Innovation in Energy Incentives in R&D

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Economics for Energy Workshop
Madrid, 30 January 2012

UAB Universitat Autònoma de Barcelona
MOVE

Three challenges to energy supply

1. **Limit the disruption of global climate** by the emissions from fossil-fuel use due to the increase in energy production necessary to provide energy for humankind

2. **Decrease the economic vulnerability** due to the oil dependence, the balance-of-payments and the foreign-policy liabilities associated with oil imports

3. **Solve the lack of energy services** for two billion poor people worldwide

There is an need to change the current energy systems
and rely much more on technologies less dependent of fossil fuels

The introduction of renewable energy

- not only helps in lowering carbon dioxide emissions

It also induces other **positive externalities**:

- provides a larger set of technologies available to offer energy services to everybody
- decreases the dependence of fossil fuels imports
- helps keep fossil fuels prices at reasonable levels

- The need for **technological improvements** (R&D, innovation and diffusion) of renewable energy sources is clear

- The main question is

  which are the most efficient policies to promote R&D, innovation and diffusion of renewable energy sources

  (and other environmentally friendly technologies)

Governments use various policies to promote the introduction of renewable energies and push firms to reduce the level of pollution in existing plants

It is useful to consider two groups of policies:

- *market-based instruments*
- *command-and-control instruments*

Policies

market-based instruments

- **tradable permits**: An authority sets a cap on the amount of pollutant. The cap is allocated or sold to firms as emissions permits. Firms are required to hold a number of permits equal to their emissions. They can buy or sell the permits
- **auctioned permits**: Instead of allocating the permits according to some criteria, they are auctioned
- **taxes** (price is fixed)

command-and-control instruments

- **emission standards**: emissions limits on emissions sources
- **technology standards**: specific control technology to be installed

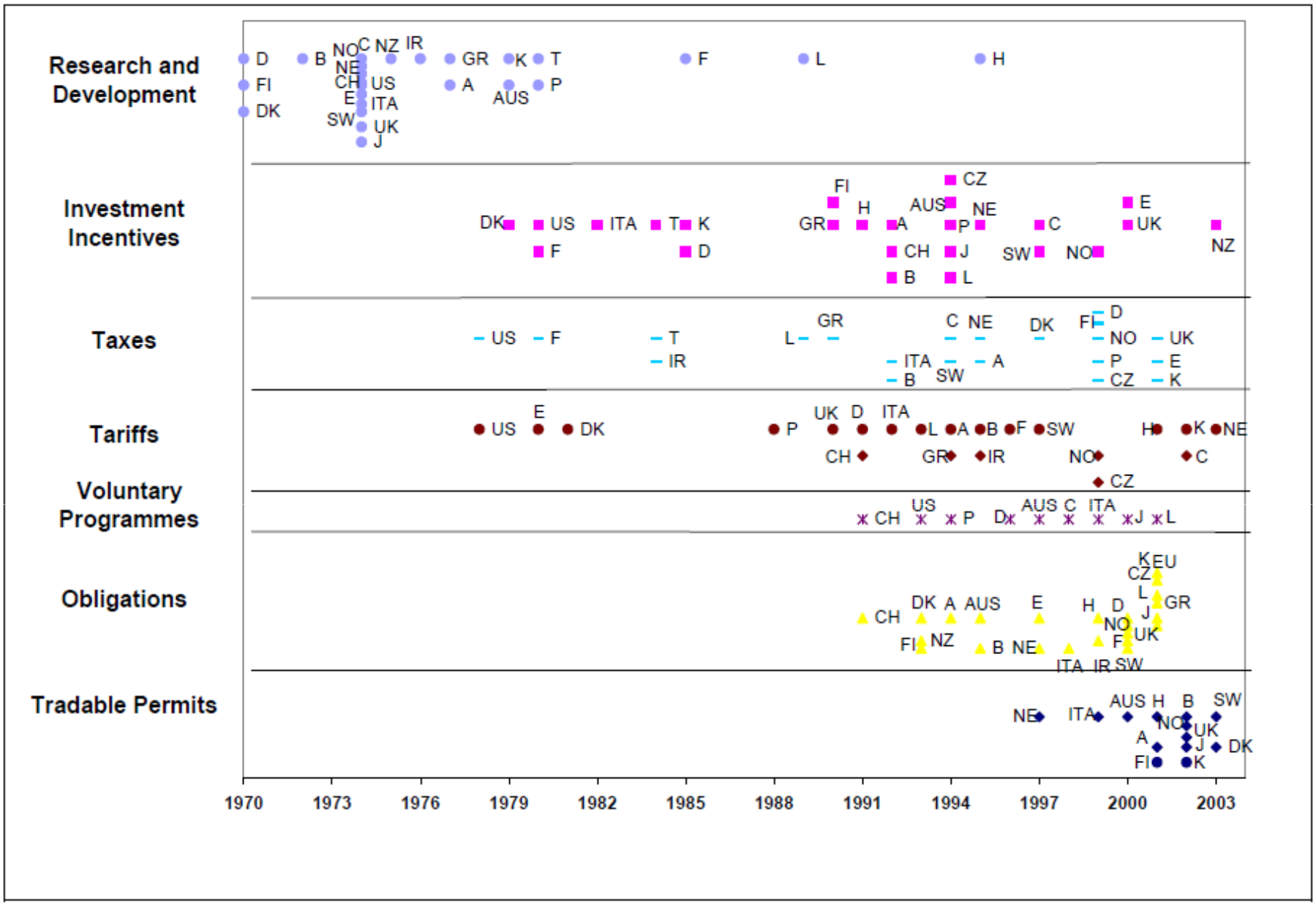
Other Policies

- **feed-in tariffs**: LT contracts that award a certain per-kWh price
- **production tax credits**: reduce income taxes of owners of renewable projects based on output
- **investment tax credits**: reduce income taxes of owners based on capital investment in renewable
- **renewable obligations**: make electricity suppliers source a certain proportion from renewable
- **voluntary programs**

- **R&D funding**
- **Public-private partnerships**

In the OECD countries

- Initially **R&D programs** were introduced in a number of countries
- Then, **investment incentives** (third-party financing, investment guarantees), **tax incentives** and **feed-in tariffs**
- Next, **voluntary programs** were developed in some countries
- More recently, **quantitative obligations**
- Finally **tradable permits** have been applied


Research and Development
Investment Incentives
Taxes
Tariffs
Voluntary Programmes
Obligations
Tradable Permits
1970
1973
1976
1979
1982
1985
1988
1991
1994
1997
2000
2003

The objectives of the policies are:

- to induce the market (the firms, the consumers) to "internalize" the positive externalities that the renewable sources induce
- to spur innovation and diffusion of these emerging technologies to reduce the cost of production of existing renewable sources (and to discover new sources)

It is crucial to understand the relationship between government policies, market incentives, and technological improvements

Which policy provides the best incentives in the less expensive way?

Three steps in the process by which new technology enters the market place

Invention
The first development of a scientifically or technically new product or process

Innovation
The new product or process is available in the market

R&D

Diffusion
The innovation earns a significant share of the purchases of firms

Policies

- may have effect on the three steps that lead to technological improvement
- may also affect the intensity in the use of current technologies

For example, consider tradable carbon permits on carbon content

The implications of its introduction may be

- Short term: For the current set of plants, lower utilization of the most pollutant plants
  → lower level of pollution from current set of plants

- Medium term: (if the policy is expected to continue) Among the menu of equipment available, more efficient technologies are chosen
  → improvement in the set of plants

- Long term: (if the firms anticipate that it will continue) Greater investment into research and design of efficient technologies
  → improvement in the menu of equipment available

Short-term effects are positive, but they do not help solving our three challenges (climate change, economic vulnerability, and lack of energy services worldwide)

Policies should aim at technological improvement

There is nowadays a substantial theoretical literature that compares the effect of various policy instruments on firms' incentives to adopt less polluting technology and to develop new technologies

Main conclusions:

- ***market-based instruments*** *such as tradable permits and taxes provide more incentives to develop and adopt new technologies than do command-and-control instruments such as emission and performance standards*

- ***auctioned permits*** *and* ***taxes*** *provide the most incentives and performance standards the least*

- *issuing permits provide substantially less incentives than* ***auctioning permits***

- It is known that command-and-control instruments are less likely to promote static efficiency than market-based instruments

- Dynamic efficiency also favors the use of market-based instruments

  The arguments are similar:
  - market-based instruments give incentives to all firms and plants to take action until the marginal cost of the reduction in pollution equals the permit price or the tax
  - command and control instruments forces all plants to achieve a target

  In terms of political feasibility, it has been argued that command-and-control instruments are likely to be favored by politically influential industry groups due to the initially lower compliance costs associated to this instrument and its potential for increasing entry barriers

The empirical analysis of technological innovation is not an easy task

How do we measure innovation?

Some studies use patent data to estimate the effect of policies and other variables on technological innovation in renewable energy sources

They find:

- Strong, positive impact of energy prices on new innovations
- The quality of the stock of knowledge available to the inventors is an important factor

Main empirical results using patent data

- Public policy has a very significant influence on the development of new technologies in the area of renewable energy

  → *there are medium- and long-term effects*

- Taxes, obligations and tradable permits are the only statistically significant instruments for the patent activity in renewable energy overall

  → *market-based instruments indeed provide more incentives than do command-and-control instruments*

Other empirical results using patent data

- Investment incentives are effective in supporting innovation in solar and waste-to-energy technologies
  - → Significant uncertainty associated with early stages of technological development

- Obligations and tradable permits support wind technology
  - → policies similar to market-based instruments

- Higher electricity prices provide an incentive for increased patenting activity in the solar and biomass technologies
- Tariff structures are important for biomass
- Voluntary programs are helpful in inducing waste-to-energy innovations

	Wind	Solar	Geo-thermal	Ocean	Biomass	Waste	All renewables	1978-2003 Total
AT	2.54	**6.55**	**6.76**	0.85	**1.48**	**5.07**	**23.24**	110
AU	0.49	**4.82**	1.08	0.49	0.29	1.08	8.26	84
BE	**4.17**	2.26	1.91	0.17	0.70	1.39	10.60	59
CA	0.88	0.82	0.35	0.12	0.18	1.76	4.05	66
CH	2.66	**11.07**	**6.97**	0.41	0.82	**6.97**	**28.90**	138
DE	**8.14**	**7.51**	**4.10**	0.41	**2.07**	**6.90**	**28.99**	1285
DK	**27.16**	3.70	1.54	**3.40**	**1.23**	**5.86**	**42.91**	137
ES	1.49	1.25	0.12	0.71	0.00	0.12	3.69	61
FI	2.55	3.27	1.09	0.73	0.00	4.73	12.37	34
FR	1.42	1.51	2.23	0.27	**1.27**	1.48	8.15	267
GB	1.65	1.10	0.78	0.81	**4.59**	1.62	10.41	322
GR	1.27	1.27	0.00	0.51	0.00	0.51	3.55	14
HU	0.68	1.71	1.71	0.68	0.34	0.00	5.13	15
IE	2.95	2.36	0.00	**2.95**	0.00	0.00	8.27	14
IT	0.97	1.10	0.75	0.50	0.25	1.06	4.63	148
JP	0.64	2.68	0.64	0.16	0.29	**5.00**	9.41	656
KR	0.66	0.08	0.00	0.08	0.08	0.33	1.23	15
NL	**5.74**	**4.53**	**2.76**	0.55	0.99	3.42	17.78	161
NO	2.51	2.20	1.57	**3.76**	0.31	0.94	11.29	36
NZ	0.59	0.00	0.59	0.59	0.59	1.77	4.13	7
PL	0.11	0.23	0.23	0.00	0.11	0.11	0.80	7
PT	1.37	1.37	0.00	0.27	0.00	0.27	3.29	12
SE	**6.86**	3.14	**5.69**	**3.14**	0.78	2.16	**21.76**	109
TW	0.70	0.56	0.14	0.14	0.00	0.70	2.25	16
US	0.52	0.81	0.51	0.28	1.19	1.60	4.92	925

Number of EPO Patent Applications in Renewable Energy Technologies per Unit of GDP (1978-2003)

	Wind	Solar	Geo-thermal	Ocean	Biomass	Waste	All renewables
AT	0.67	**1.75**	**1.76**	0.22	**0.39**	**1.33**	**6.13**
AU	0.39	**3.75**	**0.86**	**0.42**	0.25	0.84	**6.50**
BE	**1.31**	0.69	0.61	0.06	0.17	0.44	3.28
CA	0.73	0.68	0.30	0.08	0.16	**1.38**	3.34
CH	0.29	1.15	**0.75**	0.03	0.08	0.74	3.03
DE	1.10	1.01	0.55	0.05	0.27	0.93	3.91
DK	**7.65**	1.03	0.44	**0.92**	**0.35**	**1.64**	**12.04**
ES	**2.62**	**2.29**	0.24	**1.31**	0.00	0.24	**6.70**
FI	0.47	0.60	0.20	0.13	0.00	0.85	2.25
FR	0.37	0.39	0.60	0.07	**0.33**	0.39	2.15
GB	0.51	0.35	0.24	0.25	**1.46**	0.50	3.32
IT	0.53	0.61	0.42	0.28	0.14	0.59	2.57
JP	0.16	0.65	0.16	0.04	0.07	**1.21**	2.29
KR	0.62	0.08	0.00	0.08	0.08	0.31	1.16
NL	1.11	0.88	0.55	0.10	0.20	0.68	3.52
NO	**1.68**	**1.41**	**1.01**	**2.39**	0.20	0.61	**7.31**
SE	1.05	0.49	**0.90**	**0.49**	0.11	0.31	3.36
TW	**1.48**	**1.19**	0.30	0.30	0.00	**1.48**	4.75
US	0.21	0.33	0.21	0.11	**0.48**	0.66	2.01

Number of EPO Patent Applications in Renewable Energy Technologies
Normalized by Overall Patenting Activity (1978-2003)

The increase in the patent activity is only one of the consequences of the policies that support the introduction of renewable energy sources

The multiplication of the number of plants that produce electricity from renewable sources also leads to incremental improvements in design, logistics, operations, or management

For example, it is estimated that the cost of solar panels has fallen by 10-20% for every doubling of the manufacturing volume

In addition to policies that encourage the installation of new renewable plants and the decrease in the level of pollution, governments put in place other policies to directly promote R&D on energy-related activities

These policies include

- Financing of R&D in universities and research laboratories
- Setting-up public-private partnerships
- Different types of subsidies to private R&D

- Invention and Innovation are necessary steps to develop new technologies
- A healthy research environment enhances the positive effects of the previous policies and also benefits from them

- The International Energy Agency collects public RD&D budget data related to energy

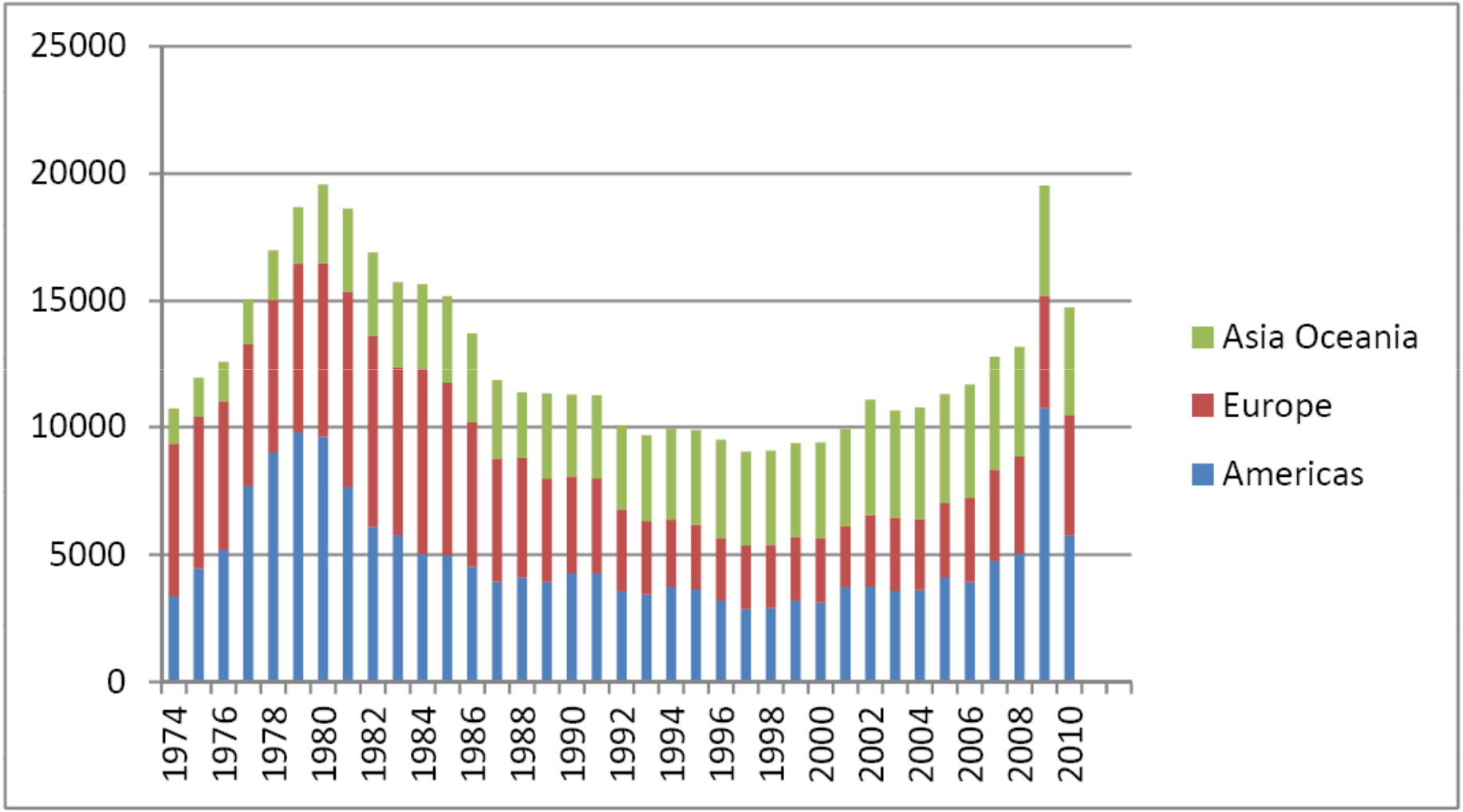
- RD&D collected by the IEA designates **government budgets for energy RD&D, regardless of who the performer is**

  Energy RD&D covers research, development and demonstration related to the production, storage, transportation, distribution and rational use of all forms of energy

- This information measures the governments' effort (although it can not assess the impact of the policies on the technological improvement)

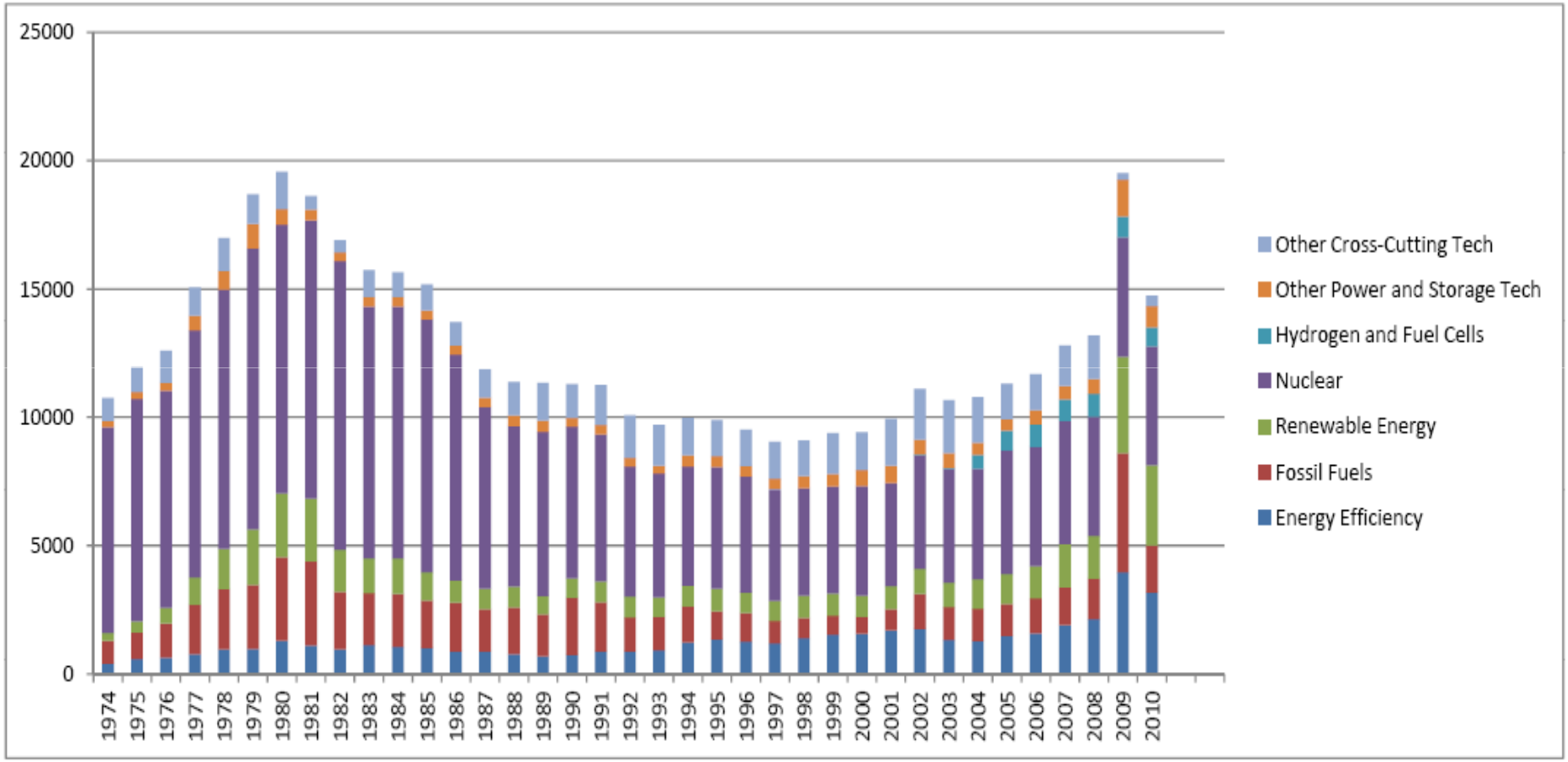
Estimated RD&D Budgets by Regions in Million USD (2010 prices and PPP)

Total RD&D



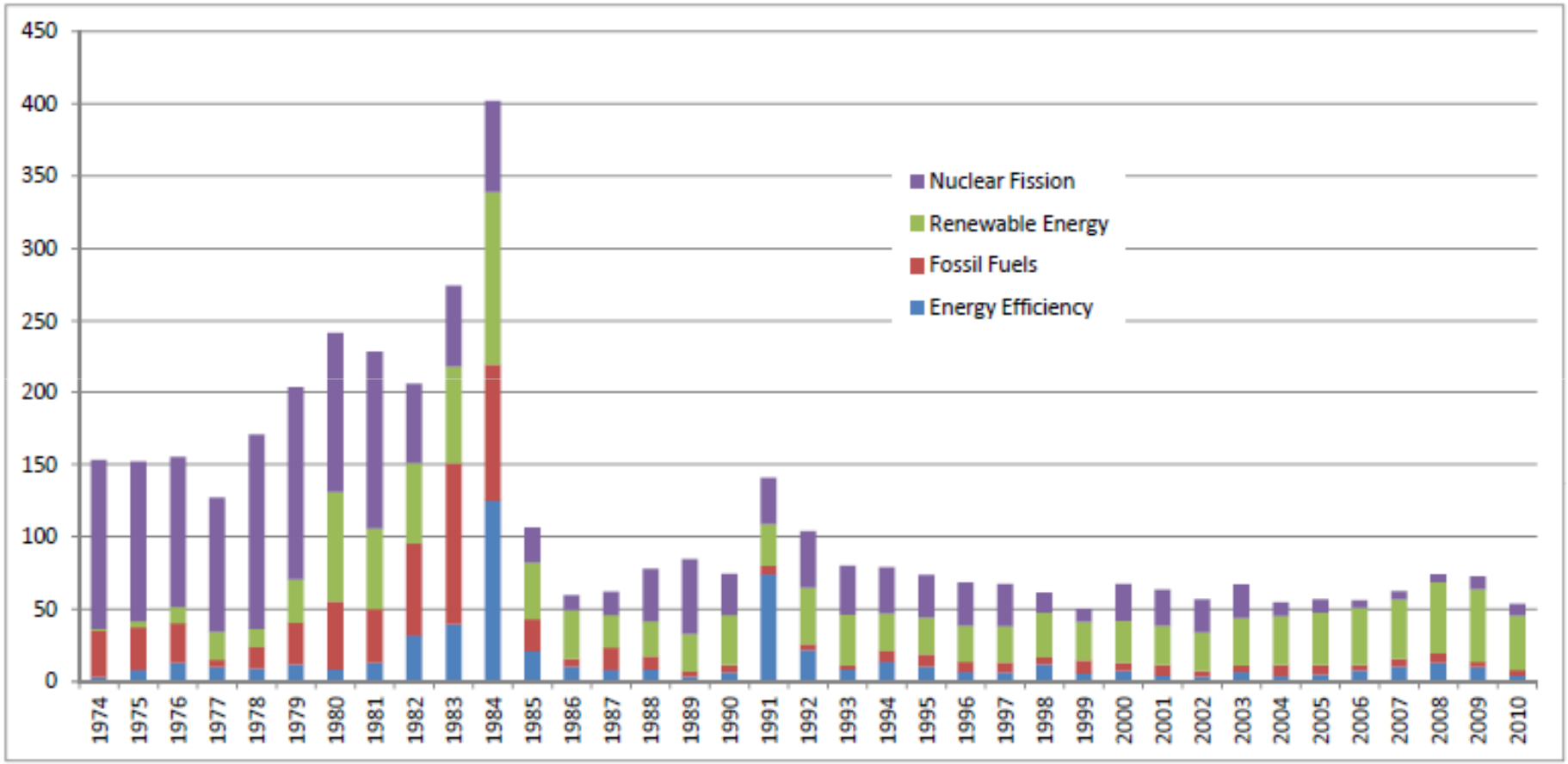
Estimated Total RD&D Budgets in Million USD (2010 prices and PPP)

All groups



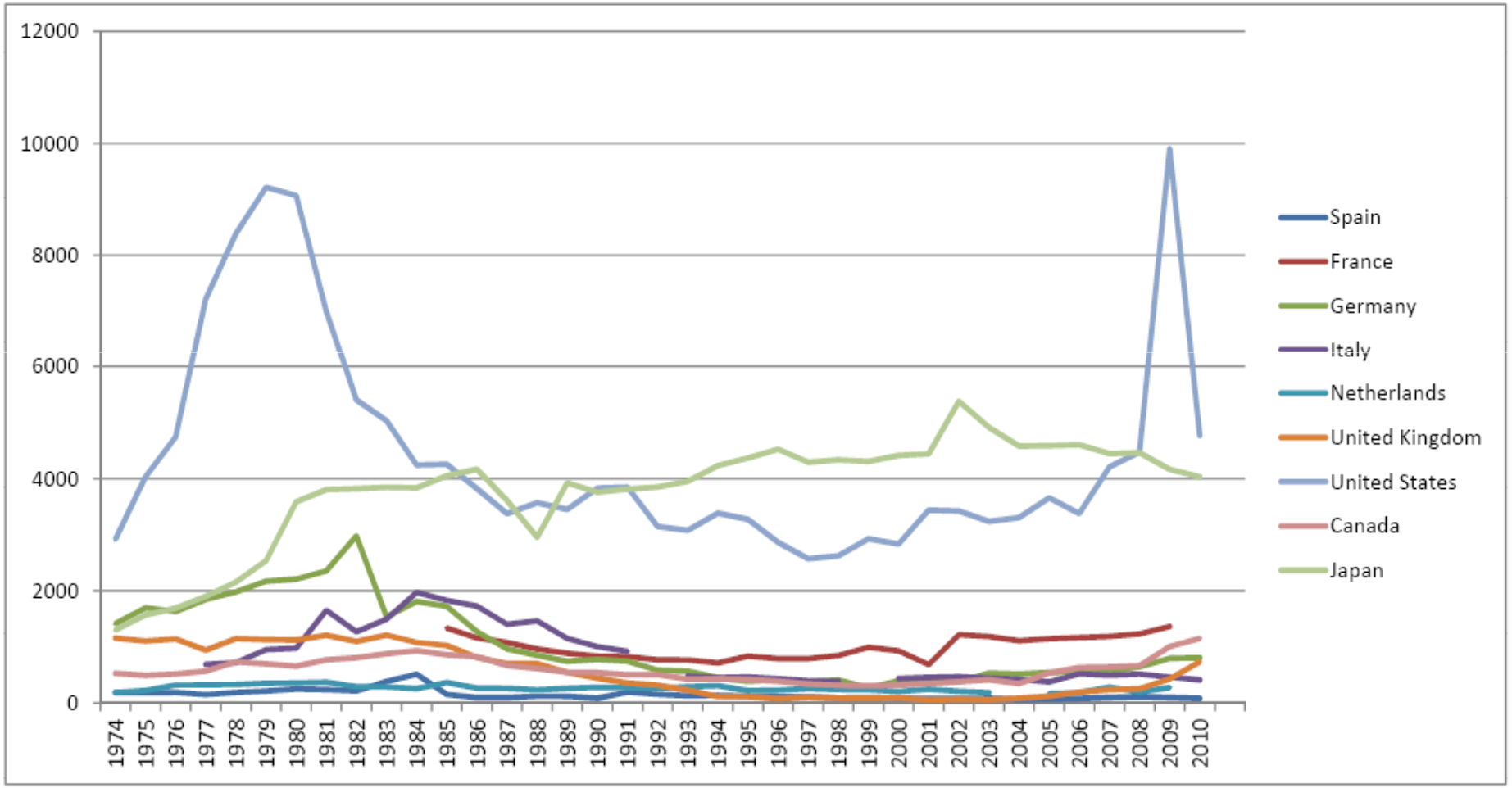
Estimated RD&D in Million USD (2010 prices and PPP)

Spain



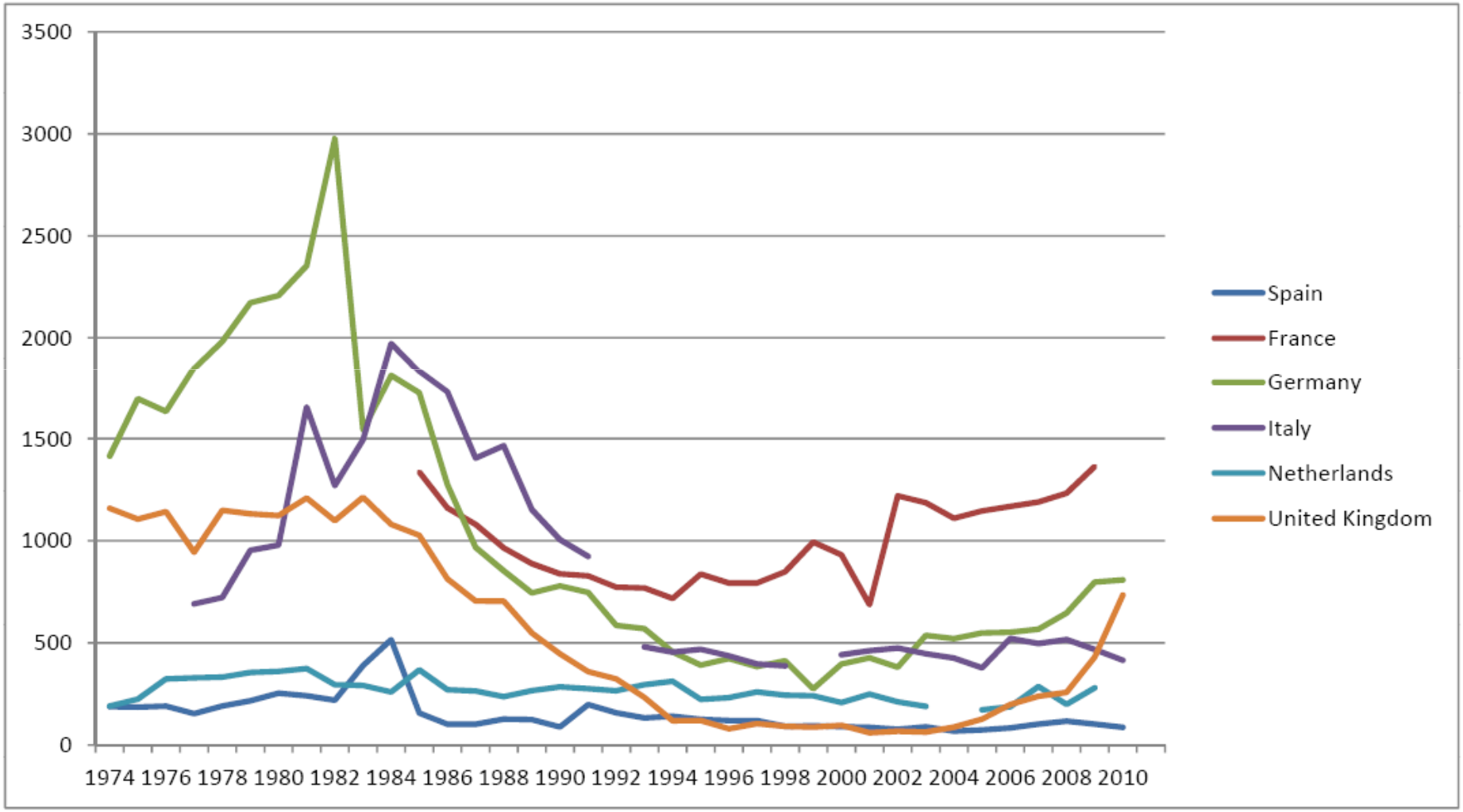
Estimated RD&D in Million USD (2010 prices and PPP)

Several Countries



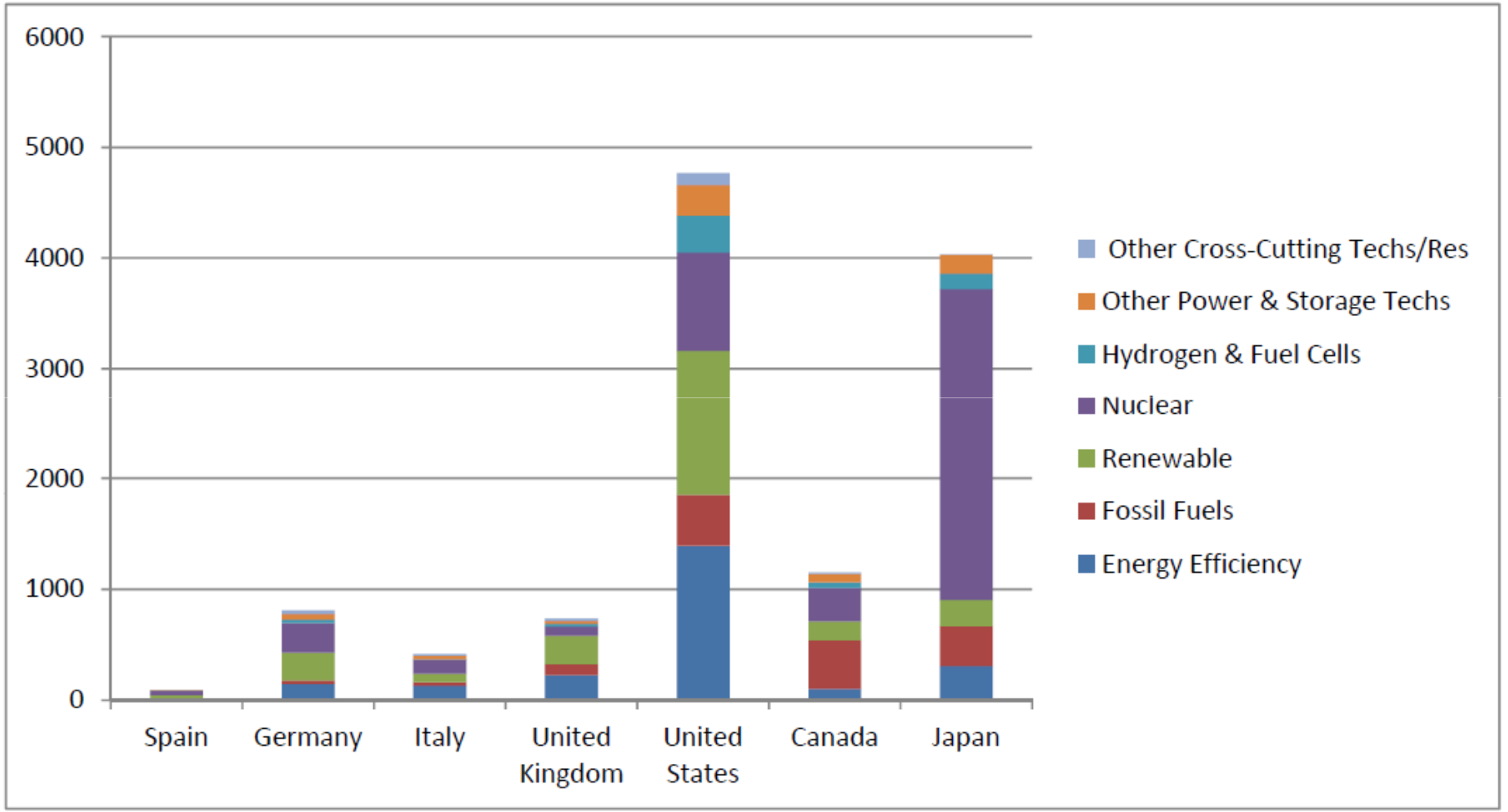
Estimated RD&D in Million USD (2010 prices and PPP)

Several European Countries



Estimated RD&D in Million USD (2010)

Several Countries



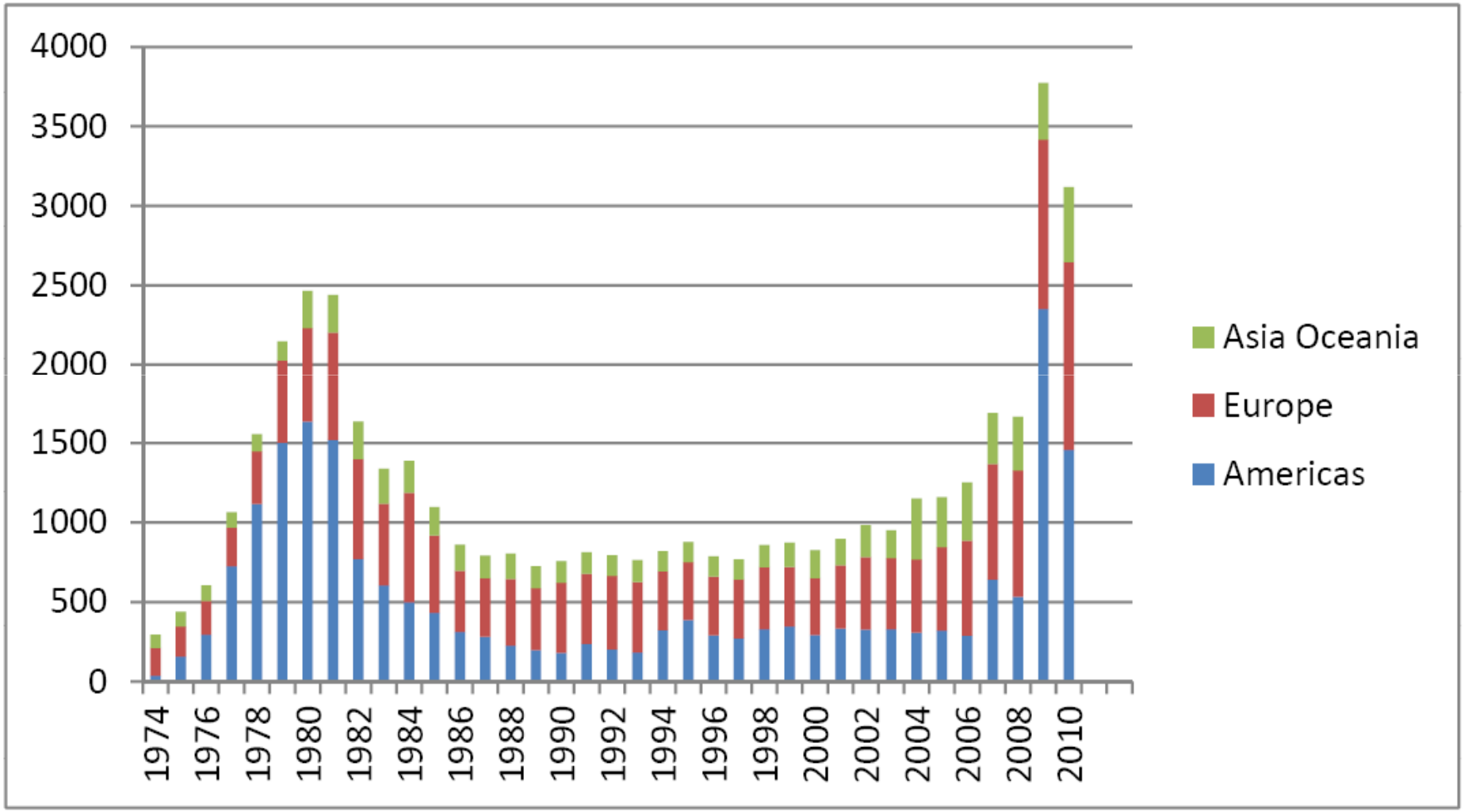
Estimated RD&D in Million USD (2010)

Several Countries

	Spain	Germany	Italy	UK	US
Energy Efficiency	4,175	143,828	132,45	224,54	1392
Fossil Fuels	3,728	35,077	29,139	98,4	460
Renewable	37,845	248,403	75,497	256,687	1310
Nuclear	37,748	268,297	124,503	84,546	888
Hydrogen & Fuel Cells	1,788	30,525	6,623	23,454	333
Other Power & Storage Techs	0,993	50,224	33,113	24,407	275
Other Cross-Cutting Techs/Res	0	31,491	13,245	22,008	110
TOTAL BUDGET	86,278	807,844	414,57	734,042	4768

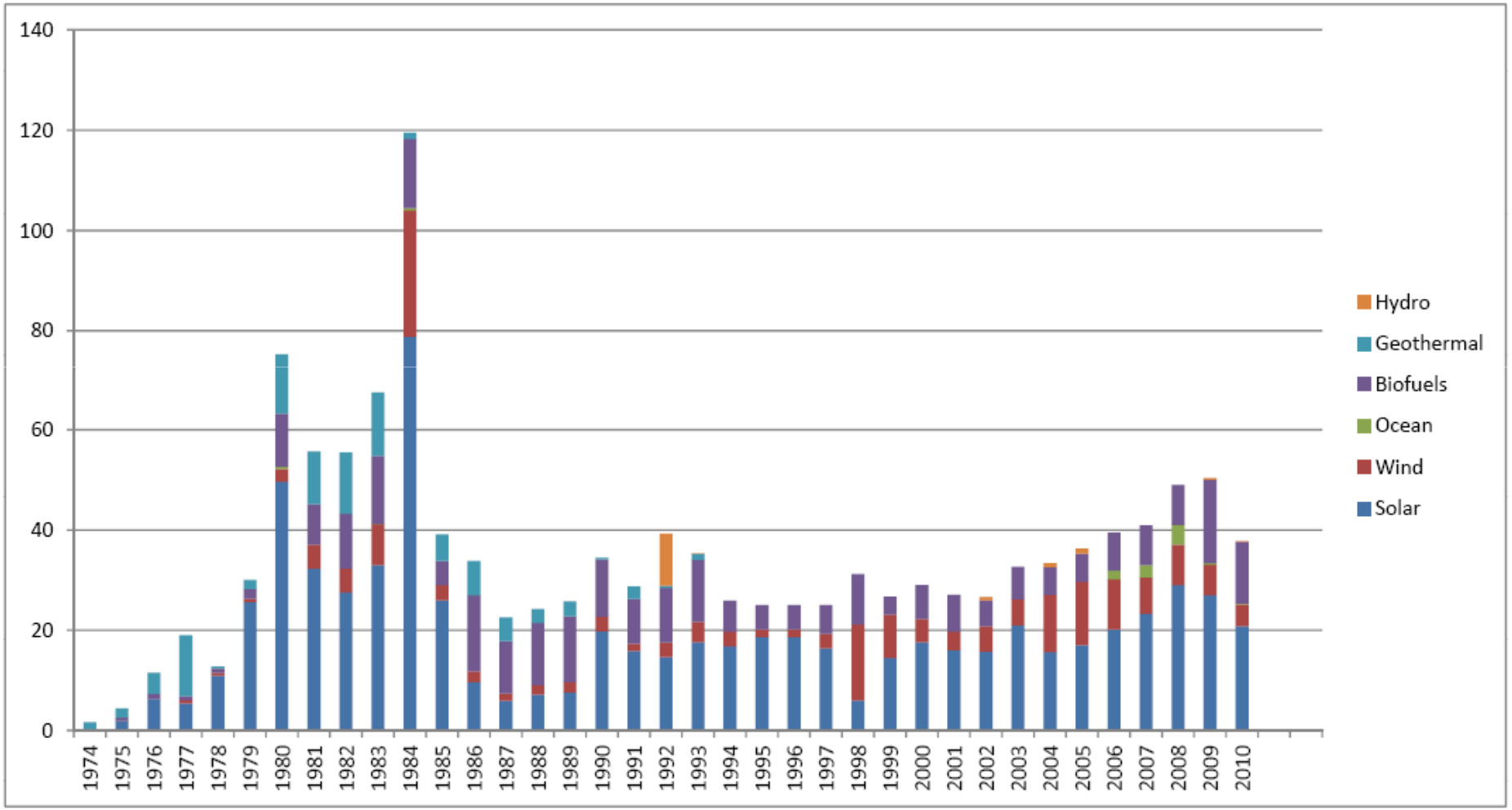
Estimated RD&D Budgets by Regions in Million USD (2010 prices and PPP)

Renewable Energy Sources



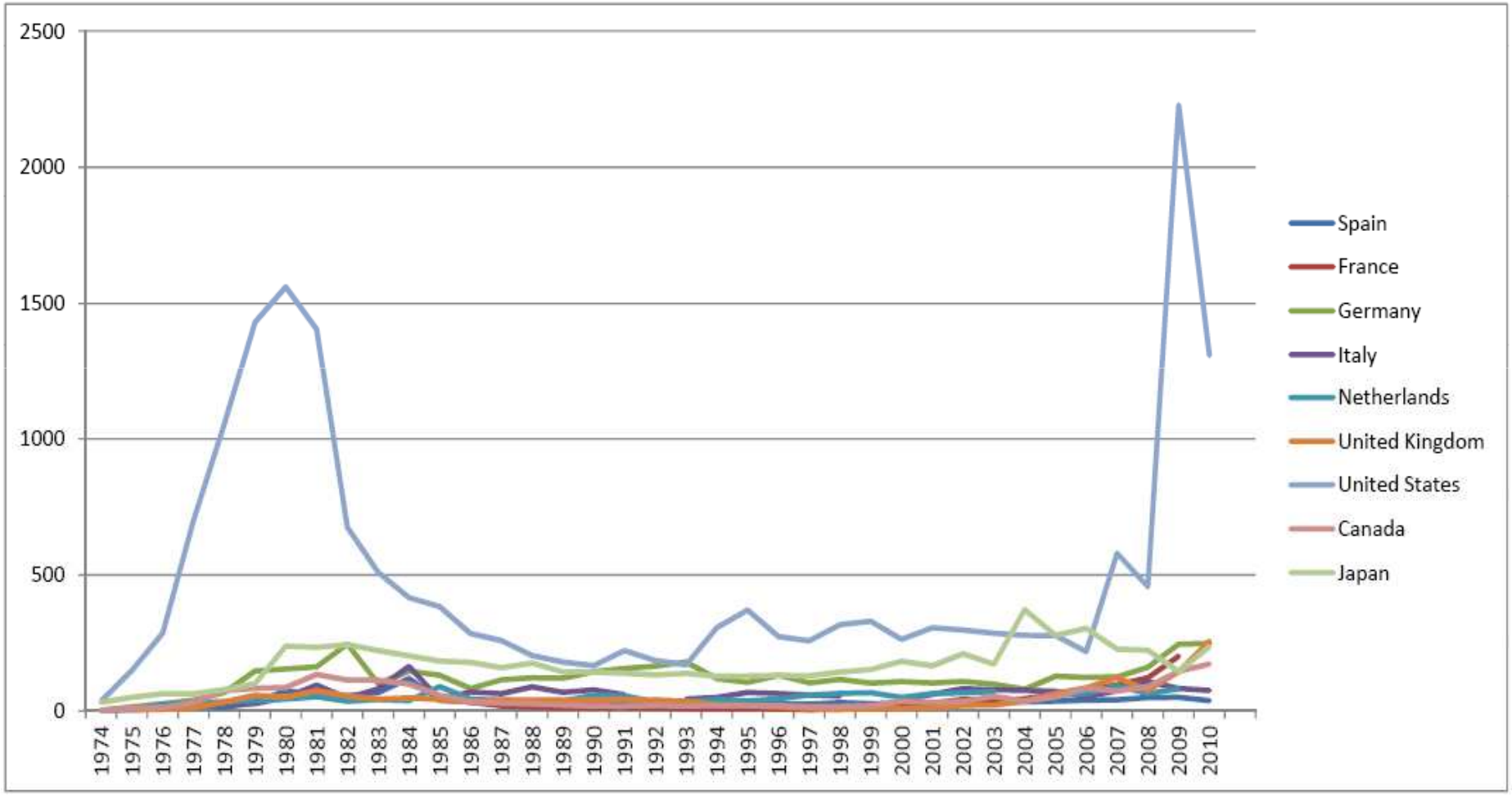
Estimated RD&D in Million USD (2010 prices and PPP)

Spain: Renewable Energy Sources



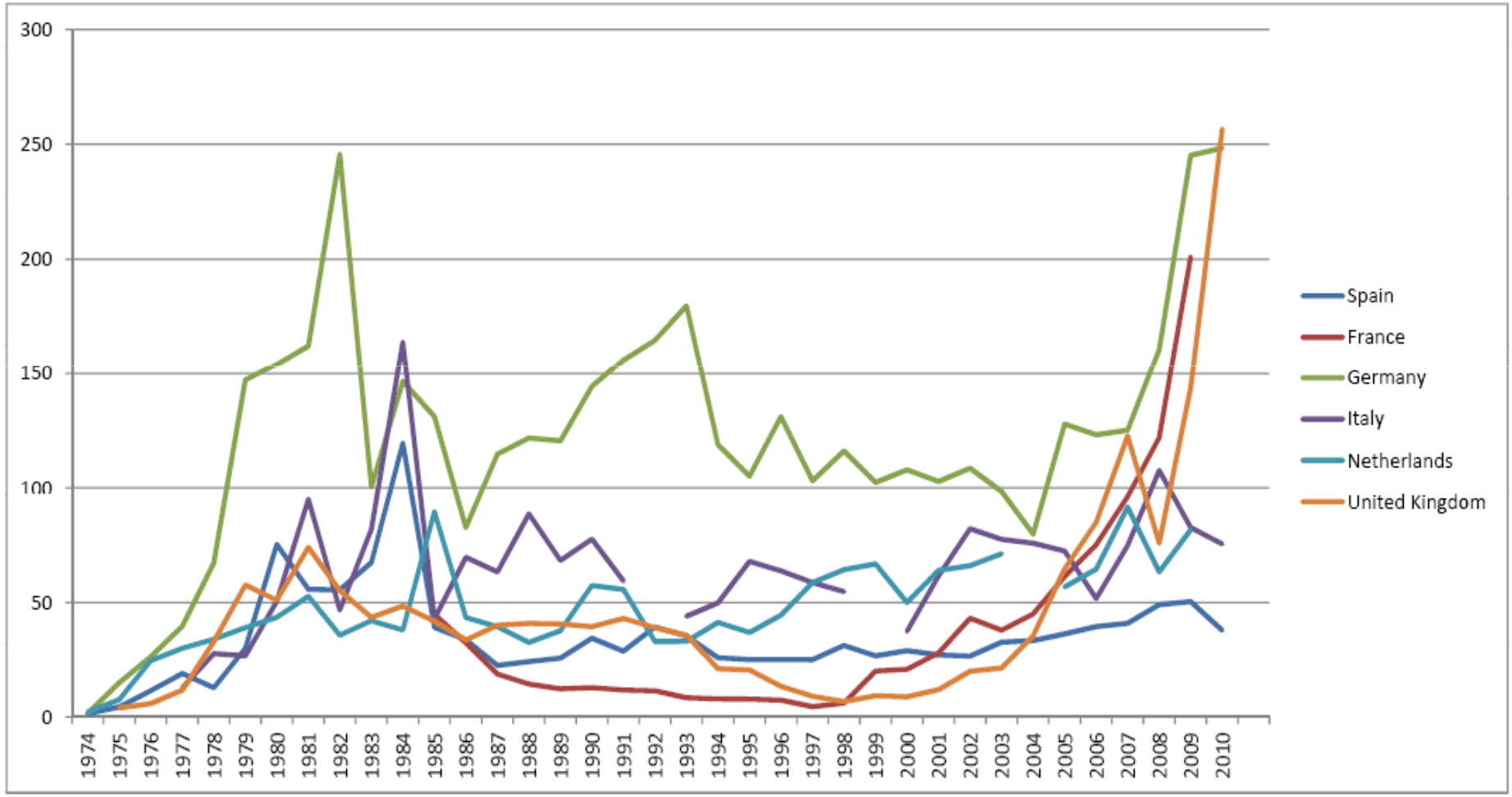
Estimated RD&D in Million USD (2010 prices and PPP)

Several Countries: Renewable Energy Sources



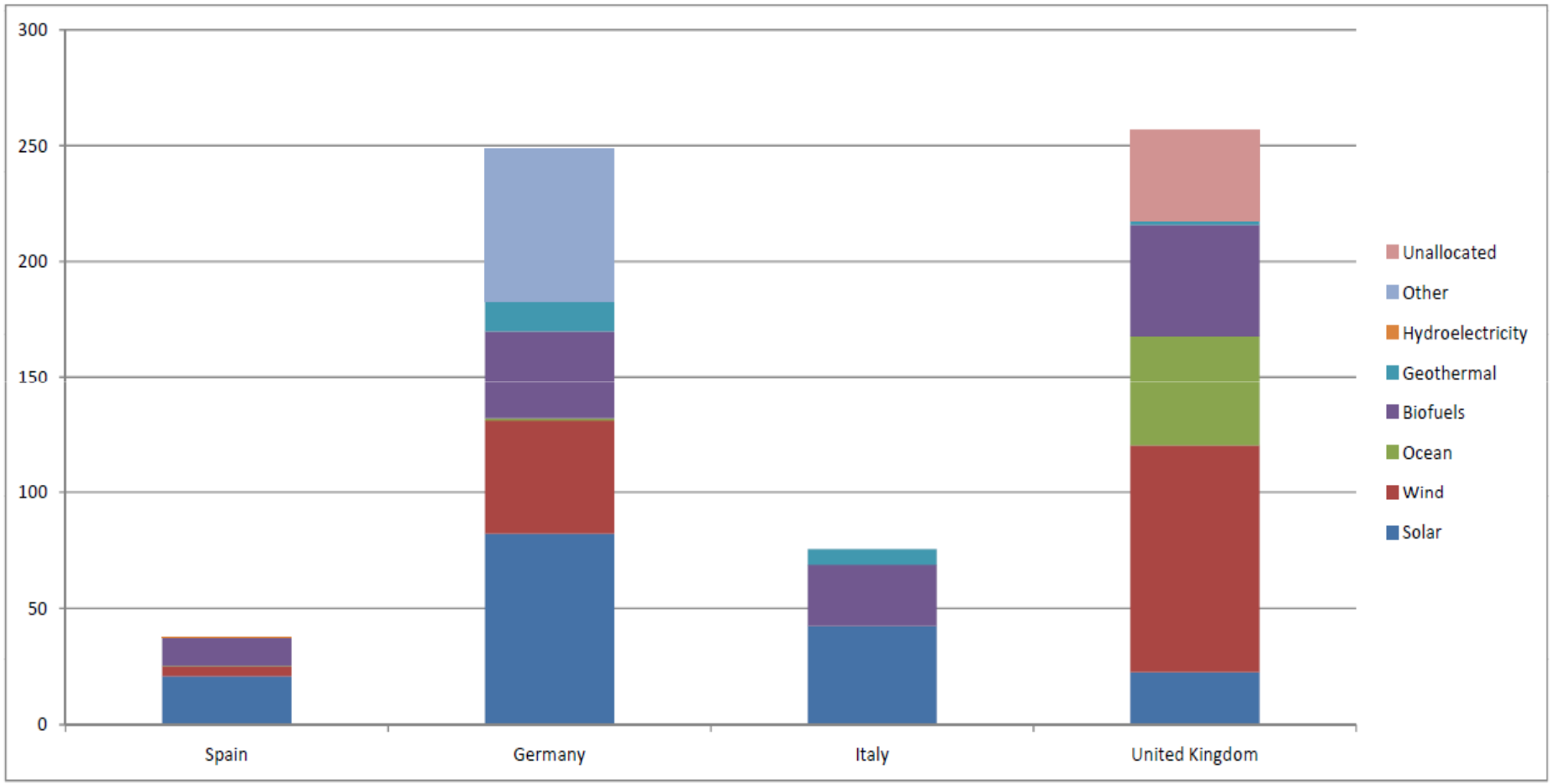
Estimated RD&D in Million USD (2010 prices and PPP)

Several European Countries: Renewable Energy Sources



Estimated RD&D in Million USD (2010)

Several European Countries: Renewable Energy Sources



Estimated RD&D in Million USD (2010)

Several European Countries: Renewable Energy Sources

	Spain	Germany	Italy	United Kingdom
Solar	20,834	82,146	42,384	22,588
Wind	4,35	48,707	0	97,583
Ocean	0,154	1,009	0	47,448
Biofuels	12,323	38,032	26,49	48,21
Geothermal	0	13,098	6,623	1,813
Hydroelectricity	0,184	0	0	0
Other	0	65,411	0	0
Unallocated	0	0	0	39,045
Total	37,845	248,403	75,497	256,687

Concluding remarks

- There is an need to change the current energy systems
- The existence of several externalities and the need for major technological innovations call for the intervention of the governments
- Market-based instruments provide more incentives to develop and adopt new technologies than do command-and-control instruments
- Many governments are increasing the budget allocated to energy R&D, particularly in the area of renewable energy and energy efficiency

- Innovation, development, and adoption of renewable energy sources and other environmentally friendly technologies requires a good balance between policies to promote their adoption and policies to do and promote energy R&D