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Abstract	This paper discusses how to foster development of renewable energy business. Factors that impede or enhance renewable energy in the EU 27 member states in the period 1998–2008 are analyzed. Nine factors are considered: population density, production output and energy sector output to indicate market conditions, public total expenditures, subsidies and environmental protection expenditures to indicate institutional conditions, R&D, share of students in population and venture capital to indicate firm's resources. Scarce space for business development and vested energy interests are the main impediments. R&D and venture capital are main drivers. The US and EU support for R&D and venture capital in renewable energy are compared. The US support is larger and mainly based on R&D grants. It has generated large, innovative enterprises. The EU support is mainly based on price guarantees for renewable energy delivery to grid. It has generated many enterprises. Building capabilities through stakeholders' networks in early phase of business development and clusters in the later phase is recommended.

Keywords (separated by '-')	Renewable energy - Factors - EU - Clusters - Networks

Business Development in Renewable Energy

Yoram Krozer

Abstract This paper discusses how to foster development of renewable energy business. Factors that impede or enhance renewable energy in the EU 27 member states in the period 1998–2008 are analyzed. Nine factors are considered: population density, production output and energy sector output to indicate market conditions, public total expenditures, subsidies and environmental protection AQ1 expenditures to indicate institutional conditions, R&D, share of students in population and venture capital to indicate firm's resources. Scarce space for business development and vested energy interests are the main impediments. R&D and venture capital are main drivers. The US and EU support for R&D and venture capital in renewable energy are compared. The US support is larger and mainly based on R&D grants. It has generated large, innovative enterprises. The EU support is mainly based on price guarantees for renewable energy delivery to grid. It has generated many enterprises. Building capabilities through stakeholders' networks in early phase of business development and clusters in the later phase is recommended. AQ2

Keywords Renewable energy · Factors · EU · Clusters · Networks

Highlights

1. Main barriers for renewable energy business are space scarcity and vested energy business, main drivers are research and development and venture capital.
2. More public support for renewable energy in US than in EU invoked larger firms in the US, price guarantees in the EU invoked more enterprises and employment in the EU than in the US.

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3. Demand for renewable energy, high margins and growing consumption in electricity in the EU has generated €135 billion market that grows €13 billion a year.
4. Renewable energy capability can be developed through the stakeholders' networks entailing specialization in business clusters.

1 Introduction

Business aiming to serve a common good is challenging because people rarely pay for public interests without direct private gains unless social sense of urgency generates public demands [21, 25]. Public demand for good environment is irrefutable, for instance for mitigation of climate change. The reasons why these demands emerge is discussed in other papers with regard to knowledge intensive societies [17, 29, 60]. Given these demands, this paper discusses countries' and regions' possibilities of developing renewable energy business. Herewith, renewable energy is considered a quasi-common good that serves energy for private consumption and energy security, climate change mitigation and others for public interests. The renewable energy business covers production, distribution and consumption of biomass and waste, hydro, geothermal, solar and wind resources, as well as energy efficiency through storage, distribution, co-generation, processing, saving with related management and policymaking.

The renewable energy business is a large and growing business. The global cleaner technologies sales in 2010 were USD 499 billion (euro 372 billion), out of which 45 % was renewable energy, 14 % energy efficiency, 34 % water treatment, 5 % waste treatment and 2 % others (Copenhagen Cleantech Cluster 2012). In comparison, these sales approximate to the total global car sales in the same period. The data are based on the investors' sources. Investments in renewable energy business grew during 2004–2010 on average 30 % a year to euro 211 billion in 2010 though with a large range of 0.4–75 % a year [36]. This average growth rate is higher than the average growth rate in informatics. The growth is expected to continue in the next decades. Global scenarios tend to assume a higher energy growth than income growth due to demands in emerging and low-income economies, and even higher renewable energy growth due to climate change mitigation and resource diversification [42, 47, 51, 56]. The share of renewable energy in the global final energy consumption is expected to be higher than the present 19 % measured in 2011 [46]. The subsequent energy scenarios expect higher shares [57, 61], whereas recent ones envisage the possibility of a fully renewable energy dependent supply in the EU by 2030 [54] and globally by 2050 [4]. These scenarios suggest that the renewable energy business can develop capabilities to satisfy global energy demands. AQ3

The renewable energy business generates many innovations. These innovations are studied from various angles. One approach is the managerial view focused on

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the firms' resources as presented in Sharma and Vredenburg [48]. Another one is the mainstream (neoclassic) perspective that underpins the roles of prices for signaling and allocation, which is reviewed among others in Ruttan [45]. The institutional perspective addresses decision making with respect to technological, social, ethical and economic issues, which is reviewed in Steger et al. [52]. This paper uses the evolutionary argumentation for discussion about barriers and drivers for the renewable energy business. Herewith, Jacobsson and Johnson [21] presented a framework with factors that pose main barriers: imperfect actors and markets (poorly articulated demand, established technology with increasing returns, local search processes, market control by incumbents), deficient networks (poor connectivity and wrong guidance with respect to future markets) and failing public institutions (legislative failures, failures in the educational system, skewed capital market and underdeveloped organisational and political power of new entrants). Hekkert et al. [19] presented a framework with factors that are main drivers: entrepreneurial activities, knowledge development, knowledge diffusion through networks, guidance of search, market formation, resource mobilization, and creation of legitimacy. Other studies bring in many nuances [14, 33, 39]. In this paper main barriers and drivers are assessed with statistical data in Sect. 2. Experiences with policy support in the US and EU are presented in Sect. 3. Business opportunities in the EU are discussed in Sect. 4. Policies to generate capabilities are addressed in Sect. 5. Conclusions are in Sect. 6.

2 Factors in Renewable Energy Business

What are the barriers and drivers for the renewable energy business? In order to answer this question, an assessment of statistical data in the EU with respect to its macro-economic conditions and international fuel prices is done. Given that the main macro-economic change occurred after the financial crash in 2008 when the economic slow-down entailing a dip in renewable energy investments, the analysis in this paper stops in 2008. The internationally traded fuel prices, so called Free On Board (FOB), fluctuate. High oil prices influence all fossil fuel prices, which makes renewable energy attractive. Regarding the oil prices two periods are specified: 1998–2002 when the annual average real oil prices fluctuated at the level of the 2002 price and 2003–2008 when the real oil prices increased two times followed by fluctuations at the level of the 2008 price. Also the fossil fuel mix prices for electricity generation in the EU is calculated based on the fuel prices corrected for consumed volume in electricity generation. All prices accounted in the real USD 2000 price that is inflated with consumer price index and converted per year into euro.

Nine factors that can impede or foster renewable energy business development are selected with regard to the Jacobsson and Johnson [21] framework and available EU statistical data (Eurostat). The factors are: population density, production output and energy output that refer to the market conditions, public expenditures, subsidies

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and environment protection expenditures that refer to the institutional conditions, research and development expenditures (R&D), students' share in population and venture capital that refer to firms' resources. All factors are calculated per capita per year and compiled into the averages during 1998–2002 and 2003–2008. Since the largest renewable energy producing countries are not always the largest consumers the analyses cover all producers and all consumers, as well as ten largest producers and ten largest consumers. The annual average change in each of the factors and the change in renewable energy production and consumers are compared to indicate whether the trend is converging (when correlations are positive), or diverging (when correlations are negative). For consistence in the data used, only the Eurostat is used. Malta is excluded because it does not provide sufficient data. Croatia is excluded because it joined the EU in 2013. Some missing data are linearly extrapolated. Only a few data on the regional renewable energy are found: eight regions in Austria that has produces much renewable energy and seven regions in Hungary that produces little renewable energy. However, these data are insufficient for analyses. Pearson correlations coefficients (R^2) between the factors and renewable energy production and consumption are calculated.[1] Sensitivity analyses cover: correlating per year and compiling into the average correlation coefficient per period and correlating for every renewable energy resource: biomass and waste, hydro, geothermal, solar and wind. Herewith, it can be noted that nearly 50 % of all renewable energy production in the period 2003–2008 is biomass and waste based. For interpretation of results it is assumed that R^2 larger than 0.5 or smaller than −0.5 indicate important factors but not causal relations. The results are summarized in Table 1. Appendix 1 shows the data: annual average per capita MW renewable energy production and consumption, and the factors.

The correlation is formally:

$$R^2(x, y) = \sum (x - \bar{x}) \cdot (y - \bar{y}) \Big/ \sqrt{\sum (x - \bar{x})^2 \cdot \sum (y - \bar{y})^2}$$

Columns show producers and consumers in the EU, ten largest producers and consumers and the annual change in the EU, all these divided into periods 1998–2002 and 2003–2008. The first row presents per capita renewable energy production and consumption. Large differences in the EU exist: ten largest producers are nearly three times larger per capita than the EU average and ten largest consumers are seven times larger per capita than the EU average. The renewable energy production and consumption have grown much faster during increasing oil prices than during low prices: production growth was 6 to 2 % and consumption 4 to 1 %. Other rows present factors. High positive or negative correlations of the factors and renewable energy production and consumption are shown bold. These are the main impediments and drivers.

[1] x is the annual average volume and change and y is the annual average factor volume or factor change.

Table 1 EU cross countries Pearson correlations (R^2) between production and consumption of renewable energy and several business development factors during steady and increasing oil prices (all data based on Eurostat)

Correlation are annual averages of the periods							Renewable energy producing countries		Renewable energy consuming countries			
	All EU		Ten largest		Change		All EU		Ten largest		Change	
	1998–2002	2003–2008	1998–2002	2003–2008	1998–2002	2003–2008	1998–2008	2003–2008	1998–2008	2003–2008	1998–2008	2003–2008
MWh/capita	2.3	3.0	7.4	8.3	2 %	6 %	1.0	1.1	7.0	7.8	1 %	4 %
Market conditions												
Population density	(0.5)	(0.5)	**(0.6)**	**(0.7)**	(0.2)	(0.3)	(0.4)	(0.4)	(0.4)	(0.4)	0.1	(0.0)
Production volume	0.2	0.1	0.5	0.5	0.3	0.2	0.3	0.3	**0.6**	**0.6**	0.1	(0.2)
Energy output	0.3	0.0	(0.4)	**(0.6)**	(0.2)	(0.1)	0.3	(0.2)	0.0	(0.3)	0.0	(0.2)
Public institutions												
Public expenditure	0.3	0.2	0.5	0.4	0.1	0.1	0.5	0.4	**0.6**	**0.6**	0.1	(0.3)
Subsidies volume	0.5	0.3	0.3	0.3	(0.1)	0.3	0.5	0.5	0.5	0.5	0.0	(0.1)
Environment protection	0.3	(0.0)	0.1	0.2	0.0	0.3	(0.0)	(0.0)	0.5	0.5	(0.1)	(0.3)
Firms resources												
R&D expenditures	**0.6**	0.5	**0.7**	**0.7**	0.2	(0.1)	**0.6**	**0.6**	**0.8**	**0.8**	(0.0)	(0.3)
Students share	0.1	0.4	0.5	0.3	0.1	0.1	0.2	0.1	0.2	(0.1)	(0.0)	(0.1)
Venture capital	0.3	**0.7**	**0.8**	**0.7**	**0.6**	0.1	**0.7**	**0.8**	**0.9**	**0.8**		0.1

2.1 Market Conditions

Population density, defined as the number of people per square kilometer, indicates space scarcity for renewable energy. Since the renewable energy resources have lower energy density than fossil fuel resources more space would be needed for the state-of-the-art renewable energy technologies to meet all energy demand in densely populated countries like the United Kingdom [34] and the Netherlands [55]. The factor analysis shows that the limited space is an important impediment for the production, not for the consumption. The sensitivity assessment with correlation per year confirms this finding. In particular, the biomass production is constrained by scarce space.

Production volume is indicated by the Gross Domestic Product in euro per capita. It is observed that environmental technologies and renewable energy production was larger and grew faster in the rich countries than in the emerging and developing economies [31, 41]. The factor analysis confirms these studies only insofar that the largest per capita EU economies are also the largest renewable energy consumers. Sensitivity analysis confirms that the countries' production volume is moderately important for renewable energy production and consumption; it is relevant for solar energy.

Energy output is indicated by the Index Energy Output in euro per capita. Intuitively, it would be expected that large energy producers also produce much renewable energy due to scale advantages. Gross et al. [18], for instance, observed that the renewable energy production growth in the 1990s was associated with decreasing unit costs albeit doubts exist whether scale of the renewable energy production is important compared to other factors [14]. A positive correlation could be expected but the energy output is negatively correlated with the renewable energy production, less negatively with its consumption. The sensitivity analyses per year and per renewable resource confirm this finding. Low renewable energy production is found in the large energy producing countries such as Belgium, Cyprus, Netherlands, Poland and UK. The large energy producers possibly do not care much about renewable energy because other resources are available and vested energy interests could have impeded renewable energy business [10].

2.2 Public Institutions

Public expenditure is indicated by the total government expenditure in euro per capita. It is often argued that high government expenditures for the renewable energy production and consumption are necessary because these are in development phase [20]. Given priority for the renewable energy in many EU countries, one would expect a lot of renewable energy production and consumption in the countries with high public expenditures. An indication of it is the observation that renewable energy in the EU grows twice as fast as in other OECD countries thanks to government expenditures [3]. High positive correlations would be expected but only moderate correlations are found for the renewable energy production and higher for its consumption. Big public spenders per capita are often small renewable energy producers, for instance Belgium, Ireland, Luxemburg, Netherlands and UK. The sensitivity analysis per year confirms this finding. The analysis per resource shows that the government expenditures are important for the solar energy consumption but hardly for the other renewable energy resources.

Subsidies are indicated by the total subsidy in euro per capita. All subsidies are included, which means the subsidies in favour of the renewable energy business and ones in support of the fossil-fuel businesses. The subsidies in support of fossil fuels were until 2008 much larger than for renewable energy in the EU [12, 30]. Regarding the ambivalent allocation of subsidies one could expect moderate correlations. This analysis confirms this expectation. Nevertheless, the subsidies for hydro and wind production are important.

Environment protection is indicated by the total expenditures on environment protection in euro per capita. High expenditures suggest political interest in renewable energy as a tool of environmental policy next to other instruments, such as emission trading [38]. High correlations could be expected. However, all correlations are low, even somewhat negative for the consumption. The sensitivity analysis and the resource-specific assessments confirm this finding. Environmental policies rarely foster renewable energy but can cause trade-off between renewable energy and environmental performance.

2.3 Firms' Resources

R&D is indicated by the total research and development expenditures per capita. Since high correlation between R&D and total industrial production is found in the EU [50] high R&D could foster renewable energy as well as fossil fuel. Nevertheless, high positive correlations are found between R&D and the renewable energy production. It is even higher for the consumption. This is confirmed in the sensitivity analysis and for consumption of hydro and solar energy. The renewable energy business is apparently highly knowledge intensive.

Students share is the share of students in population. Since it is argued that higher education increases managerial awareness about sustainability [37, 62], high share of students in population could foster renewable energy. High correlations would be expected. However, these are low for the production and negligible, even somewhat negative, for the consumption. The sensitivity analysis and correlations per resource confirm the results. High concentration of students is a negligible factor for the renewable energy business.

Venture capital is the available venture capital in euro per capita. It indicates the investors' equity in firms. Much venture capital could foster renewable energy and fossil fuels. High positive correlation between venture capital and renewable energy production and consumption can be expected. The factor analysis confirms this.

The sensitivity analysis also underpins this result. In particular, the biomass and hydro production and consumption benefit from venture capital.

The main impediments for the renewable energy business are scarce space and large energy output. The main drivers are large R&D and venture capital. Links between these factors are also assessed. Space scarcity is not linked to other factors. It implies that the sparsely populated countries are not necessarily poor ones, with low R&D, or lack venture capital. Energy output is also unlinked. Although public expenditures and subsidies are moderately correlated with renewable energy they are linked with R&D. The public expenditures and subsidies could foster renewable energy through R&D. R&D and venture capital are also linked. The countries in top ten R&D and top ten venture capital per capita produce nearly three times more renewable energy than the EU average, albeit only 6 out of 12 countries are in the top ten countries for both factors.

3 Public Support to Renewable Energy Business

How policies foster R&D and venture capital, two main drivers for renewable energy, is discussed based on the US and EU policy support. These were the largest investors in renewable energy until present.

Options for policy support of R&D and venture capital are explained using the managerial view on innovation process. Figure 1 illustrates this viewpoint. The figure presents the profit as a function of time: horizontal axis is time and vertical axis is profit. Typical phases, investors and usual interest rates are labeled on the figure. Dotted lines indicate options for policy support. When an entrepreneur aims to launch a new product, he or she considers several years of costly R&D to create a saleable novelty (invention), followed by start-up of an enterprise or a project and a pilot for testing its invention before sales (innovation). Profit is negative during all these phases, which implies piling up costs. The costs must be covered by the investors' equity, which means venture capital, because loans for innovations are usually too risky; innovators can seldom cover the costs and their know-how is barely saleable as guarantees. For policy support there are only two options. Policy can reduce the costs through subsidies, for example R&D grants. The subsidies add to equity. Policy can also reduce investors risks, for instance through price guarantees. A guarantee attracts investors and loans.

Many policy instruments are developed based on these two options.

An international study has identified 178 instruments in 2006 [59]. Most instruments are found in the US and Western Europe, less in Asia, Eastern Europe and Latin America, hardly any in Africa. Most of them are grants for R&D and guarantees for expansion (commercialisation), which is for beginning and end of innovation processes. Only a few instruments are found for pilots, hardly any for start-ups. Entrepreneurs know how to use the instruments. For instance, 31 interviewed entrepreneurs used 163 instruments, it means globally on average about 5 per entrepreneur though more than average in Western Europe and US. In-depth

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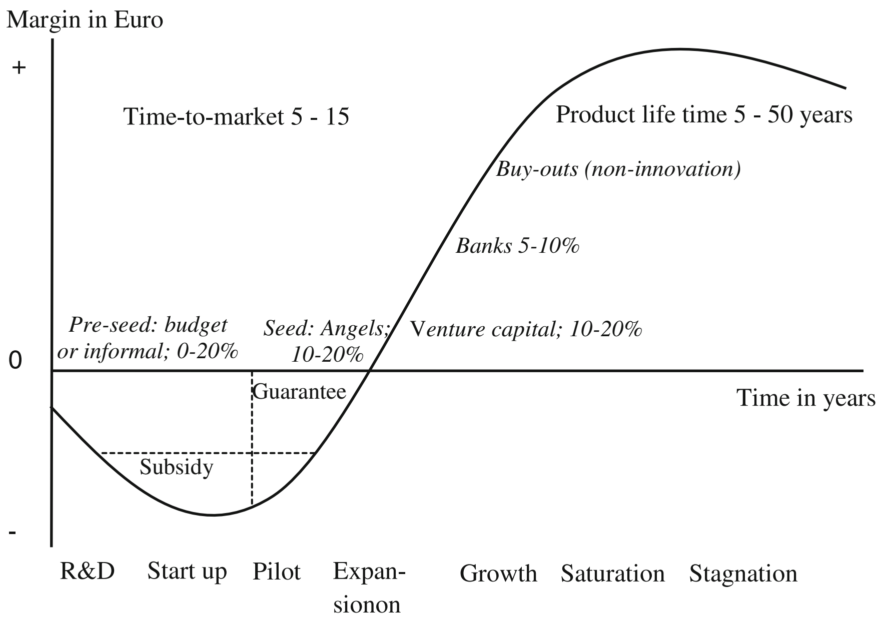

Fig. 1 Options for financing of an innovation process

country's analysis would find more instruments. In the Netherlands, for example, this study has mentioned 6 instruments; a Dutch metal branch study identified 23 instruments [16], web-based information shows many more (Subsidiedatabank.nl) and a consultant has mentioned about 1,900 possibilities [58]. The United Nations Environment Program (UNEP) advocated for more instruments, in particular to attract bankers [35]. This follows the German policy on the feed-in tariffs, which are price guarantees per unit renewable energy delivery to grid imposed by authorities on electricity generators [5]. Meanwhile, many EU countries introduced feed-in tariffs or similar subsidies albeit specifications vary with respect to renewable energy resources, years of guarantee validity, conditions for deliveries to grid and the tariff structure [24]. Many states in the US have introduced the renewable portfolio standards, which are obligatory renewable energy purchases without tariffs and a few states and networks also introduced feed-in tariffs [9]. What options is better is debated.

Several US studies have argued that high private investment in renewable energy in the US has generated its superiority. Herewith, R&D public support is valuable [1, 40, 44, 49]. The US firms were the largest by stock market value in 2008. Their value covered 42 % of the USD 560 billion (418 billion euro) global value. The US firms were also the most innovative ones, though the EU-based firms lead in wind, the Chinese in solar, and the Japanese in energy saving building and equipment. These findings are compiled in Appendix 2. The US business superiority despite the larger EU total market is attributed to high private R&D, good bankruptcy regulations, risk-taking financiers, venture capital on universities and flexible labour, whereas the EU feed-in tariffs EU would distort electricity prices [11]. However, a US study into the EU feed-in tariffs found no distorting effects [23] and the US scholars advocate more public support for the risk-taking investments [63]. Other scholars argue that the US has generated more risk-taking equity in the renewable energy business compared to the EU that has attracted more total investments but mainly in the risk-avoiding acquisition [25]. However, the arguments could be biased because investors data is scarce.

A larger public support in the US than in the EU, which is largerly based on R&D grants, could also explain the larger and innovative renewable energy firms in the US. Unfortunately, only incidental data underpin this explanation because statistical data on the private and public expenditures in renewable energy are not available. Biermans et al. [2] has found that the total public support envisaged for the renewable energy business in US in 2008 was USD 94.1 billion (euro 70.2 billion) compared to USD 22.8 (euro 17 billion) in the EU. Both were programs for overcoming financial crisis in 2008. The EU expenditures on the feed-in tariffs in 2008 approximated 25 billion euro, calculated with average feed-in tariff of minimum and maximum multiplied by production volume per energy resource [30]. Similar is estimated by the Council of European Energy Regulators [7]. Hence, the projected public support for renewable energy was 70.2 billion Euro in the US and 53.2 billion euro in the EU excluding the US feed-in tariffs because these are unknown. Moreover, the EU provides much more support to the rival fossil fuels business. The OECD (2014) data on subsidies during 2005–2008 indicate 25.6 billion euro annual average in the EU and 9.1 billion euro in the US; the EU data is about the minimum because several countries and subsidies are not covered. AQ4

The large US public support focused on R&D invoked large and innovative companies, whereas the smaller EU support focused on feed-in tariffs generate more businesses and employment. Table 2 shows the annual average number of enterprises and employees and their growth in energy sector in the US and EU during 2008–2011. This period is after the introduction of the feed-in tariffs in the EU and during the financial crisis. Herewith, it should be noted that not all starting energy companies are based on renewable energy. There are less energy businesses in the US than in the EU, the number hardly grows but they are much larger than in the EU. The EU feed-in tariffs invoked a spectacular business growth by 24 % annual average compared to only 1.9 % in the US. It also gained about 23,000 additional job a year despite an increasing scale per company. For comparison, number of ICT enterprises grew by only 3 % a year in the EU and the jobs decreased in the same period.

It is plausible that the US and EU public support for the renewable energy business matches their aims. It implies that both can be effective but risking high social costs. The US support when aiming at the large, innovative firms can consistently provide R&D grants to strengthen equity of the promising beneficiaries but

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Table 2 Number of enterprises (establishments in US), employees and their growth in the EU and US

		Average 2008–2011	Average annual change (%)
US	Number enterprises	12,634	1.9
	Employees	599,114	0.1
	Employees/enterprise	47	−1.8
EU	Number enterprises	85,237	24
	Employees	1,281,465	1.8
	Employees/enterprise	16	−18

risking that the supported firms fail in competition. The EU support when aiming at energy security and climate change mitigation can consistently guarantee non-discriminatory prices that enlarge the renewable energy markets but risk that too high tariffs compared to the market prices cause social costs. No instrument is a golden bullet but a deliberation about social cost—benefits versus social risks within bounded rationality of decision makers.

4 Renewable Energy Opportunities

What kind of energy business is attractive regarding volume and prices in the EU? The total energy consumption volume is hardly an incentive because it is stable. The volume calculated for the EU 27 during 1995–2011 covers the residential and business energy consumption on-site and in transport (more recent data is unavailable). The on-site consumption is based on the Eurostat energy statistical data, the transport consumption is derived from the Eurostat transport statistics using share of passengers and freight mileage in total mileage.[2] About 1.1 billion ton oil equivalent (t.o.e.) a year is consumed, equivalent to 13,000 GWh, out of it: 26 % residential, 43 % business, 25 % in passengers transport and 5 % in freight transport. It is about 2.3 t.o.e. or 27 MWh, per capita; the Central and East European countries consume less than 2 t.o.e., Luxemburg, Finland and Sweden more than 3 t.o.e. per capita. No significant changes occurred: the on-site energy consumptions decreased less than 1 % annually and in transport increased by 1 % a year. Nevertheless, there are several market opportunities for the energy start-ups.

[2] The share of kilometer-passengers for the residents consumption respectively kilometer-ton freight for business consumption in total is accounted per modality based on three years average mileage (2010–2012). For air and ship transport an average travel distance is assumed: 1,440 km for passengers ships and 3,600 freight ships and 2,270 km flight; a kilometer-passenger is assumed equivalent of 0.1 km-ton.

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One opportunity is due to consumption growth of the renewable energy resources. It has grown by 6 % a year to cover more than 14 % share in the total energy consumption in 2011, which is still lower than the global 19 % share due to high biomass consumption in the developing countries but even higher share is envisaged by the EU for 2020 and its progress is on track. In particular, the high-tech renewable energy consumption of solar and wind energy grows fast. Other opportunities relate to high gross margins, i.e. sales minus energy resources purchase. The EU 27 gross margins are calculated only for gas and electricity in the on-site energy consumption because transport price data are unavailable, though energy-efficiency in transport is an attractive market regarding high oil prices, duties and taxes. Table 3 shows four indicators for the residential and business gas and electricity consumption. Appendix 3 shows countries data. The first indicator is the share of fossil fuel price in sale price in euro per kilowatt hour, which indicates possible value addition: the smaller this share the larger value can be added. The second indicator is the total gross margin. This shows the market volume for energy business. The third one is the average annual margin increase which indicates the market growth. The last one is the average annual sale price increase, which shows the price factor of the market growth.

The residential electricity consumption generates by far the highest value addition. Various value adding services and products are attractive, such as energy-efficient lightning, electricity monitors and so on. The largest market is in the business electricity consumption. Large energy-efficiency investments can be economic. The electricity markets together cover about 78 % of the total 135 billion euro market for the energy-efficient innovations. For comparison, it is twice larger than the ICT market or similar to the real estate market. Gas is mainly consumed for heat. It is a smaller market with low value addition, albeit gas volume in kWh is larger than in electricity. High value addition in electricity compared to gas can attract new services and products that add value, e.g. co-generation for transforming heat into electric power. Furthermore, the gross margins increased in all cases because volumes have grown, particularly gas consumption has grown due to subsidies in several EU countries and policies aiming at substitution gas for coal

Table 3 Indicators of the gas and electricity market in the EU 28 Member states during 2004–2011

All are annual averages	Euro/kWh	Million euro	Annual increase	
	Fuel to sale price (%)	Gross margin	Gross margin (%)	Sales prices (%)
gas business	75	17,415	50	2
gas residential	23	12,312	8	5
electricity business	26	62,222	4	5
electricity residential	7	43,474	2	1
Total		135,424		

Annual average increase of the FOB gas price is 21 % and fossil fuel mix price is 10 %

and oil. The sales prices of energy products also increased albeit slower than the FOB prices of fossil fuels, which makes local resources attractive. When margins grow faster than sales prices it means that more is consumed despite higher prices, i. e. low or positive price elasticity of demand for energy products. This holds true for all energy sources except the electricity consumption in businesses. The price inelastic demand for energy attracts cost-effective energy management, such as optimization of electricity consumption and better heat utilization.

The high growth of energy enterprises and their success, measured by employment, can be explained by the cumulative effects of growing demand for renewable energy and growing energy consumption despite higher prices. This stimulates innovations in using local resources, in value adding processing of fossil fuels and energy-efficient management. The distributed energy systems emerge, called smart grid.

5 Renewable Energy Capabilities

Regarding opportunities for renewable energy through value adding products how can policies foster the entrepreneurial capabilities? This is discussed with reference to theories on knowledge interactions for innovations, so called knowledge spillover.

In the mainstream train of thought, knowledge spillover occurs due to proximity of specialisms. Specialist clusters would generate know-how entailing innovations. Hence, specialists are pulled to companies (e.g. to Dassault aerospace in Toulouse, France or to Glaxo biotechnology in North Triangle, North Carolina, U.S.) and vice versa, specialist research centres aim to generate industries (e.g. Joint Research Centre on energy near Milano, Italy, or Santa Fe Institute on complex systems in the U.S.). Porter's work on clusters popularized this argumentation for policy making (Porter 2000). Many embraced this view for creation of "top-tech" valleys, campuses, incubators, and similar. The renewable energy clusters also multiplied, often called cleantech. The cluster policy promised business development, which attracted billions of euros in public funding (EU 2003, Laffitte 2006). Results, however, are dubious. Statistical studies relating the numbers of patents and innovations to employment and turnover show that clustering has positive effects only within a sector or in a region but not across sectors or regions (Baptista and Swann 1998; Moreno et al. 2005). This is to say that public funding for strong industries may work, which is tautology. Case studies do not indicate positive effects of clusters on innovations (Malmberg and Maskell 2002; Martin and Sunley 2003). Studies also suggest that enterprises have too little local interdependencies to justify the clustering policies (Niosi and Zhegu 2005; Bekele and Jackson 2006). Know-how is also mobile. A statistical study on the French cluster policy argued that 1.8 billion euro public funding have not invoked clustering because firms spontaneously spur know-how efficiently (Martin et al. 2008). A similar case was found in the Cambridge region that hosts several excellent innovation centers (Webb 2008). A case study on a

Dutch energy cluster suggests that clusters often impede innovations because vested interests are reinforced due to public funding [27].

Another view focuses on the knowledge and cultural diversity. The argument is that innovation processes involves numerous gradual improvements and interactions that are unpredictable, let alone steerable [43] (Allen 1988). Knowledge spillover, therefore, would flourish due to variety of potential customers, suppliers, investors, experts interacting in formalized and tacit manner [32]. This image of diverse interactions that are structured by local and regional stakeholders created a metaphor of learning networks, popularized as “triple helix” (Cook and Morgan 2002). Cases suggest that such networks generate innovations, which attracts businesses (Hospers 2004). Florida (2002) underpinned that statistically for the US. The culturally diversified, urban work and living environments would attract highly educated and skilled professionals who generate knowledge spillovers in networks (Florida 2002), but also large science and arts projects could attract knowledge (Florida 2005). A trustful cultural setting would foster risk-taking, which is necessary for innovations (Babcock-Kumish 2006). A study on the renewable energy networks in the EU underpinned the diversity of the successful stakeholders’ networks, which implies that there many ways to foster the entrepreneurial capabilities [28].

These views do not necessarily exclude each other. The clusters and networks metaphors could address different phases in business development. The networking would apply to the early phases when skills must be generated and innovators scouted for start-ups. The networking, herewith, fosters the starting entrepreneurs and reduces investors’ risks. Policies that enable life-long learning, scouting of talents, matchmaking between groups, co-funding of start-ups and pilots and other tools for the experimentation before commercialization would foster the entrepreneurial capabilities. The policy focus on those elements in energy portfolios that match regional socio-economic and natural potential would generate innovations entailing business clusters. The clusters would generate economies of scale that is needed for the commercialization. The policies that attract external businesses and know-how with public and private funds could be justifies when competitive businesses are established.

6 Conclusions

The renewable energy business is relevant to economic development not only to meet global energy demand but also to generate income while mitigating climate change. The question about how public policies can foster renewable energy business has been discussed based on the factor analysis of renewable energy production and consumption with the EU statistical data during 1998–2008. Among nine factors analyzed, which are population density, production output, energy sector, public expenditures, subsidies, environment protection, R&D, share of students and venture capital, the main impediments for the EU renewable energy business are limited space and strong fossil fuel interests and the main drivers are large R&D and available venture capital. Public support for the R&D and policies that foster venture capital are instrumental. Comparison of the US and EU policy support indicates that the US attained a larger and more innovative renewable energy business mainly due to much larger public support for its R&D. The EU, however, has generated many new enterprises and jobs mainly due to its policy of price guarantees called feed-in tariffs. The energy market generates many opportunities for highly valued services and products. In addition to renewable energy for fossil fuel substitution opportunities are due to high and growing margins in energy consumption. Value adding services and products for the residential electricity consumption are, such as energy-efficient lightning, electricity monitors and so on. Energy-efficiency increase in the business electricity consumption is often economic. Co-generation for transforming heat into electric power and reuse of heat waste can be net beneficial. Low price elasticity of energy demand makes energy management attractive. Development of capabilities in renewable energy largely depends on the knowledge spillovers. When such energy are in the early development phase capabilities can be developed through stakeholders networks. Public support to attract skills and innovators is needed. The propositions to generate clusters can be attractive in situations with the developed renewable energy business aiming at commercialization. The renewable energy business is sufficiently large and fast growing to justify public efforts in its development for the sake of income, jobs and good environment.

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Appendix 1

See Tables 4, 5a, 5b and 5c.

Appendix 2

See Table 6.

Table 4 Per capital renewable energy production, consumption and growth, the largest ten producers and consumers are underlined, the fastest ten growers are bold

42 GJ = 11.6 MWh	Production renewable energy		Production growth		Consumption electricity generation		Consumption growth	
	1998–2002	2003–2008	1998–2002 (%)	2003–2008 (%)	1998–2002	2003–2008	1998–2002 (%)	2003–2008 (%)
EU (27)	2.34	2.98	1.8	6.4	1.0	1.1	1.3	4.4
Belgium	0.61	1.07	5.2	**16.2**	0.2	0.3	3.8	**10.7**
Bulgaria	1.04	1.56	11.3	4.1	0.4	0.6	3.8	**6.0**
Czech Rep.	1.62	2.35	5.4	**6.9**	0.3	0.5	6.4	**8.2**
Denmark	3.85	5.52	6.1	5.5	1.2	1.8	12.7	**5.5**
Germany	1.29	2.91	9.6	**17.5**	0.5	1.0	11.2	**11.7**
Estonia	4.51	6.01	−0.1	5.5	0.5	0.8	0.5	**7.6**
Ireland	0.72	1.06	6.6	**11.5**	0.4	0.7	10.0	**12.4**
Greece	1.46	1.72	−0.1	2.7	0.5	0.7	1.1	**7.6**
Spain	2.02	2.49	0.2	5.5	1.1	1.4	2.1	**9.0**
France	3.07	3.00	−2.5	2.9	1.5	1.3	−0.5	*1.8*
Croatia								
Italy	1.91	2.25	2.5	4.9	0.9	0.9	1.3	2.4
Cyprus	0.74	0.85	−0.4	**7.2**	0.0	0.0	1.0	**16.6**
Latvia	7.59	9.11	4.1	2.7	2.0	2.2	1.0	4.2
Lithuania	2.27	3.13	7.1	5.9	0.5	0.6	3.9	**5.7**
Luxembourg	1.01	1.68	3.0	**14.2**	2.3	2.3	1.7	−0.4
Hungary	0.96	1.39	0.6	**11.2**	0.1	0.2	14.4	**12.5**

(continued)

Table 4 (continued)

42 GJ = 11.6 MWh	Production renewable energy		Production growth		Consumption electricity generation		Consumption growth	
	1998–2002	2003–2008	1998–2002 (%)	2003–2008 (%)	1998–2002	2003–2008	1998–2002 (%)	2003–2008 (%)
Malta								
Netherlands	0.99	1.41	8.4	**6.8**	0.2	0.4	8.2	**12.2**
Austria	9.40	10.12	1.8	3.8	5.7	5.6	2.3	0.8
Poland	1.19	1.42	1.3	4.6	0.2	0.3	1.3	2.4
Portugal	4.18	4.52	−1.2	3.7	1.5	1.6	−2.2	**11.5**
Romania	2.10	2.54	1.1	**6.5**	0.9	1.0	−2.2	4.2
Slovenia	3.92	4.48	5.7	2.9	2.1	2.1	3.1	4.2
Slovakia	1.25	1.84	10.7	6.0	1.0	0.9	5.5	−0.7
Finland	16.86	18.93	3.9	2.5	4.3	4.6	0.5	**5.9**
Sweden	18.17	18.30	1.9	2.6	9.6	8.6	−0.4	1.8
Un. Kingdom	0.45	0.70	6.0	**9.8**	0.2	0.3	6.8	**10.3**

Table 5a Factors per capita: market conditions

	Population density person per km^2		Gross domestic product in euro		Energy production index in euro	
	1998–2002	2003–2008	1998–2002	2003–2008	1998–2002	2003–2008
EU (27)	112	115	18,837	23,142	95	96
Belgium	334	342	24,319	29,710	55	96
Bulgaria	73	70	1,710	3,337	54	110
Czech Rep.	130	130	6,381	11,120	89	102
Denmark	124	127	32,100	39,143	67	92
Germany	230	231	24,979	27,873	94	98
Estonia	32	31	4,534	9,330	88	110
Ireland	54	59	27,543	39,998	–	
Greece	91	92	750	18,225	88	96
Spain	81	88	15,693	21,668	83	90
France	110	115	23,623	27,982	92	93
Croatia						
Italy	189	194	20,942	25,039	86	95
Cyprus	75	82	14,344	18,831	76	91
Latvia	37	36	3,403	6,822	85	110
Lithuania	54	53	3,496	6,902	71	98
Luxembourg	167	179	48,739	69,364	82	90
Hungary	110	108	5,280	8,910	87	104
Malta	1,216	1,278	10,467	12,470		62
Netherlands	425	437	26,145	32,568	55	95
Austria	95	98	25,697	30,825	84	102
Poland	123	122	4,774	6,929	99	104
Portugal	115	119	12,062	15,013	94	91
Romania	94	91	1,840	4,284	79	103
Slovenia	98	99	10,956	15,365	85	95
Slovakia	110	110	4,108	8,215	93	98
Finland	15	16	25,298	31,305		
Sweden	20	20	28,240	34,221	101	92
Un. Kingdom	241	247	26,043	30,649	113	96

Table 5b Factors per capita: institutional conditions

	Total expenditure in euro		Subsidies in euro		Environment protection expenditure in euro	
	1998–2002	2003–2008	1998–2002	2003–2008	1998–2002	2003–2008
EU (27)	8,713	10,760	246	265	131	146
Belgium	12,549	15,291	295	492	143	156
Bulgaria	777	1,427	21	31	6	17
Czech Rep.	3,184	5,085	168	202	35	57
Denmark	18,123	21,264	784	873	269	252
Germany	12,028	12,996	409	316	170	163
Estonia	1,847	3,684	50	80	6	33
Ireland	9,970	15,123	208	200	221	383
Greece	6,152	9,143	18	18	79	120
Spain	6,482	8,989	171	222	40	75
France	12,743	15,330	359	403	128	158
Croatia						
Italy	10,325	12,298	254	253	183	208
Cyprus	5,874	8,409	163	132	31	56
Latvia	1,380	2,889	32	56	3	25
Lithuania	1,415	2,701	31	51	4	43
Luxembourg	20,560	28,490	756	1,086	303	321
Hungary	2,897	4,651	92	124	17	47
Malta	4,684	5,667	189	259	41	182
Netherlands	12,530	15,565	380	411	431	498
Austria	13,708	15,983	850	1,051	180	232
Poland	2,169	3,228	23	40	33	26
Portugal	5,526	7,059	150	135	75	86
Romania	721	1,803	28	56	5	19
Slovenia	5,396	7,263	206	257	57	125
Slovakia	2,032	3,425	93	122	15	28
Finland	13,022	16,122	383	416	153	170
Sweden	16,416	18,105	483	489	73	121
Un. Kingdom	10,799	13,702	118	189	137	176

Table 5c Factors: business resources per capita

	R&D total expenditure in euro		Students in total population		Venture capital investment in euro	
	1998–2002	2003–2008	1998–2002 (%)	2003–2008 (%)	1998–2002	2003–2008
EU (27)	308	414	3.2	3.7	78	154
Belgium	432	537	1.4	3.7	50	44
Bulgaria	7	14	3.1	3.1		
Czech Rep	62	134	2.3	3.1	4	6
Denmark	627	948	3.5	4.0	56	38
Germany	545	685	2.5	2.7	34	41
Estonia	27	78	3.5	4.9		
Ireland	275	470	4.0	4.5	346	34
Greece	55	103	3.7	5.4	7	8
Spain	118	232	4.5	4.3	29	22
France	460	581	3.4	3.4	74	62
Croatia						
Italy	191	273	3.2	3.4	64	37
Cyprus	33	69		2.6		
Latvia	11	32	3.4	5.4		
Lithuania	16	45	3.1	5.3		
Luxembourg	839	1,080	0.5	0.0	1,026	117
Hungary	33	80	2.7	4.1	145	162
Malta		57		2.2		
Netherlands	442	591	3.0	3.4	7	7
Austria	487	696	3.2	3.0	74	19
Poland	26	35	3.6	5.4	4	3
Portugal	71	126	3.6	3.7	19	2
Romania	7	16	1.8	3.4	14	14
Slovenia	131	205	3.8	5.4		
Slovakia	27	36	2.3	3.3		
Finland	705	1,037	5.0	5.7	305	282
Sweden	939	1,216	3.5	4.6	1,498	1,105
Un. Kingdom	412	532	3.4	3.8	13	4

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Table 6 The main renewable energy markets innovators in the US, EU and Other countries

Businesses	Resources (input)	Products (output)	Firms stock market value by 27-6-2008, USD billion [44]			Innovators (Firms to watch, [40])		
			US	EU	Other	US	EU	Other
Biofuels	Oils	Biodiesel	N. A.	N. A.	N.A.	7	3	0
	Sugars	Ethanol						
	Waste	Biogas						
Hydropower	Inland	Electric storage	–	–	–	–	–	–
	Waves and Tide							
Geothermal	Groundwater	Heat pumps	2.2	0.5	1.1	–	–	–
	Deep							
Wind power[a]	On shore	Electric	29[b]	153	9	5	4	1
	Off shore							
Solar power	PV	Electric heat	31	27	80	6	1	3
	Thermal (CSP)							
Green buildings	Architecture	Storage certification	39[c]	1	49	7	0	3
	Lighting							
	Micro-generators							
Personal transport	Hybrid (electric)	Batteries	111	0.3	0	6	0	4
	Electric	Fuel cell						
	Hydrogen	Flywheels						
	Hybrid (air)	Compression						
Smart grid	Monitoring	Meters	24[d]	0.1	0	10		
	Point of use	Storage						
	Networks	Smart grid						
	Co-generator	Heat reuse						
Appliances (mobile)	Cells	Embedded systems				7	2	1
	PV							
Carbon trading	CO2 emissions	Trading houses	0	2	0			
Total			237	184	139	48	10	12

[a] Excluding sails and kytes for motion
[b] Assumed 10 % of the total General Electric stock value USD 261,000 million
[c] Assumed 10 % of the Procter & Gamble (Duracell) USD 184,650 million
[d] Assumed 10 % of the IBM USD 164,900 million
Based on [1, 40, 44, 49]

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Appendix 3

Fuel prices and energy sales prices in EU countries 2004–2011

	€/ kWh	€ million	Growth		€/ kWh	€ million	Growth	
	Fuel to sale price €/ kWh	Gross margin	Sale price	Gross margin	Fuel to sale price €/ kWh	Gross margin	Sale price	Gross margin
	Gas consumption business				Gas consumption residential			
Belgium	83	565	6	84	23	436	6	6
Bulgaria	127	(11)	9	−576	40	2	5	20
Czech Rep.	85	236	9	88	29	183	11	25
Denmark	91	124	10	86	20	113	9	22
Germany	60	5,567	9	14	21	3,271	3	0
Estonia	133	(6)	12	−99	47	(2)	10	−626
Ireland	132	324	−1	38	22	86	−2	6
Greece	0	(282)	0	29	0	(19)	0	83
Spain	92	929	8	157	22	489	1	4
France	75	1,680	9	37	23	1,773	5	4
Croatia	95	92	8	−58	39	21	3	143
Italy	79	2,812	5	36	24	2,114	4	2
Cyprus	0	–	0	0	0	–	0	0
Latvia	120	4	10	189	46	(0)	13	−503
Lithuania	96	67	11	−430	39	6	8	109
Luxembourg	68	76	8	16	26	22	8	21
Hungary	87	304	3	92	39	117	14	−189
Malta	0	–	0	0	0	–	0	0
Netherlands	78	1,598	3	20	23	978	5	1
Austria	75	420	6	93	23	163	5	8
Poland	86	393	9	−112	32	209	8	145
Portugal	79	212	7	29	19	43	3	12
Romania	166	(233)	5	−240	68	(67)	−1	−1,494
Slovenia	79	41	14	54	25	12	8	14

(continued)

(continued)

	€/ kWh	€ million	Growth		€/ kWh	€ million	Growth	
	Fuel to sale price €/ kWh	Gross margin	Sale price	Gross margin	Fuel to sale price €/ kWh	Gross margin	Sale price	Gross margin
Slovakia	85	168	8	41	32	82	7	33
Finland	78	216	4	224	0	(3)	0	22
Sweden	59	103	9	123	18	14	8	14
Un. Kingdom	84	2,516	5	−118	28	2,534	6	30
	Electricity consumption business				Electricity consumption residential			
Belgium	24	2,098	2	3	6	1,227	3	−2
Bulgaria	47	249	2	1	15	169	0	2
Czech Rep.	24	1,416	10	12	8	565	7	7
Denmark	28	644	3	2	7	483	3	2
Germany	23	13,837	1	1	5	8,335	0	−1
Estonia	43	78	1	0	13	38	0	0
Ireland	20	735	4	4	5	494	5	7
Greece	28	999	3	3	10	532	5	6
Spain	25	5,700	8	8	7	3,139	6	10
France	35	6,058	3	2	8	5,645	0	−1
Croatia	31	228	6	9	10	196	3	3
Italy	21	9,412	3	3	5	4,394	−2	−2
Cyprus	18	135	10	13	6	87	8	12
Latvia	41	77	8	10	12	42	6	10
Lithuania	31	153	7	8	11	66	5	8
Luxembourg	24	193	3	2	6	49	0	1
Hungary	27	679	3	3	8	429	4	4
Malta	19	56	15	17	7	27	14	14
Netherlands	24	2,904	0	−1	6	1,313	2	1
Austria	26	1,347	6	7	6	867	4	4
Poland	31	2,238	10	13	8	987	5	6
Portugal	26	1,088	3	3	6	693	−4	−3
Romania	37	620	5	5	13	211	3	8
Slovenia	29	264	3	2	9	110	1	1

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	€/ kWh	€ million	Growth		€/ kWh	€ million	Growth	
	Fuel to sale price €/ kWh	Gross margin	Sale price	Gross margin	Fuel to sale price €/ kWh	Gross margin	Sale price	Gross margin
Slovakia	23	696	7	8	7	206	2	1
Finland	34	1,380	2	−1	8	807	2	2
Sweden	31	2,211	7	8	7	1,770	5	3
Un. Kingdom	25	7,031	9	8	7	5,862	5	3

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