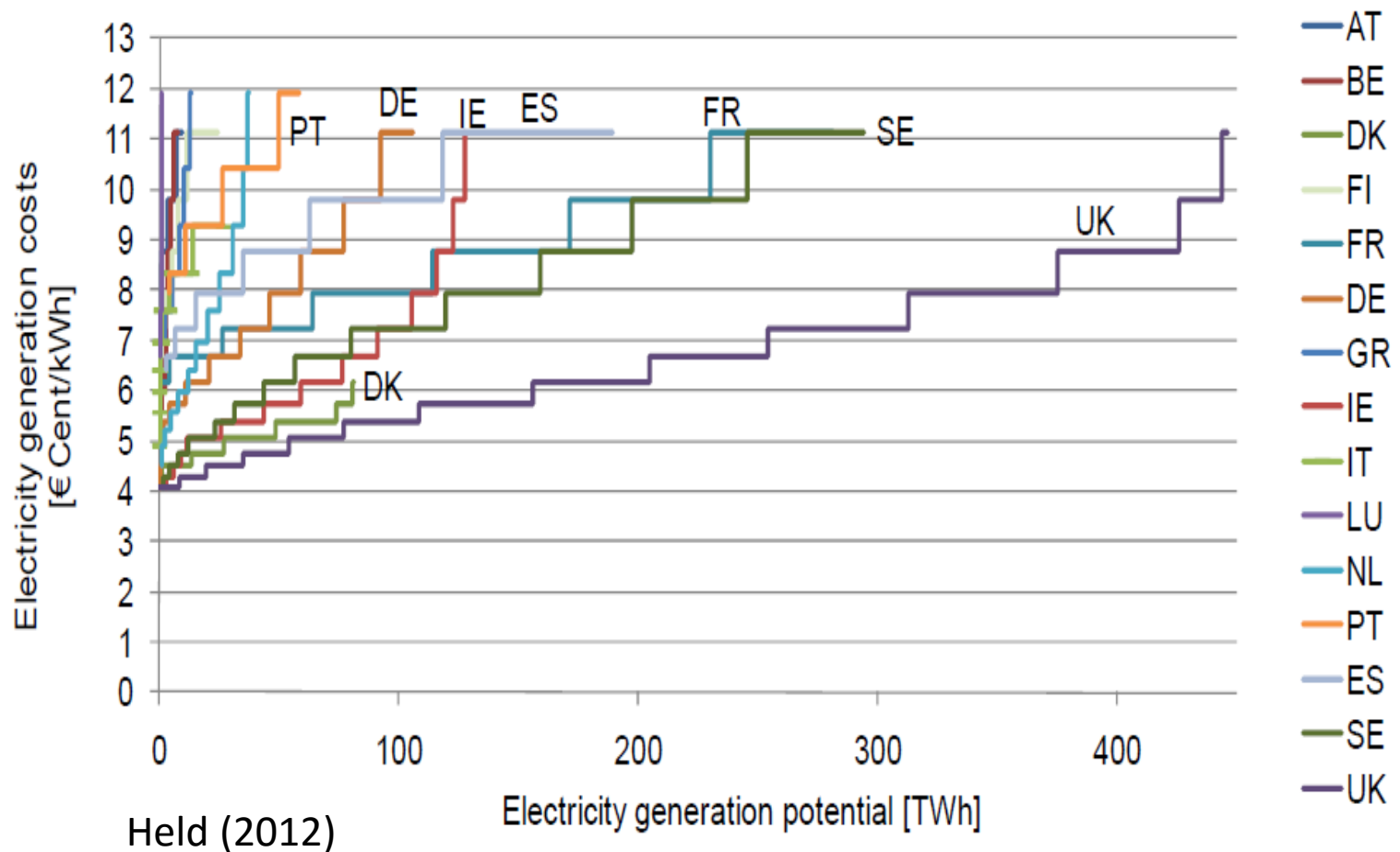
<div>crit</div>	<div>GMC</div>	<div>DNE</div>	<div>SNI</div>
<div>locus drivers / regime</div>	<div>in</div>	<div>in</div>	<div>in</div>
<div>proposition: discontinuity more likely?</div>	<div>UK</div>	<div>UK</div>	<div>UK</div>

criterion

RENEWABLE RESOURCE ENDOWMENTS (RRE)

case

Cost Resource Curve, Wind Energy



Summary of Key Patterns

<div> <div> criterion </div> <div> case </div> </div>	RENEWABLE RESOURCE ENDOWMENTS (RRE)
- Germany	<ul style="list-style-type: none"> - significantly lower overall resource - significantly more expensive on average
- UK	<ul style="list-style-type: none"> - 40% of European economic wind potential - 50% wave and tidal potential of Europe - no major difference in PV potential

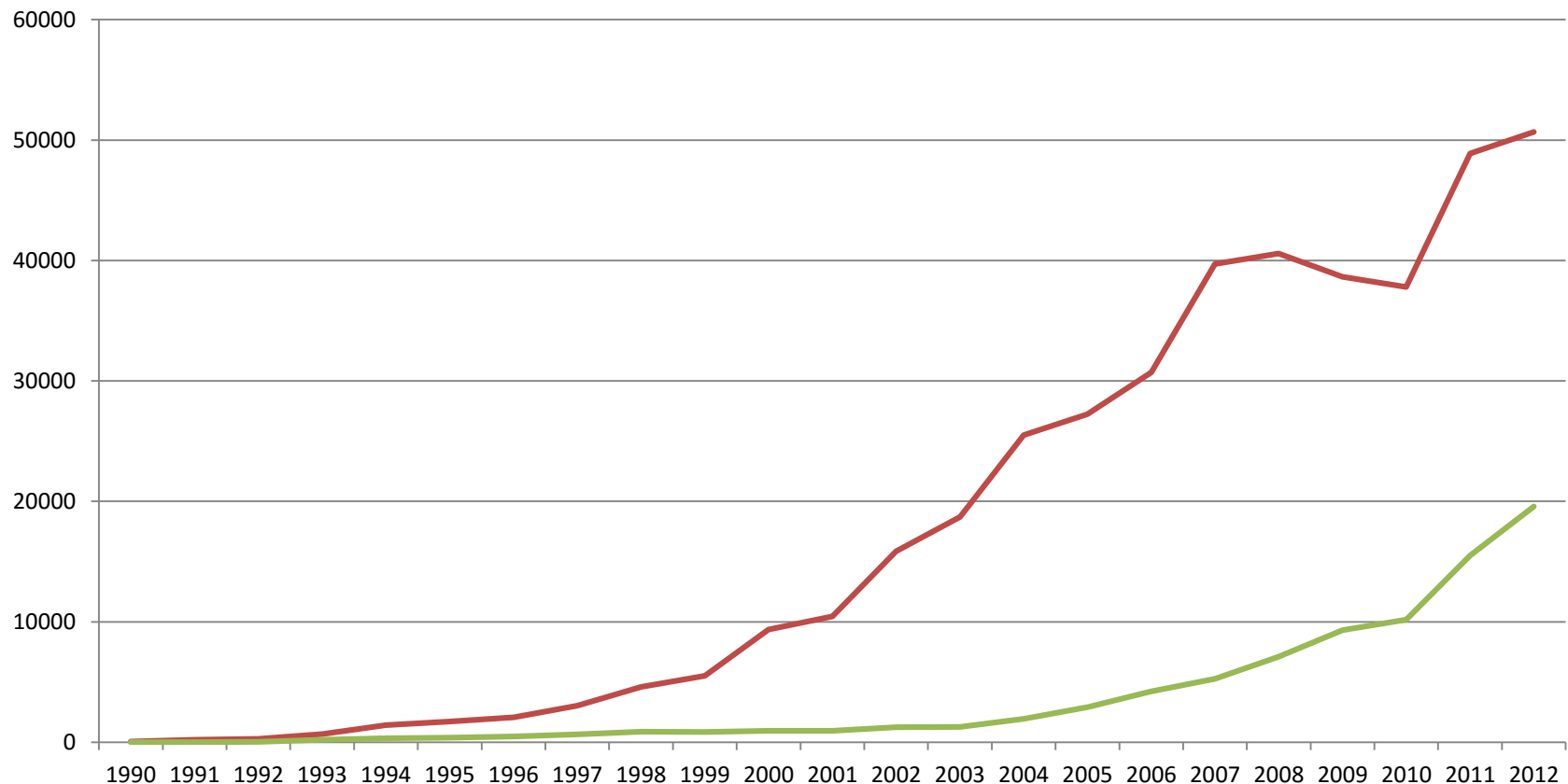
criterion	GMC	DNE	SNI	RRE
locus drivers / regime	in	in	in	in
proposition: discontinuity more likely?	UK	UK	UK	UK

criticon

RENEWABLE SUPPLY INDUSTRIES (RSI)

case

Onshore Wind power capacity (GWh)

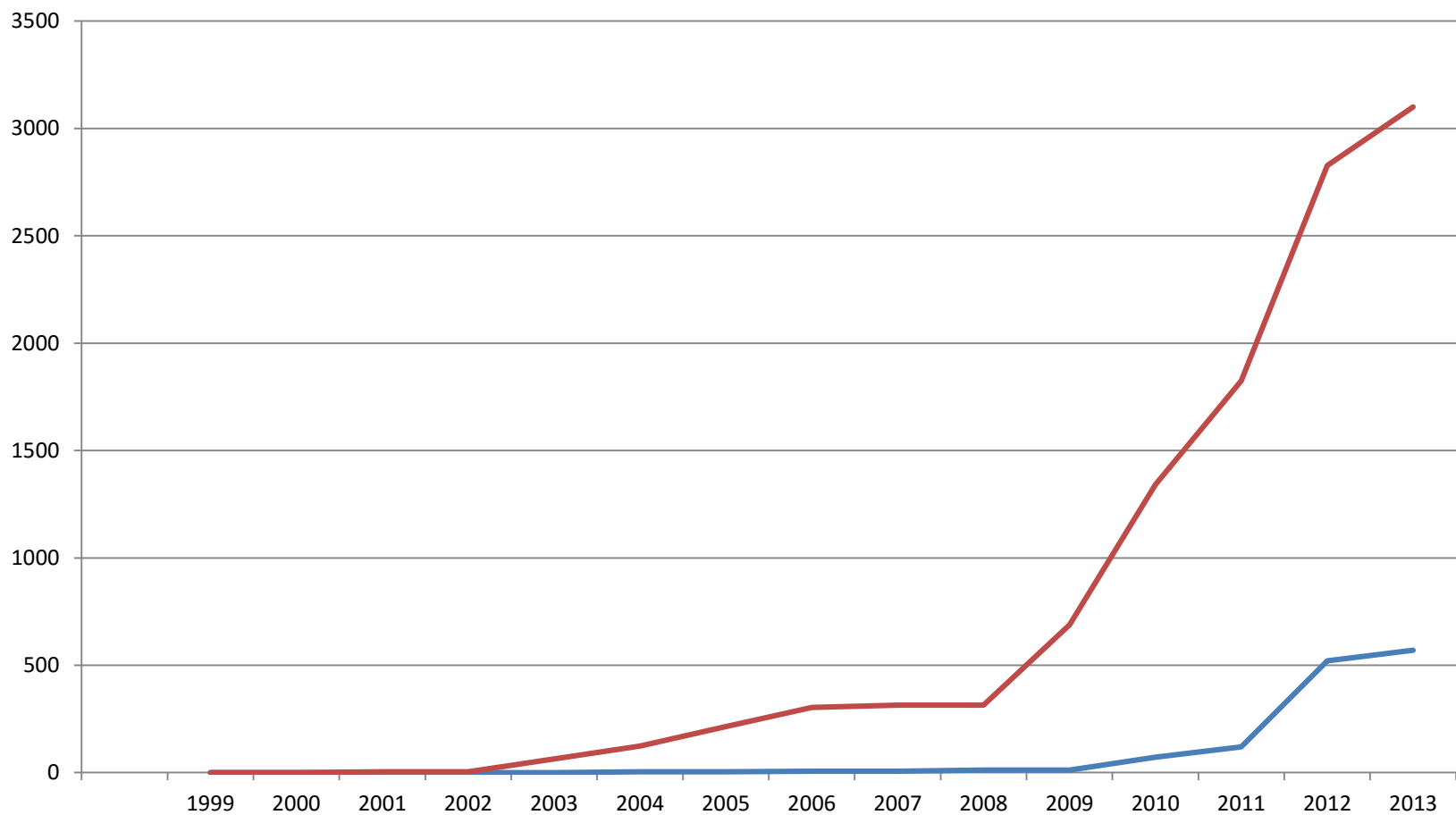


criticon

RENEWABLE SUPPLY INDUSTRIES (RSI)

case

Offshore wind capacity (GWh)

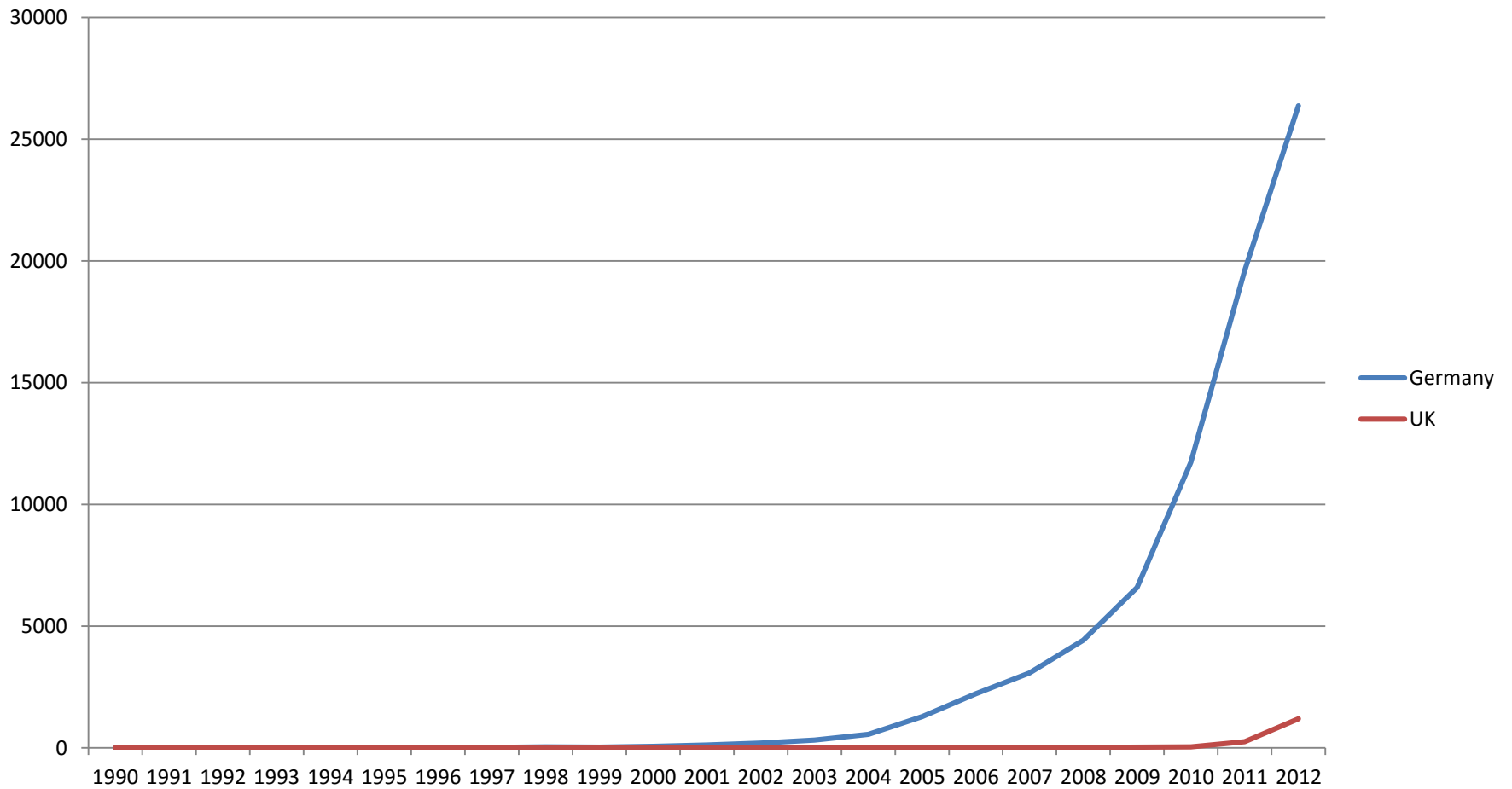


critterion

RENEWABLE SUPPLY INDUSTRIES (RSI)

case

Solar Capacity (GWh)

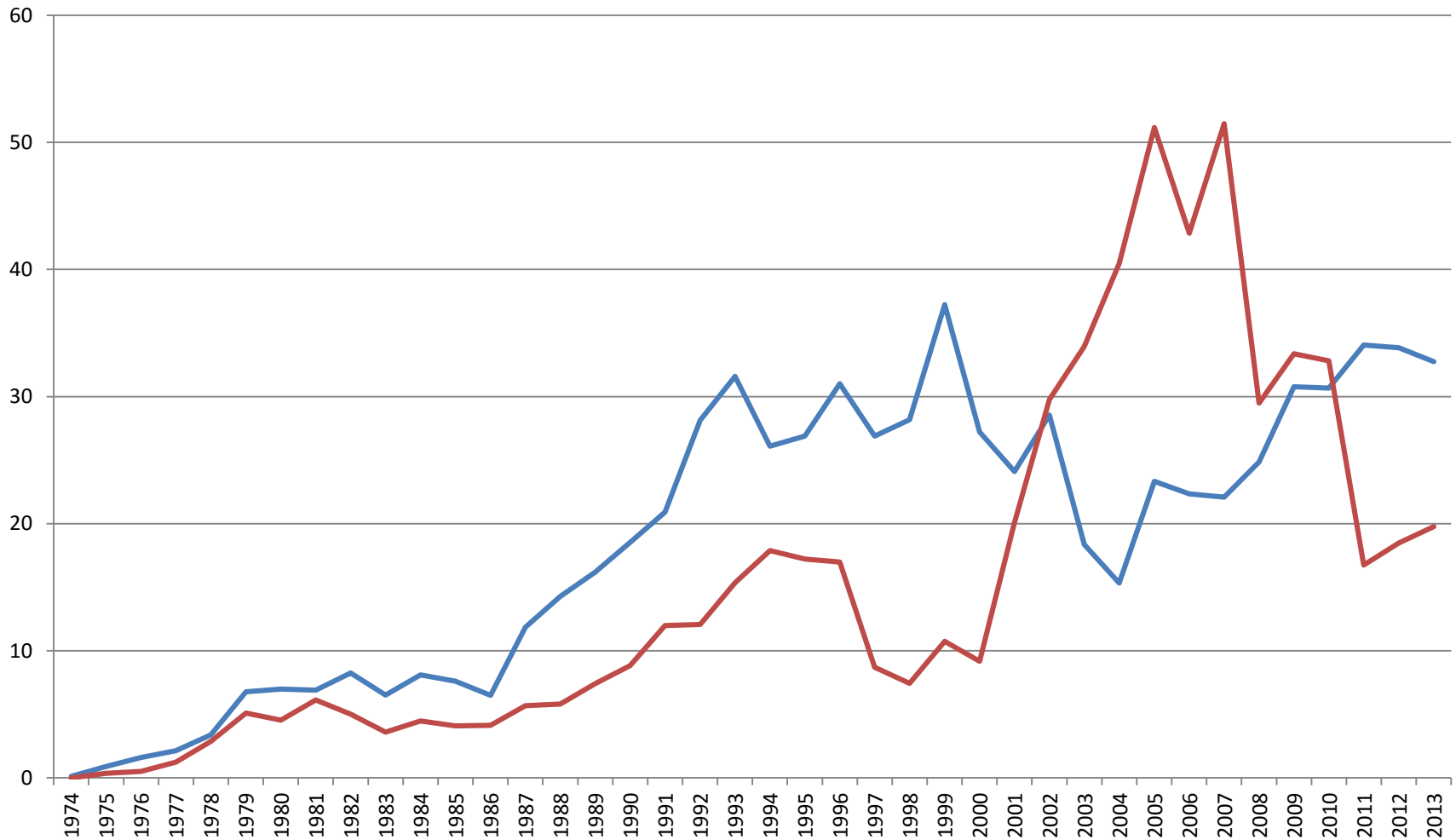


criticon

RENEWABLE SUPPLY INDUSTRIES (RSI)

case

Renewable energy R and D as % total Energy R and D

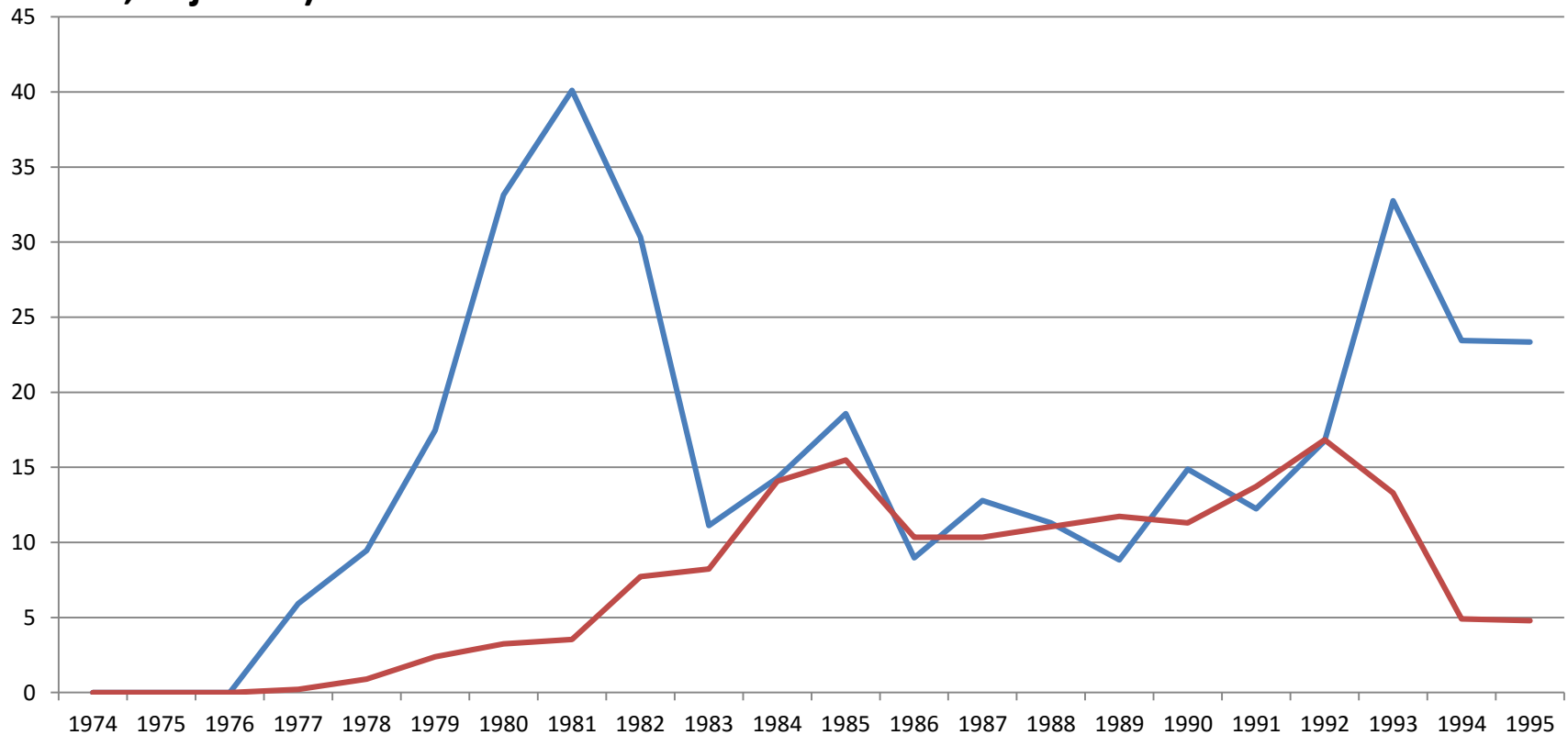


criticon

RENEWABLE SUPPLY INDUSTRIES (RSI)

case

**Renewable Energy R and D Spend (Million
Euro, adjusted)**

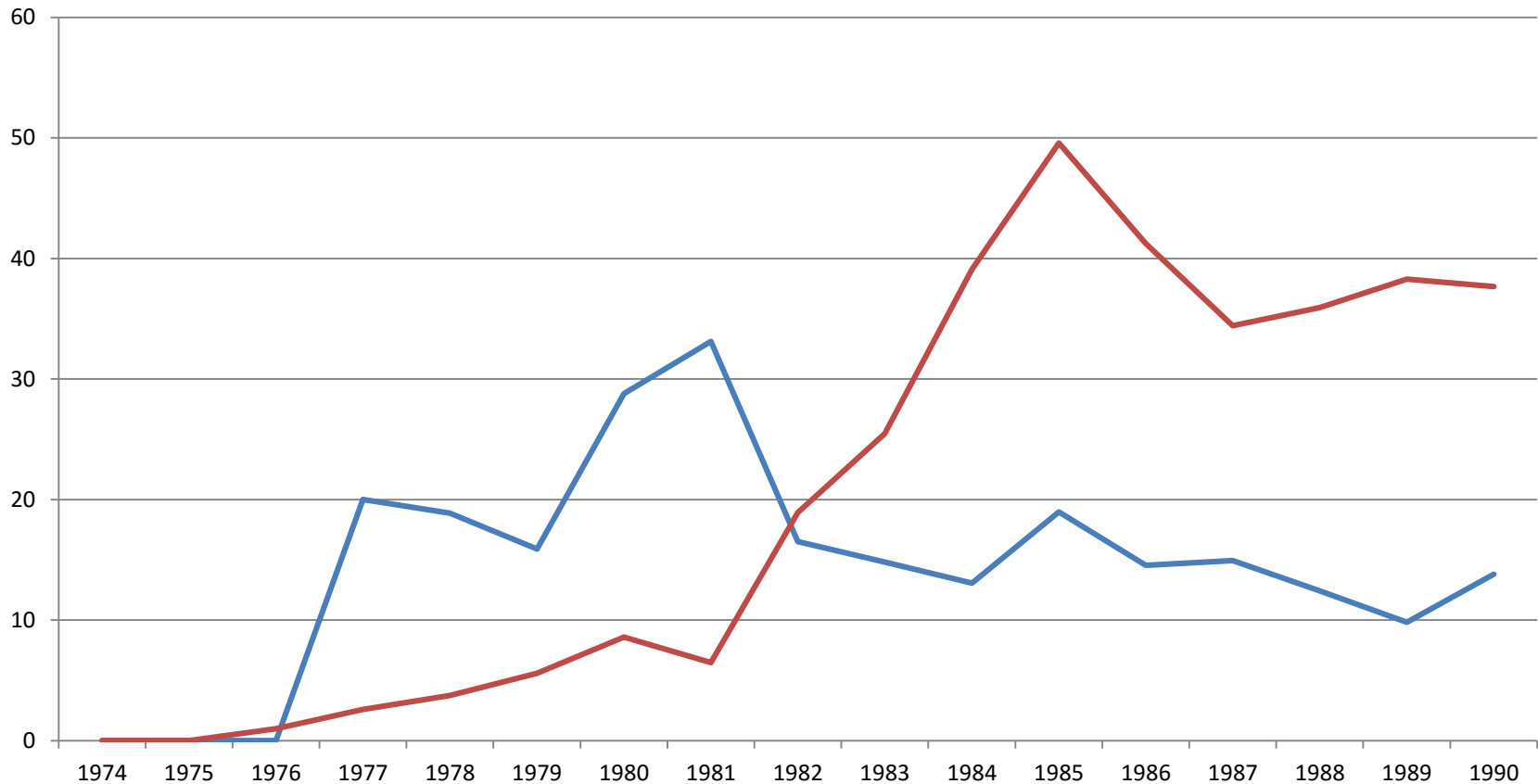


critterion

RENEWABLE SUPPLY INDUSTRIES (RSI)

case

**wind energy R and D spend as share of overall
renewable R and D funding, 1974-1990.**



Summary of Key Patterns

<div> <div> criterion </div> <div> case </div> </div>	<div> <div>FORMAL POLITICAL INSTITUTIONS</div> <div>(FPI)</div> </div>
<div> - Germany </div>	<div> - decentralised state, proportional representation - strong Green Party and more minorities - ‘consensus building’ culture, more deliberative </div>
<div> - UK </div>	<div> - centralised state, 2 party systems - low Green Party involvement in Parliament - adversarial, expert ‘science-based’ culture </div>

criterion	GMC	DNE	SNI	RRE	RSI	MNA	FPI
locus drivers / regime	in	in	in	in	in	out	out
proposition: discontinuity more likely?	UK	UK	UK	UK	?	D	D

Summary of Key Patterns

<div> <div> criterion </div> </div>	<div> <div>RENEWABLE SUPPLY INDUSTRIES</div> <div>(RSI)</div> </div>
<div> <div>case</div> </div>	<div> <div>- criterion not fully documented</div> </div>
<div> <div>- Germany</div> </div>	<div> <div>- becomes wind industry leader, during transition</div> <div>- early solar industry since exported to China</div> <div>- no significant offshore supply industry</div> </div>
<div> <div>- UK</div> </div>	<div> <div>- less general manufacturing industry strength</div> <div>- no indigenous turbine manufacturers</div> <div>- significant offshore wind industry, but foreign</div> <div>- very strong offshore equipment supply industry</div> </div>

<div> <div>criterion</div> </div>	<div> <div>GMC</div> </div>	<div> <div>DNE</div> </div>	<div> <div>SNI</div> </div>	<div> <div>RRE</div> </div>	<div> <div>RSI</div> </div>
<div> <div>locus</div> <div>drivers / regime</div> </div>	<div> <div>in</div> </div>	<div> <div>in</div> </div>	<div> <div>in</div> </div>	<div> <div>in</div> </div>	<div> <div>in</div> </div>
<div> <div>proposition:</div> <div>discontinuity</div> <div>more likely?</div> </div>	<div> <div>UK</div> </div>	<div> <div>UK</div> </div>	<div> <div>UK</div> </div>	<div> <div>UK</div> </div>	<div> <div>?</div> </div>

Summary of Key Patterns

<div> <div> criterion </div> <div>case</div> </div>	MILITARY-RELATED NUCLEAR ACTIVITIES (MNA)
- Germany	- no military nuclear activity
- UK	<ul style="list-style-type: none"> - nuclear ballistic missile infrastructure - nuclear-propelled submarine fleet - world-leading military nuclear supplier - significant nuclear military renewal plans

criterion	GMC	DNE	SNI	RRE	RSI	MNA
locus drivers / regime	in	in	in	in	in	out
proposition: discontinuity more likely?	UK	UK	UK	UK	?	D

Summary of Key Patterns

<div> <div> criterion</div> <div>case</div> </div>	<div> <div>FORMAL POLITICAL INSTITUTIONS</div> <div>(FPI)</div> </div>
- Germany	<ul style="list-style-type: none"> - decentralised state, proportional representation - strong Green Party and more minorities - ‘consensus building’ culture, more deliberative
- UK	<ul style="list-style-type: none"> - centralised state, 2 party systems - low Green Party involvement in Parliament - adversarial, expert ‘science-based’ culture

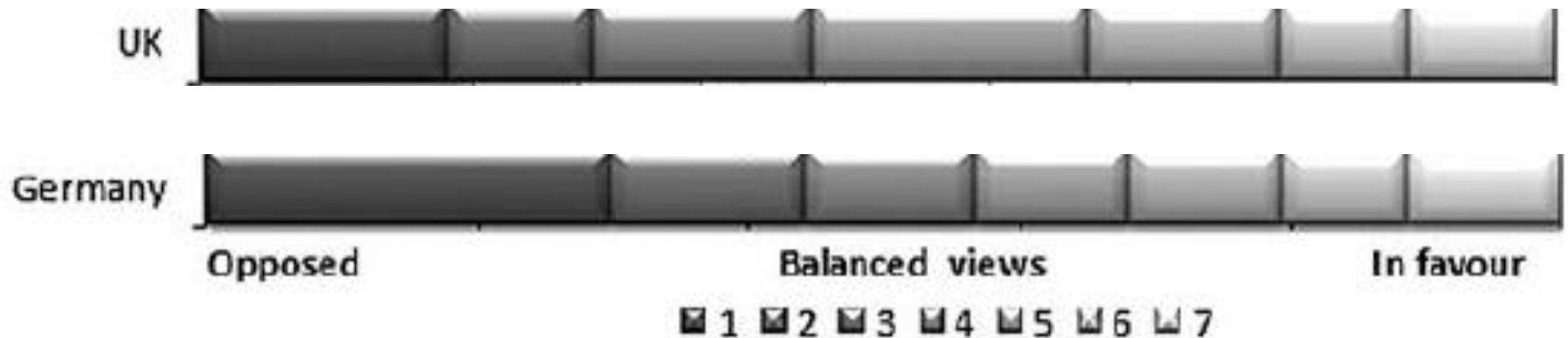
crit	GMC	DNE	SNI	RRE	RSI	MNA	FPI
locus drivers / regime	in	in	in	in	in	out	out
proposition: discontinuity more likely?	UK	UK	UK	UK	?	D	D

Summary of Key Patterns

criterion

**SOCIAL MOVEMENT ACTIVITY
(SMA)**

Degree of support for nuclear energy in countries with nuclear programmes (NEA 2010)

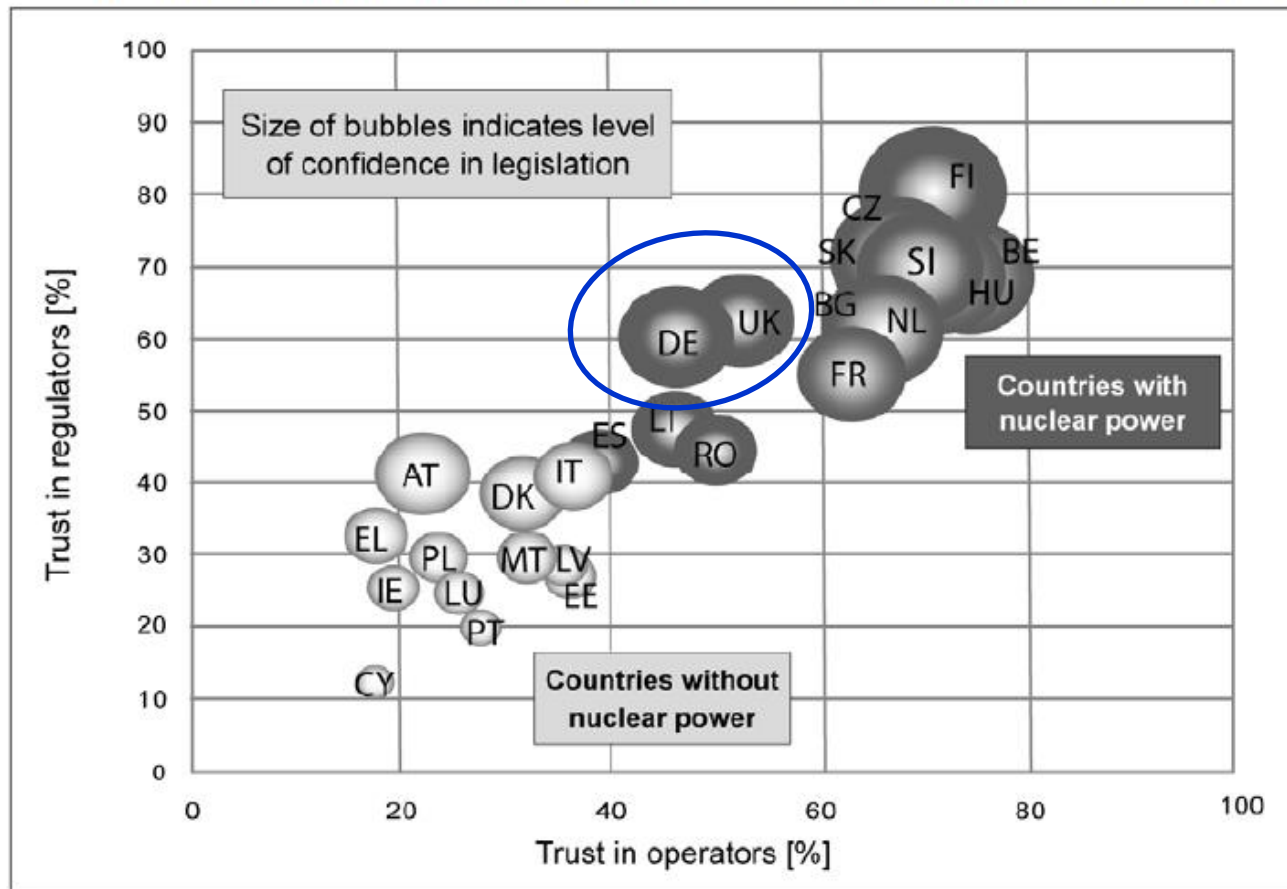


Summary of Key Patterns

criterion **SOCIAL MOVEMENT ACTIVITY
(SMA)**

Figure 12: Confidence in nuclear regulators, operators and legislation*

* AT-Austria, BE-Belgium, BG-Bulgaria, CY-Cyprus, CZ-Czech Rep., DE-Germany, DK-Denmark, EE-

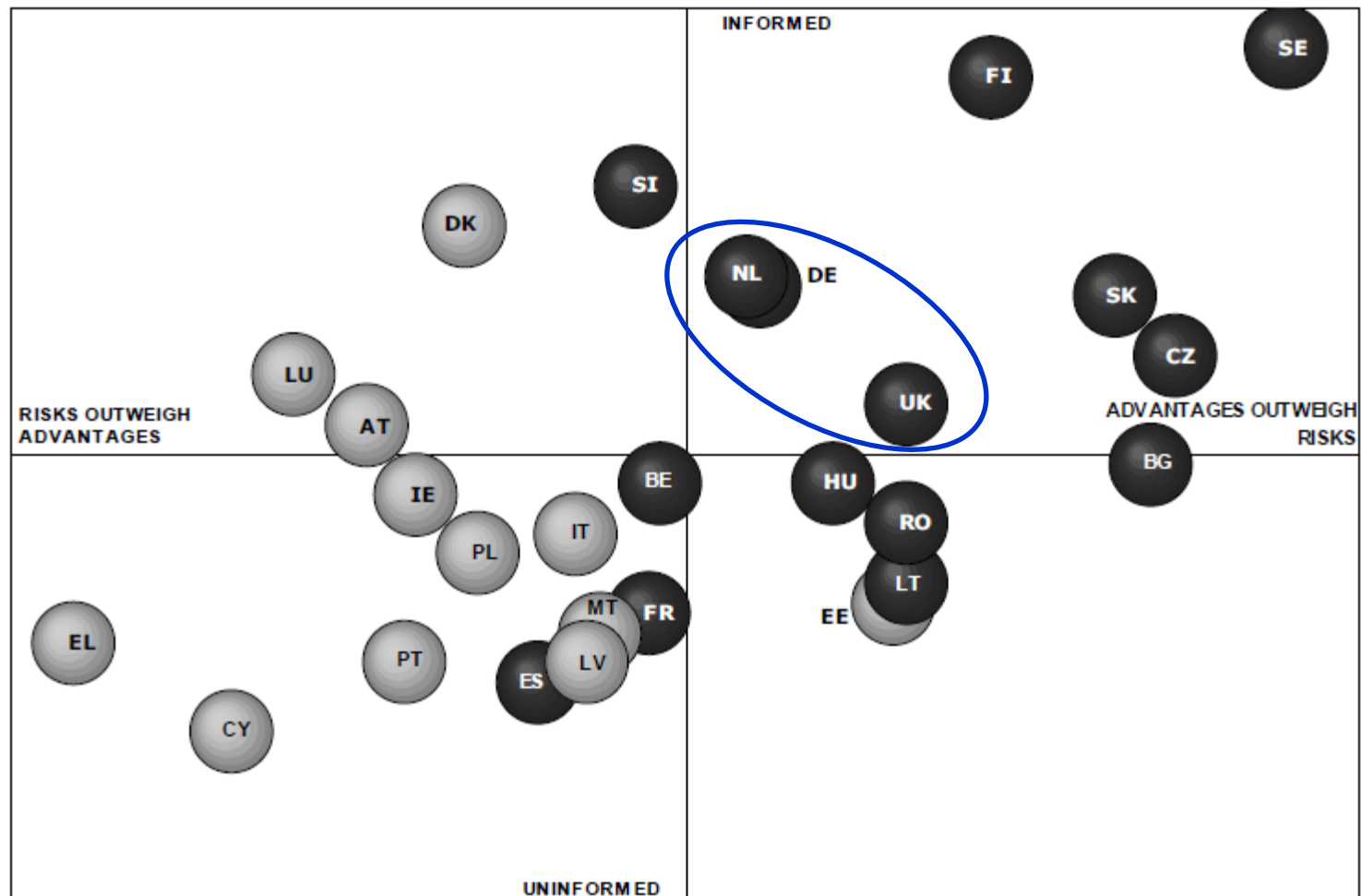


Summary of Key Patterns

criterion

**SOCIAL MOVEMENT ACTIVITY
(SMA)**

POSITION OF EUROPEAN COUNTRIES ACCORDING TO RISK PERCEPTION AND THE FEELING OF
BEING INFORMED



Summary of Key Patterns

<div> <div> criterion</div> <div>case</div> </div>	<div> SOCIAL MOVEMENT ACTIVITY (SMA) </div>
- Germany	<ul style="list-style-type: none"> - strong anti-nuclear movements - 100,000 person protests - extensive public debate on nuclear
- UK	<ul style="list-style-type: none"> - not such a large protest movement - NGOs often excluded from public debate? - public opinion ambivalent on nuclear

crit	GMC	DNE	SNI	RRE	RSI	MNA	FPI	SMA
locus drivers / regime	in	in	in	in	in	out	out	out
proposition: discontinuity more likely?	UK	UK	UK	UK	?	D	D	D

Summary of Key Patterns

critterion	Qualities of Democracy (QoD)
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	Majoritarian	Consensual
Executive power	Concentration of executive power in single party	Power-sharing in coalitions
Executive-Legislative relationships	Executive is dominant	Executive-legislative balance
Party system	Two party system	Multi-party system
Voting system	Disproportionate representation	Proportional representation
Interest group systems	Pluralist interest groupings with 'free-for-all' competition	Coordinated and corporatist interest group systems aimed at compromise and concentration

critterion	Qualities of Democracy (QoD)
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Rating system	German ranking	UK ranking
<i>Democracy Barometer</i>	11 th	26 th
<i>Economist Intelligence Unit 2010</i>	14 th	19 th
<i>Global Democracy ranking</i>	8 th	13 th

Summary of Key Patterns

crit case	Qualities of democracy (QoD)								
Germany/ UK	Germany consistently ranks higher than the UK in every kind of ranking of democracy.								
crit	GMC	DNE	SNI	RRE	RSI	MNA	FPI	S`MA	QoD
locus drivers / regime	in	in	in	in	in	out	out	out	out
proposition: discontinuity more likely?	UK	UK	UK	UK	?	D	D	D	D


Comparing Within and Beyond Focal Regimes

Provisional Emerging Picture

Criteria that pertain ***most directly*** to ***focal regimes*** are not most relevant to comparative contrast in developments in these cases.

Instead, it appears that criteria more relevant to understanding this contrast, concern ***much wider and more general politics***.

So, ***difficult to understand*** in terms of ***direct conditions*** of ***incumbent***, or ***circumstances of key challengers*** (renewables).



criterion	GMC	DNE	SNI	RRE	RSI	MNA	FPI	SMA	SMA
locus drivers / regime	in	in	in	in	in	out	out	out	out
proposition: discontinuity more likely?	UK	UK	UK	UK	?	D	D	D	D

Concluding remarks

- Political factors have overridden factors related to ‘internal’ drivers of socio-technical regimes yet research on these factors arguably limited.
- Incumbency in the UK: Qualities of democracy, voting systems, wider democratic cultures.
- UK puzzle remains: Hinkley C, Small modular research R&D, support for renewables cut.
- Is the UK the anomaly in Europe rather than Germany?
- Wider implications for comparative research on ‘external’ drivers (social science) of nuclear trajectories.