Analyzing the impact of a national green economy strategy on small communities: the case of Lolland Municipality

Energy Series

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Abstract

An important aspect of the successful implementation of the “Danish example” is represented by the sharing of responsibilities and the dialogue between national and local authorities, such as in the case of Lolland Municipality (Lolland). Our analysis indicates that as a result of green investments GDP would grow primarily as a consequence of the implementation of mega projects -an outcome of national policies-, as they would generate employment and income. An important transitional factor emerges from the analysis: energy consumption and emissions are projected to increase when mega projects are implemented both due to their energy consumption and their positive impact on GDP. On the other hand, most of the energy needed to build and run this infrastructure would be generated using renewable energy. It is estimated that, when accounting for extra expenses for social services and public infrastructure, the policy driven investment at the municipal level would grow considerably in the short and medium term. Without support from the national government, allocating funds to large renewable energy projects, the municipality could face debt issues, especially in the short term.

Introduction

The success story of Denmark’s green development over the past decades and its ability of transforming itself into a forerunner in the renewable energy sector is these days more visible than ever, especially in relation to the latest COP15 that took place in Copenhagen in December 2009. In 1992 Denmark was one of the first EU countries to introduce a tax on CO\textsubscript{2} and upon ratification of the Kyoto Protocol the Danish Government committed to achieve 21% reduction in GHG emissions (compared to 1990) by 2012. Ever since, the country has embarked upon ambitious and long-term policies stimulating and supporting (also in financial terms) concrete initiatives in the field of renewable energy and energy efficiency (IEA, 2006).

Today Denmark is among the top ten most prosperous countries in the world (Legatum Institute, 2009), and has a GDP per capita (about USD 37,000/inhabitant, PPP, in 2008 –CIA, 2009) that is higher than the EU15 average (Eurostat, 2010) and that has grown by nearly 260% in the period 1980-2007 (IMF, 2009). Danish unemployment stays also lower than the EU15 average, at 3.8% in 2007 (Eurostat, 2010). Since 1990, there has been a significant shift in the use of energy fuels, with the consumption of natural gas and renewable energy increasing at the expense of coal (Danish Energy Agency, 2007). This shift in fuels has led to a reduction in CO\textsubscript{2} emissions\textsuperscript{1} despite the fact that gross energy consumption has slightly gone up by 6.7% since 1990. Specifically, in 2007 one kWh of electricity sold in Denmark generated 41.6% less emissions than in 1990 (547 versus 937 grams per kWh) (Danish Energy Agency, 2007). Today biomass represents about 70% of renewable energy production in Denmark, with wind energy being the second production source at 20% (increasing by an outstanding 1075% in 1990-2007). The dramatic increase in the production of renewable energy since 1980 and, in particular, since 1990, is accompanied by a recent increase in net imports of renewable energy, which in 2007 were 15.3

\textsuperscript{1} Adjusted for fluctuations in the weather and in cross-border exchange in electricity, CO\textsubscript{2} emissions have been reduced by more than 13% since 1990, reaching 52.7 million tonnes in 2007. However, if considering total observed emissions, the reduction is less remarkable, -0.3% (Danish Energy Agency, 2007).
PJ - as 19.0 PJ (primarily biomass) were imported and 3.7 PJ (bio diesel) were exported (Danish Energy Agency, 2007).

An important aspect of the successful implementation of the “Danish example” is represented by the sharing of responsibilities and the dialogue between national and local authorities, such as in the case of Lolland Municipality (Lolland). The growth history of Lolland, an island in the southern part of Denmark, stems from the effort of the public sector in supporting a specific development strategy that would help the island coming out of a period of strong economic depression and related social problems. In the mid-eighties, a severe economic recession hit the island, generating a vicious circle of raising poverty, brain drain, high unemployment (reaching also 40% for unskilled workers), disinvestments, etc. By the end of the nineties, an economic business strategy was developed, which, in line with the “green developments” at national level, was specifically targeting environment and the promotion of environmentally-friendly technologies, through the establishment of new Public Private Partnerships and innovative full scale demonstration projects in real communities (Magnoni and Bassi, 2009). As a result of this strategy, Lolland enjoys today a remarkably lower unemployment rate (from 15% in 1994 to 2.8% in 2008 - Figure 1a-) and hosts a high number of RE demonstration facilities, that guarantee a huge amount of electricity and heat production generated locally from alternative sources (wind energy, biomass/biofuels, hydrogen, biogas): the island has a total annual electricity generation amounting to MWh 1,150,000, against an electricity consumption of MWh 750,000 (Figure 7b). The Municipality of Lolland is therefore fully self-sufficient as far as clean electricity is concerned, which entails that the surplus of electricity produced (nearly 50%) is sold and transported to neighbouring regions.

The successful case of this Municipality, and the challenges ahead, are analyzed with a Lolland model, to investigate how communities can stand up to the challenges of facing the environmental and social consequences of climate change while creating economic opportunities. The key sectors considered in this case study are energy, waste recycle and reuse, agriculture, industry and transport.

Figure 1a and b: Historical unemployment rate din Denmark and Lolland municipality (Maribo and Nakskov) (7a); wind power growth on Lolland (capacity and output) (7b). Source: Statistics Denmark.

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2 Together with the neighbouring island of Falster, with which it forms a Danish geographical sub-region, Lolland covers an area of 1,797 square kilometres (Utkvinte and Alsen, 2006) with a population of nearly 112,000 inhabitants (Statistics Denmark, 2010). The sole Lolland Municipality covers only half of the geographical Lolland, 892 square kilometres (Lolland Municipality, 2010), with a population of approx. 48,000 citizens. The three major private economic sectors are construction services, the metal industry and agriculture, followed by tourism. The island is only 150 km from Copenhagen, but is considered a peripheral region in Denmark. This perception of remoteness goes along with relatively poor infrastructure, the continuing emigration of younger well-educated people and with having a higher percentage of its labour force on permanent welfare than the national average.
Greening local economies: the case of Lolland Municipality

An important aspect of the successful implementation of the “Danish example” is represented by the sharing of responsibilities and the dialogue between national and local authorities in the area of sustainable and greener economy. In this respect, two elements should be taken into consideration:

1. The Danish energy system is much decentralised, encompassing a very large number of CHP plants, windmills, waste incinerators with energy recovery and biogas facilities. The Danish municipalities play therefore a role in energy planning and management of the facilities on their territory.

2. Industrial policy is an important part of the municipalities' responsibility for financial sustainability in the local community. Development of a strong and competitive business environment is the basis for the general development of the community. With the new "Act on Industrial Promotion", the Danish municipalities have taken over the activities involved in business service. This makes them the only public access to entrepreneurship and therefore they have a major responsibility for ensuring sustainability in Denmark in the future.

There are various municipalities now in Denmark that are paying increasing attention to green economy issues, also in relation to the upcoming COP15 event in December 2009. But there is one municipality that, by undergoing an economic growth process based on green businesses and cleantech, can show, in smaller scale, the viability of the Danish experience: Lolland Municipality.

The island of Lolland, in the southern part of Denmark, is a showcase example of a remote local community being able to stand up to the challenges of facing the environmental and social consequences of climate change while creating economic opportunities. The growth history of Lolland stems from the effort of the public sector in supporting a specific development strategy that would help the island coming out of a period of strong economic depression and related social problems. In the mid-eighties, a severe economic recession hit the island, forcing the closure of the main businesses. This instance generated a distort circle of raising poverty, brain drain, high unemployment (reaching also 40% for unskilled workers), disinvestments, etc. By the end of the nineties, an economic business strategy was developed, which, in line with the “green developments” at national level, was specifically targeting environment and the promotion of environmentally-friendly technologies. Such a strategy aimed at attracting businesses on the island, with a particular focus on those companies who were developing RE/energy efficiency technologies and products. These companies could establish their demonstration activities for innovative technologies on the island, having the possibility of testing them full-scale and directly in real communities. This innovative strategy, lately called Lolland Community Testing Facility – CTF, on one side proved to be a successful business development tool, as it attracted new businesses on the island, with the relative benefits in terms of economic growth and employment; on the other, it appeared an appealing partnership for entrepreneurs and start-ups, who could enjoy the unique possibility of testing and demonstrating their new technologies on a full-scale (vs pilot projects) and in real communities (vs laboratories). As a result of this strategy, the island enjoys today a remarkably lower unemployment rate (2.8% in 2008 compared to 1.7% as national
average) and hosts a high number of RE demonstration facilities, that guarantee a huge amount of
electricity and heat production produced locally from alternative sources (wind energy, 
biomass/biofuels, hydrogen, biogas): the island has a total annual electricity generation 
amounting to MWh1,150,000, against an electricity consumption of MWh750,000. The island is 
therefore fully self-sufficient as far as clean electricity is concerned, which entails that the surplus 
of electricity produced (nearly 50%) is sold and transported to neighbouring regions.

The relevant achievements the island has been able to reach in the past decades, both in terms of socio-economic development and in terms of RE production, are in line with the policies and strategies pursued by Denmark in the past 30 years. In particular:

1. The island has focussed its efforts in developing a decentralised energy system of based on alternative sources of energy, including CHP and the subsidised sectors of windpower and biogas production. The island hosts a manure-based biogas plant and around 400 windmills spot its territory. Also, the world’s leader Danish wind turbines manufacturer, Vestas, was one of the first companies to invest on the island as a result of the local business attraction efforts, thus setting-up one of its subsidiaries – a blade factory. Also, Lolland has a well-developed district heating system working on straw and woodchips.

2. Lolland has benefited from national and regional funding available for the demonstration of cutting-edge RE technologies, as well as for local development. By welcoming demonstration facilities on its territory, Lolland Municipality has contributed to filling the gap between research and commercialisation, and has therefore qualified for the national available funding put at place for these specific purposes. Further, given the close link between demonstration activities and business development at local level, the island has also been able to take advantage of the EU funding (Structural Funds) available at regional level for the promotion of socio-economic development and the revitalisation of the area, against structural difficulties.

3. The greening of Lolland economy has evolved in line with the national objectives of GHG emissions reduction, increased energy security and development of technologies for export markets. Specific data for emissions reductions achieved at local level are not available, and indeed broad energy efficient programmes are not at place at the time being. However, all the electricity consumed and nearly 75% of the heat generated is coming from RE sources, instead from fossil fuels, which would be the natural energy source in a rural area, as Lolland, where the natural gas is not available. Also, the increasing outflows of clean electricity from Lolland to the neighbouring Danish regions contribute to the country’s greening of the energy supply, less dependence from fossil fuels and self-sufficiency. Finally, by demonstrating innovative technologies, Lolland and its entrepreneurs contribute to the development of unique RE products that can be representing new sources of export earnings at national level.

4. The creation of interactive relationships among companies, Lolland Municipality and the academia addresses the national priorities of increased research collaborations among these stakeholders for the development and demonstration of new technologies. The whole of Lolland CTF strategy lays on the establishment of strong Public Private Partnerships between local authorities, private companies and the academic sector,
aiming at exploiting mutual synergies and capabilities, while moving from basic and applied research through to validation and large-scale demonstration.

To conclude, Lolland Municipality has been able to combine national targets for a more sustainable economic development with its local needs for a restored economy and improved social conditions, by pursuing a specific “green economy” strategy, where renewable energy and the research and demonstration of advanced products were the main pillars. The municipality took the chance of investing in the “green sector” in a period of economic recession, working towards a sustainable future with inclusive growth, new jobs and reduced poverty. The result has been the implementation of specific policy responses, land planning activities and infrastructure projects, which, in the course of almost 30 years, turned out to return yields in the form of higher employment rates, stronger local economy, greener energy supply and, overall, improved services to the inhabitants.

**Relevant existing green economy provisions**

The “Danish example” is often referred to as the way towards an energy efficient, renewable-based sustainable economy. RE and efficiency measures have been accompanied by specific policies for preserving the country’s quality of life and economic performance (Kemin, 2009). When considering a local perspective, the relevant achievements Lolland Municipality has been able to reach in the past decades, both in terms of socio-economic development and in terms of RE production, are in line with the policies and strategies pursued by Denmark in the past 30 years. These policies include:

**Energy:** In February 2008, an Energy Agreement was signed to set out a number of initiatives with the target of having renewable energy constituting at least 20% of gross energy consumption in 2011 (30% by 2025) (Regeringen, 2009). The Government’s renewable support policies (consisting of a mix of regulations promoting wind\(^3\), CHP and biogas facilities and technological development, developing a reliable RE infrastructure in the country, setting-up feed-in tariffs, favouring cost-effective framework conditions, etc.) did not come without a cost, with electricity consumers, for instance, ending up paying a surcharge on every kilowatt-hour (kWh), which in 2005 was equal to approximately 3% of the household consumer’s final bill (taxes and grid charges included) and approximately 9% of the electricity bill for businesses (IEA, 2006). In the field of energy efficiency, where the country has achieved positive records (from 1973 to 2003, Danish TPES per unit of GDP fell by 37%), the Government released the “Energy Strategy 2025” in 2005, as well as an Agreement on Energy-Saving Initiatives, both aiming at ensuring intensified, documentable energy-saving efforts. Additionally, a Green Tax Package was introduced in 1996 in order to promote energy savings at company level through differential tax rates according to the energy-intensity of production methods (IEA, 2006). Finally, the Danish Climate and Energy Policy for 2008-2011 meets or surpasses EU environmental goals in several

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\(^3\) Substantial subsidies have been directed to the Danish wind turbine industry over years: from 2001-2005 the yearly subsidy has been DKK 1.7-2.6 billion. These subsidies have also contributed to an increase in the employment generated in the industry, which today counts 28,400 employees (CEPOS, 2009).
areas, while making Denmark the first country in the world to commit itself to reduce overall energy consumption—the target is a 2% reduction by 2011 in relation to 2006, and a 4% reduction up to 2020 (UM, 2009).

**Agriculture:** Agriculture accounts for 5% of the country’s CO₂ emissions and employs nearly 89,000 people. The organic production area covers 5% of the total agricultural area, placing Denmark in the top 5 of the EU-15 countries (Statistics Denmark, 2009). At the beginning of 2009 the Danish Government has launched a DKK 13.5 billion Green Growth plan that aims at ensuring better conditions for the country’s nature and environment (i.e.: increased use of animal manure for green energy, support to biogas, efficient organisation of agricultural research and development), while allowing agriculture to develop. The total investment is estimated to reach DKK 1.7 billion a year to be used in the period 2010-2013 (Danish Government, 2009).

**Industry:** The Danish industry works under the boundaries of the European Union Emissions Trading Scheme, with nearly 380 production units included in this framework—accounting for half of the national CO₂ emissions (Danish Energy Agency, 2009). In October 2009, the Danish Government launched the national Business and Climate Strategy, aiming at stimulating a green growth economy in Denmark, while promoting the exports of Danish products and technologies in the field of energy and climate (Danish Government, 2009).

**Waste:** In Denmark, waste is treated in the following priority: recycling, incineration with energy recovery, landfilling. The country has one of the highest rates of recycling worldwide: in recent years, the total average recycling rate has been around 60 to 65% (Danish Environmental Protection Agency, 2007). According to the Danish Environmental Protection Act (June 2000) the municipalities are also responsible for waste management in Denmark, being in charge of the assignment of treatment and disposal facilities for commercial and industrial waste in their territory (Waste Centre Denmark, 2010).

**Transport:** Despite Denmark’s considerable efforts in greening its own economy, the transport sector has historically been neglected by the Government’s efficiency programmes. Limited initiatives have been implemented in the past decades for decreasing the energy demand in transport, including mandates for the use of biofuels, tax rebates for scrapped older cars in the mid nineties and high registration taxes, easily reaching 180% of the ex-tax value of the car, for discouraging car ownership (IEA, 2006). Hydrogen powered cars will be tax-exempt, and the current tax-exempt status of electric cars will be extended to 2012. Further, the Danish Government introduced in 2008 the Green Transport Vision, an integrated plan for a green transport system, with three key components: adjusting vehicle tax to greener vehicle levies; more and better public transport; new sustainable technologies. The Government’s high ambitions for the green transport of the future will require considerable investments: more than DKK150 billion ($27 Bn) in infrastructure works up to 2020 (Danish Government, 2008).

**Technical specifications**

There has been a long-standing perception among both the general public and policy makers that the goals of economic growth, environmental protection, national and energy security involve a

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4 The Agreement on Energy-Saving Initiatives signed in 2005 explicitly excludes the transport sector from future targets.
complex set of trade-offs (Brown and Huntington, 2008; CNA, 2007; Howarth and Monahan, 1996). The analysis presented in this paper, focusing on the evaluation of social, economic, and environmental impacts of green investments requires an integrated and multidisciplinary approach.

Finding that most currently available national planning models are either too detailed or narrowly focused, this study proposes an approach that: a) extends and advances the policy analysis carried out with other tools by accounting for the dynamic complexity embedded in the systems studied; and b) facilitates the investigation and understanding of the relations existing between energy and society, economy and the environment. The inclusion of cross-sectoral relations supports a wider analysis of the implication of alternative policies, and the long-term perspective proposed allows for the identification of potential side effects and sustainability of different strategies.

The approach proposed uses the System Dynamics method as its foundation, and makes extensive use of scenarios. Firstly, a causal map of the system analyzed was developed (see Figure 3) to highlight the main drivers of the current economic structure of Lolland, excluding the traditional reliance on agriculture. Secondly, the causal map was validated with local actors to ensure that it would represent the rational for RE and clean tech investments and emerging structural changes. Finally, the integrated approach following the feedbacks depicted in the diagram was used to evaluate the impact of investments on socio-economic development and environmental preservation (i.e., emissions).

Figure 3: Causal map of the system analyzed. Clean energy investments were intended to stimulate economic growth, reduce unemployment and create intellectual capital. Positive side effects include the growth of green tourism initiatives and commercial activities. On the other hand, with demographics changing and with companies requiring adequate infrastructure, several infrastructure investments are required to keep Lolland competitive. If not implemented, the initial design of the development would be challenged and the private sector, as well as local high skilled individuals would move to different locations.
Scenarios of increased investment

In line with the policies outlined above, over the past decades the country of Denmark has considerably invested in programs, activities and projects in the field of RE, energy efficiency and, broadly, sustainable use of resources. These investments are going to continue, with recently agreed strategies injecting additional financial flows for further greening the Danish economy and society. The Green Growth plan (Danish Government, 2009) introduced in 2009 will provide DKK 13.5 Bn ($2.5 Bn) for programs and projects aiming at protecting nature and the environment, while favouring economic growth (i.e. increased use of animal manure for biogas generation, doubled organic production). DKK 600 million ($110 million) is made available through the Government’s Business and Climate Strategy for stimulating growth and jobs, while generating technology solutions to the climate issue. Further to this, the Green Transport Vision will require an ambitious green investment plan of more than DKK 150 Bn ($27.4 Bn) up to 2020. As for prior investments, these new amounts will be injected into the national, regional and local community for encouraging appropriate infrastructure, research and technology plans and projects.

As traceable in the case of Lolland Municipality, the use of governmental investments at local level translates into the possibility of implementing mega projects, i.e.: relatively large scale projects -in consideration of the rural and peripheral condition of Lolland- which would otherwise not take place without the support of significant national sources. The island has indeed started mega project activities in the latest years only, when consistent national and regional funding has been made available for specific actions in the fields of rational use of natural resources and RE that would in parallel generate new sources for resilient local growth. In earlier times, instead, it has mainly been the private initiative of individuals, farmers and associations that has brought the first RE investments on the island, through community-owned wind turbines and/or biogas plants. Such fragmented initiatives have afterwards evolved into more structured public-private partnerships, which have created bigger projects (waste-to-energy incineration; straw and woodchips based CHP), where synergies among energy facilities and processes were better exploited. With the later connections to the academia and the increased national focus on testing and demonstration projects in the RE and energy efficiency sector, the Municipality of Lolland has seen the inflow of national and regional financial sources, which have allowed for the implementation of large scale projects in a relatively small community.

To analyze the impacts of national policies and funding made available to support the creation of a greener economy at the community level, we have considered two scenarios: a baseline (BAU) and an additional one that includes selected clean energy mega projects. Investments in these scenarios are directed toward:

- **BAU:** Construction of the Fehmarn Belt bridge, connecting Lolland (and Denmark) to Germany. Expected construction duration: 10 years.

- **Green economy scenario:**
  
  - Construction of Rødsand 2, one of the world’s biggest offshore wind parks with a planned expansion of 207 MW;
- Implementation of a dike-based water management system, where algae basins are used for biofuel production;
- Setting-up of a biorefinery facility, using various biomass resources (manure, straw, other vegetable matter, waste) for biogas generation for the local district heating system. The total cost is estimated at DKK 150 million, or $27.4 million.

Further, the green economy scenario includes the allocation of local investments to reduce fossil fuel consumption through energy efficiency in the residential, agriculture, commercial and industrial sectors (DKK 5.2 million per year, or $960,000), as well as the substitution of fuel oil with renewable energy (e.g. geothermal) for residential heating (DKK 12.8 million per year, or $2 million). These local investments add up to 0.24% of Lolland’s GDP on average between 2010 and 2030, or $4.1 million per year.

Results of this scenario exercise indicate that local GDP would grow primarily as a consequence of the implementation of mega projects, as they would generate employment and income. The construction of the bridge is expected to have the most notable impacts, increasing GDP by 30% in 2030 and generating 5,000 direct construction jobs and about 1,600 indirect jobs related to construction, 200 maintenance jobs and about 3,000 indirect jobs for activities related to the operation of the bridge. Assuming that about 75% of these workers would come from outside Lolland (due to the lack of local labour force), the construction of the bridge would potentially reduce local unemployment -of the current local population- to zero until 2024 and considerably increase Lolland’s population. The implementation of renewable energy and green economy projects, despite being of a smaller size relative to the Fehmarn Belt bridge, would still generate employment and contribute to GDP, which is expected to be higher than BAU on average, peaking around 2020. The employment generated by the construction of the wind farm, the dikes and the biorefinery would add up to about 1,500 jobs during construction and 150 jobs for operation and management (O&M). These projects, when fully operational, are expected to contribute DKK 340 million to GDP yearly ($62 million). While not extensively contributing to GDP and employment, investments in energy efficiency and the substitution of fuel oil for renewable energy would reduce fossil fuel consumption and the generation of CO₂ emissions, directly favouring households and business on Lolland -that would save on energy bill and on carbon tax. In fact, energy consumption and emissions are projected to increase when mega projects are implemented, both due to their energy consumption and their positive impact on GDP. Effectively, most of the energy needed to build the bridge and other mega projects comes from onshore and offshore wind farms located on the island, greatly reducing the carbon intensity of these projects (e.g. all the electricity needed for the construction of the bridge would only be a fraction -12%- of the output generated by Rødsand 2). Overall, per capita emissions are projected to grow by 2030, due to the heavy construction projects.

Worth noting, with the allocation of green investments and the creation of mega projects that generate employment opportunities, -often high quality jobs for skilled candidates- the municipality of Lolland has to improve its social services, as well as develop its infrastructure. To avoid that these become bottlenecks to development, municipal expenses have to increase over time, following the growth of GDP. Interestingly, the municipality would be able increase its expenditure only after a revenue stream is generated by the mega projects or once co-financing is made available, which is often after construction has initiated. For this reason, per capita
expenditure is expected to decrease in the short term, at least until positive GDP impacts become visible. Hence, the accumulation of large investments on “green projects” does not come without a cost. This is in line with what has happened in the whole Denmark in the past 25 years, when Danish tax payers have had to finance the transition to a more sustainable economy and society through taxes and charges on both emissions and energy consumption. The 1996 Green Tax Package introduced three taxes into the Danish economy (CO\textsubscript{2}, SO\textsubscript{x} and energy tax), thus increasing government revenues, as well as a green tax shift in the national system. In addition, electricity customers have been paying a green energy levy on every kWh of electricity bought: 2005 data shows that this surcharge equalled to nearly 3% of the bill for household consumers (incl. taxes and grid charges) and approximately 9% of the business final bills (IEA, 2006). In the specific case of Lolland, these costs have often been coupled by a transitional increase in local emissions, generated by the hosting of mega projects that, if on the one hand, are testing and demonstrating cutting-edge RE technologies, on the other hand are favouring the creation of side activities on the island, hence new social and economic infrastructures. The ambition of Lolland Municipality of attracting innovative cleantech businesses and demonstrating new RE products is thereby spurring the local GDP, while surely working towards the overall reduction of emissions worldwide, but at the cost of having increased local emissions on the island.

On the island of Lolland, both small and large-scale projects fall under the framework of the local business development policy, called Lolland Community Testing Facility (CTF). This is a locally initiated, bottom-up strategy, aiming at transforming Lolland Municipality into an international platform for the testing and demonstration of RE products and technologies. A specific characteristic of Lolland CTF strategy is represented by the creation of synergies, which are identified at three main levels:

- **Synergies at partner level**: by adopting the Triple Helix spiral of innovation model when implementing energy-related activities on the island (Leydesdorff, 2000), synergies of competences, human capital and financial capital are established among the public and private sector, and the academia.

- **Synergies at technical level**: when dealing with RE sources, the main problem is intermittency. By investing in more RE initiatives, Lolland Municipality is trying to create synergies to make each single investment more appealing (and economically profitable). Many can be the examples recalled in this instance: use of surplus of wind power available at night for hydrogen production and storage in the hydrogen village; use of the oxygen obtained through electrolysis in the hydrogen generation process to increase the efficiency of water purification in the municipal water treatment plant; creation of algae production testing grounds, with the goal to capture CO\textsubscript{2} and produce biofuels, in ponds built in the dikes complex; use biomass (i.e., straw) for combined heat and power production and use of manure in the biogas plant are specifically designed to create a revenue stream for local farmers. This, in turns, alleviates the economic burden created by the increased taxation level on Lolland.

- **Synergies at policy level**: the relevant achievements the island has been able to reach in the past decades, both in terms of socio-economic development and in terms of RE production, are in line with, complement and implement the policies and strategies pursued by Denmark in the past 30 years.
Conclusions

Denmark’s wealthy living conditions and prosperous economy, accompanied by declining energy intensity and greenhouse gas emissions, are the results of the successful implementation of the Danish development strategies, focusing on achieving sustainable growth through targeted and long-sighted policies aiming at rationalising the use of natural resources, reducing energy consumption, increasing the output of alternative sources of energy and favouring a market for energy efficient and renewable energy technologies produced by Danish companies. These effective initiatives have allowed the country to emerge as an international leader in the RE sector, while ensuring a healthy economic development that is socially-balanced and environmentally-friendly. Besides, the key role played by the Danish local government in promoting and managing energy/environment-related activities as a means for further economic development, as it is the case for the island of Lolland, allows for the combination of top-down national policies with bottom-up concrete initiatives, consequently guaranteeing for a decentralised, participatory and, hence, more sustainable approach in the implementation of energy, environmental, social and economic development policies. Experience from Denmark also shows that with a persistent and active energy policy, mainstreamed in different sectors of the society, it is possible to exploit synergies and fuel sustainable growth at national, regional and local level.

The analysis of the Danish community-based development case indicates that GDP in the green economy scenario would grow primarily as a consequence of the implementation of mega projects -an outcome of national policies-, as they would generate employment and income. While not extensively contributing to GDP and employment, local investments in energy efficiency and the substitution of fuel oil for renewable energy would reduce fossil fuel consumption and the generation of CO₂ emissions, directly favouring households and business on Lolland -that would save on energy bill and on carbon tax. An important transitional factor emerges from the analysis: energy consumption and emissions are projected to increase when mega projects are implemented both due to their energy consumption and their positive impact on GDP. On the other hand, most of the energy needed to build and run this infrastructure would be generated using renewable energy, greatly reducing the carbon intensity of these projects and risks related to energy price volatility. Worth noting, with the allocation of green investments and the creation of mega projects that generate employment opportunities, -often high quality jobs for skilled candidates- the municipality of Lolland is in need to improve its social services, as well as develop its infrastructure. It is estimated that, when accounting for extra expenses for social services and public infrastructure, the policy driven investment at the municipal level would likely grow considerably. Without support from the national government, allocating funds to large renewable energy projects, the municipality could face debt issues, especially in the short term. Concerning the medium to longer term, the success story of Denmark is based on coordinated action at the national level, where carbon taxes are collected at the national level, and partly redistributed to municipalities to reduce their carbon intensity. The economic growth generated by these investments ensures sustainability in the longer term.
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