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State of the art report
Current use of energy and the role of RES

PROJECT: RES-CHAINS
PROGRAM: SOUTH BALTIC PROGRAM
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FOR: SOUTH BALTIC PROGRAM USERS
DATE: DEC 2011

Abstract

This report presents a summary of the use of energy and the role of renewable energy sources in the regions covered in the RES-CHAINS project.

- It is clear from this report that the development of renewable energy is not limited by the access and availability of resources but that state legislation) and technicalities are major obstacles.
- With land-based wind power, the capacity factor is about 19-20 % but this can be almost doubled with off-shore installations. Today's experiences from off-shore installations are indicating that there are no technical hindrances.
- The use of residues from agriculture and from forestry is well established or heat and for CHP-production and there is no reason whatsoever not to make full use of these resources an any region.
- It is also clear that even in smaller rivers with limited heads may hydropower produce a significant amount of energy. From the case studies it is also clear that such small-scale hydropower installations can also contribute to the conservation of cultural assets – and not only to the energy balance.
- Finally, one may conclude that also in the South Baltic, geothermal energy may provide significant amounts of renewable energy even in regions where it might not be the first thing that comes in mind.

THIS PROGRAM IS PART FINANCED BY THE SOUTH BALTIC PROGRAM AND THE EUROPEAN UNION.

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The global outlook

The questions of energy supply and climate change are global and to set the regions in an over-all perspective it is good first to have a general outlook. One of the most well-renowned sources for energy statistics is the International Energy Association (IEA). The following data are adapted from *Key world energy statistics – 2012*, www.iea.org/publications/freepublications/publication/kwes.pdf.

Due to the recalculations and re-arrangements of the original statistical data, the numbers in the following tables do not exactly reproduce the original data from the IEA but deviations are small and the main aim is only to convey the over-all picture. It shall also be understood that not even the original data always sum up to 100 % but there are insecurities also in the original data.

	Net energy production 1973 – by sources – PWh/year							
	Coal/peat	**Crudeoil**	**Ref. oil**	**Foss.gas**	**Nuclear**	**Hydro**	**Bio/waste**	**Other**
Tot:	7.37	0.19	22.93	7.37	0.19	1.28	7.43	≈ 0
(el)	*2.32*	*0.08*	*1.25*	*0.76*	*0.19*	*1.28*	*0.01*	≈ 0
	Net energy consumption 1973 – by sectors – PWh/year							
Ind:	4.21	0.19	5.02	4.15			1.06	≈ 0
Trsp:	0.38	≈ 0	11.85	0.21	Cannot be separated		≈ 0	≈ 0
Dom:	2.78	≈ 0	6.06	3.02			6.19	≈ 0

Table 1a: Over-all energy data adapted and re-calculated from IEA statistics.
Original data, *Key world energy statistics – 2012*, IEA 2012

	Net energy production 2010 – by sources – PWh/year							
	Coal/peat	**Crudeoil**	**Ref. oil**	**Foss.gas**	**Nuclear**	**Hydro**	**Bio/waste**	**Other**
Tot:	9.50	0.22	34.21	13.58	2.59	3.44	13.43	21.33
(el)	*7.68*	*0.12*	*0.81*	*3.61*	*2.59*	*3.44*	*0.35*	no data
	Net energy consumption 2010 – by sectors – PWh/year							
Ind:	7.88	0.15	3.61	5.39			2.28	8.87
Trsp:	0.04	≈ 0	25.54	1.04	Cannot be separated		0.67	0.28
Dom:	1.58	0.08	5.07	7.13			9.87	12.17

Table 1b: Over-all energy data adapted and re-calculated from IEA statistics.
Original data, *Key world energy statistics – 2012*, IEA 2012

The total increase in energy consumption from 1973 to 2010 has thus been 85.7 %and this has been an approximately linear increase. However, looking at the distributions as shown in table 2 below, reveals a few interesting trends.

	Change (%, 1973 reference) in net energy production by source							
	Coal/peat	**Crudeoil**	**Ref. oil**	**Foss.gas**	**Nuclear**	**Hydro**	**Bio/waste**	**Other**
Tot:	+29	+16	+49	+84	+1 260	+169	+81	+∞
(el)	*+231*	*+50*	*–35*	*+375*	*+1 260*	*+169*	*+3 400*	no data
	Change (%, 1973 reference) in net energy consumption by sector							
Ind:	+87	–21	–28	+30			+115	+∞
Trsp:	–90	-	+115	+395	Cannot be separated		+∞	+∞
Dom:	–43	-	–16	+136			+60	+∞

Table 2: Over-all energy data adapted and re-calculated from IEA statistics.
Original data, *Key world energy statistics – 2012*, IEA 2012

As seen from the upper part of table 2, the relative increase in energy production has occurred for all energy sources. For nuclear energy, the total increase from 1973 to 2010 has been 1260 % yielding that the total production of electricity from nuclear plants was 13.6 times bigger in 2010 than it was in 1973. For renewables, hydroelectricity is the one showing the fastest growth so that the production in 2010 was 2.69 times the production in 1973, followed by biomass and waste.

Looking aside from nuclear power production, there has been a change in the electricity production so that the use of refined oil fuels for electricity production has decreased and has been replaced mainly by fossil gas, coal and crude oil. The main part of the increase in coal-based electricity production is due to the rapid expansion in China from the mid 1990's. There has also been a huge relative increase in the amounts of biomass and waste used for electricity production but the total output (see table 1b) from these plants is still only about 10 % of the total output from fossil-gas-fired power stations.

Finally, table 2 reveals that the consumption patterns have changed so that industry has switched from using liquid oil fuels to using coal and gas, fossil gas has been introduced into the transport sector and biomass and waste are increasing in industrial use, in the transport sector and in the domestic sector alike.

1.1 The federal European outlook

European energy statistics as available in the publication *EU Energy in figures*, 2012 issue, available from ec.europa.eu/energy/publications/doc/2012_energy_figures.pdf, are not exactly compatible to the IEA statistics.

	Net energy production 2010 – by sources – PWh/year, EU27						
	Solid	**Petroleum**	**Gases**	**Renewable**	**Waste**	**Electric**	**Heat**
Tot:	0.58	5.31	3.12	0.91	0.04	*2.84*	*0.62*

Table 3: Over-all energy data for the EU.
Original data, *EU Energy in figures*, The European Commission 2012

Just as for the rest of the world, the energy supply within the European Federation is based on liquid petroleum fuels followed by gas but solid fuels play a significantly smaller role in the EU than it does from a global perspective. Total energy consumption in EU27 amounts to 40.8 MWh/capita and electricity accounts for 5.6 MWh.

The total energy consumption in 2010 amounted to 13.41 PWh, 25.3 % of which was consumed in the industrial sector, 31.7 % used for transports, 26.6 % in households, 13.2 % used in public and commercial services and about 3 % used in agriculture, fishing and other sectors. With a gross supply about 20.46 PWh, the total efficiency in the system becomes 65.6 %.

While the total share of renewables according to the IEA ("*biofuels-and-waste*" + "*hydro*") amounts to about 15 % of the total energy used, the corresponding number in EU 27 was just below 12 % in 2009. It must then be stressed that the IEA statistics does not distinguish between renewable wastes and non-renewable, so the IEA number referred above will be at the high end.

The renewable electricity in the European federation 2010 is mainly hydropower (397.7 TWh), wind power (149.1 TWh), biomass and renewable waste (123.3 TWh), solar PV 23.1 TWh and geothermal, 5.6 TWh. Tidal and wave power production is still mainly at the experimental stage and contributed only 0.5 TWh in 2010.

1.2 The states in the South Baltic region

The current project deals first with the South Baltic region and more specifically with only some of the regions around the Southern periphery of the Baltic Sea.

Data in this section are from *EU Energy in figures*, The European Commission 2012.

1.2.1 Denmark 2010 – 5.5 million, 224.4 TWh, 19.9 % RES

With a total population of 5.5 million and a per capita energy resources consumption equal to 40.5 MWh (electricity 5.8), Denmark is one of the states represented in the study. The energy production is dominated by crude oil and liquid petroleum fuels (80.2 TWh) and fossil gas (51.1 TWh) followed by hard coal (44.2 TWh) and complemented by renewables (45.4 TWh). Another 3.6 TWh are supplied by biogas, waste and other sources.

The total consumption equals 82.8 % of the total supply yielding losses 17.2 % which puts Denmark up front with respect to total efficiency. The industry sector consumes 15.6 % of the total energy, the transport sector 33.8, households 31.8, public and commercial services 13.6 and other sectors the remaining 5.2 %.

In Denmark, target values are that in 2020, the total share of RES shall be 30 % and specifically for the transport sector the target is 10 %.

1.2.2 Germany 2010 – 81.8 million, 3 908.8 TWh, 9.8 % RES

The German energy was, 2010, based on crude oil and gas-derived liquid fuels (1 126.9 TWh) and on fossil gas (853.6 TWh) followed by brown coal (454.7 TWh), hard coal (441.9 TWh). Petroleum-based fuels accounted for 201.2 TWh and renewables total 379.1 TWh. Total fuel input to the nuclear power stations was 422.2 TWh corresponding to an electricity output of 140.6 TWh. The remaining energy was mainly supplied from waste combustion. Per capita energy supply amounts to 47.8 MWh (electricity 6.5).

The total consumption equals 64.4 % of the total supply yielding losses 35.6 %. The over-all energy efficiency in the German energy system is the lowest of all the states represented in this project. The industry sector consumes 27.9 % of the total energy, the transport sector 28.6, households 28.6, public and commercial services 14.8. Other sectors are marginal.

German target values are a total share of RES 18 % by 2020 and 10 % for the transport sector

1.2.3 Lithuania 2010 – 3.3 million, 80.2 TWh, 17.0 % RES

In Lithuania, the energy supply is based on equal shares petroleum and petroleum-based fuels (30.2 TWh) and fossil gas (29.1 TWh) complemented by renewables (12.8 TWh), hard coal (2.3 TWh) and electricity import making up for the rest. Lithuania has lower annual per-capita energy consumption than most of the Baltic states, 24.3 MWh/person, and also a lower specific electricity consumption, 2.5 MWh.

The total consumption equals 66.7 % of the total supply yielding losses 33.3 %. The industry sector consumes 19.6 % of the total energy, the transport sector 32.6, households 37.8, public and commercial services 13.0. Other sectors are marginal.

In Lithuanina, the target values are a total share of RES 23 % by 2020 and 10 % for the transport sector

1.2.4 Poland 2010 – 38.2 million, 1 182.8 TWh, 8.9 % RES

The Polish energy supply system is based on coal (hard coal 557.1 TWh, brown coal 77.9 TWh), on crude oil and petroleum-derived liquid fuels (271.0 TWh) and fossil gas (148.9 TWh). Renewables (84.9 TWh), waste and other petroleum product fuels make up for the rest. The total energy turnover per capita amounts to 31.0 MWh whereof electricity 3.1 MWh.

Total inland consumption (772.2 or 65.3 % of total input) is distributed among industry (23.2 %), transport (26.5 %), households (31.6 %), public and commercial service (13.0 %) and other sectors like agriculture, fishing etc (5.7 %).

Polish target values are 15 % total share of RES by 2020 and 10 % for the transport sector

1.2.5 Sweden 2010 – 9.4 million, 597.8 TWh, 47.3 % RES

The Swedish energy supply system is unique by it huge share of renewables (hydroelectricity and biofuel), 202.4 TWh while the transport sector still is operated using petroleum-based fuels (168.6 TWh). Condensing nuclear power electricity production (efficiency 33 %) demanded 173.3 TWh of fuel input, delivering 57.8 TWh of electricity. The remaining energy input was mainly supplied by hard coal (23.3 TWh), fossil gas (15.1 TWh), waste and brown coal making up for the rest. The specific energy consumption amounts to 63.7 MWh/capita, by far the highest among the states in the region, whereof electricity 14.0.

Total inland consumption (398.9 or 66.7 % of total input) is distributed among industry (36.7 %), transport (25.1 %), households (22.2 %), public and commercial service (14.3 %) and only less than 2 % for other sectors like agriculture, fishing etc.

The Swedish target values are 49 % total share of RES by 2020 and 10 % for the transport sector

The regions and their main characteristics

The regions involved in the project each have its own characteristics with respect to geography, to infrastructure and to natural resources. This has a great impact on the potential use of renewable energy sources and is outlined in these introductory sections.

2.1 Denmark/Guldborgsund

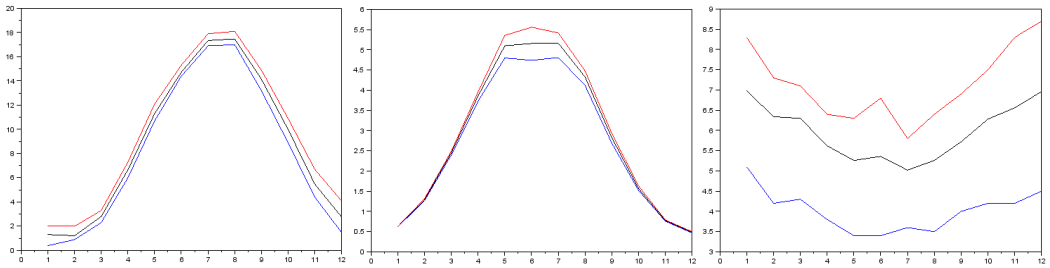

Figure 1: Over-all climate data as reported from the weather stations in Omø, Langø, Maribo, Møn and Næstved.
Data from the ret-screen database, http://www.retscreen.net/.

The left diagram shows monthly temperatures, minimum, maximum and average in °C. The middle diagram shows monthly values for the insolation to a horizontal surface, kWh per day and per m². The rightmost diagram shows monthly values for the wind speed, m/s.

Guldborgsund Municipality covers an area of 903.4 km² with a total population of 62 197, 68.8 inhabitants per km².

71 % of municipal land is used for growing agricultural crops. The forestry sector uses another 12 % of the area, while the remaining 17 % is used for a variety of purposes – urban area, protected landscapes, tourism, etc.

The total employment in 2010 was 28 092 persons with an employment rate of 74.9 %, which is close to the national average of 75.2 % (employment rate: Number of employed persons related to the size of population between 16-64 years). The employment in agriculture, forestry, fishery and industry represent altogether 22 %.

2.2 Germany/Mecklenburg

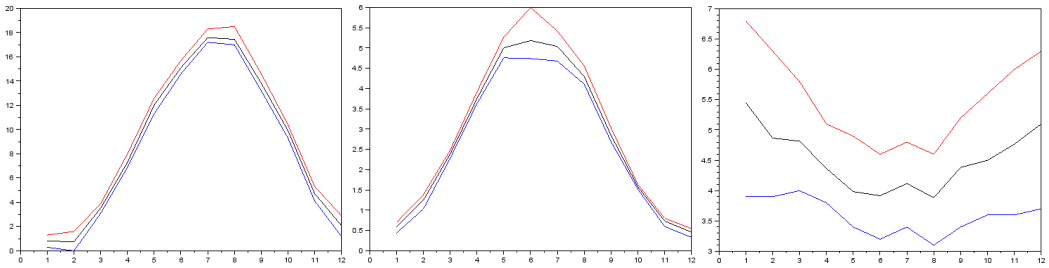

Figure 2: Over-all climate data as reported from the weather stations in Boltenhagen, Heiligendamm, Warnemünde, Greifswald, Teterow and Laage.
Data from the ret-screen database, http://www.retscreen.net/.

The left diagram shows monthly temperatures, minimum, maximum and average in °C. The middle diagram shows monthly values for the insolation to a horizontal surface, kWh per day and per m². The rightmost diagram shows monthly values for the wind speed, m/s.

The total area of the state of Mecklenburg-Vorpommern amounts to more than 23 000 km² with a total population about 1.7 million. With 70 inhabitants per km², M-V is Germany's federal state with the lowest population density.

The landscape was formed by the Ice Age: the Ridge of Mecklenburg, the Mecklenburg Lake District and the heath landscapes in the east and the west. One fifth of the state is covered with forests. Water covers six percent of the total area. With its water surface of 110 km² Müritz Lake is the largest German lake. Mecklenburg-Vorpommern's longest river is the Elde, which flows into the Elbe and is navigable within the state borders over a distance of 178 km. The Helpt Mountains at 179 metres above sea level constitute the highest elevation. The outer coastline of Mecklenburg-Vorpommern is 381 km long, 245 of which are bluffs.

Outside the industrial centres, Rostock, Schwerin and Wismar, agriculture and tourism are the most important fields of industry. It is mainly the rich cultural heritage, the unique natural environment and the multitude of cultural and recreational offers that make the country a popular tourist destination, with the Baltic Sea coast and the lake districts as the most established ones.

2.3 Lithuania/Klaipeda

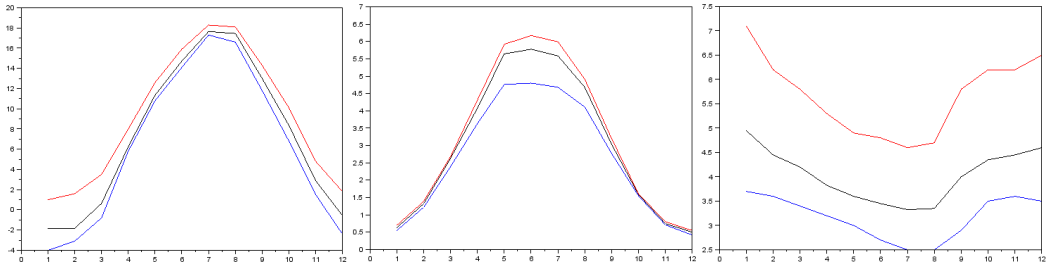

Figure 3: Over-all climate data as reported from the weather stations in Laukuva, Liepaja, Telsiai and Rybachiy. Data missing from Klaipeda itself.
Data from the ret-screen database, http://www.retscreen.net/.

The left diagram shows monthly temperatures, minimum, maximum and average in °C. The middle diagram shows monthly values for the insolation to a horizontal surface, kWh per day and per m². The rightmost diagram shows monthly values for the wind speed, m/s.

The Klaipeda region, in the western part of Lithuania covers 5 209 km² (8% of the area of Lithuania) and has a population of 366 902 (11.3% of the population of Lithuania corresponding to 70.4 per./km².

Almost half the population in the region lives in the administrative centre of the region – Klaipeda city (177 812 persons). Urban areas are extensive, making up a total of 20.4 % of the whole area. Agricultural land is 25.1 %, forests 18.2 %, water bodies 11 %, roads 4.6 % and other land 20.6 %.

The role of Klaipeda as the only Lithuanian seaport on the national scale is of particular importance. It is a symbol of Lithuania as a maritime country; therefore, urban development, architecture and planning first of all reflect its maritime character. Maritime industry (shipbuilding and repairs), maritime business (fishing, fish processing), sea transport (the seaport, terminals), centres for the preparation of marine professionals (agency service for ships) are being developed.

Small and medium businesses prevail in the Klaipeda region. The largest share of all enterprises is comprised of those engaging in retail trade and provision of services to the population, wood and stone processing, provision of agricultural and forestry, fishing, fish processing, as well as accommodation and catering services, well-developed manufacture of furniture, flax processing, real estate, renting, construction and repair, car transport, car repair. Today's development include building materials, oil extraction, chemical, food industry is being developed.

2.4 Poland/Pomerania

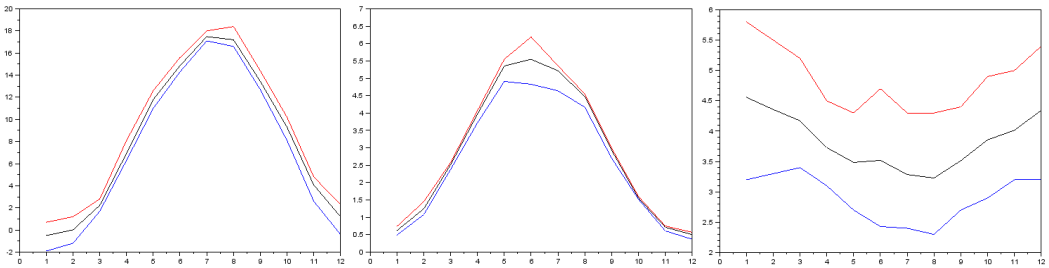

Figure 4: Over-all climate data as reported from the weather stations in Ustka, Leba, Gdynia, Gdansk/Swibno, Elblag, Chojnice and Lebork.
Data from the ret-screen database, http://www.retscreen.net/.

The left diagram shows monthly temperatures, minimum, maximum and average in °C. The middle diagram shows monthly values for the insolation to a horizontal surface, kWh per day and per m². The rightmost diagram shows monthly values for the wind speed, m/s.

Pomerania covers an area of 18 310.34 km², and accounts for 5.9 % of the country. The region has 316 km of coastline, which constitutes about 60 % of the whole coastline of the country. Based on data from December 2010 the total number of inhabitants is 2 240 319 (122.3/km²), of witch 1 477 693 live in cities.

Pomerania is the most forested area in the country (36% of the region). In Żuławy (east Pomerania) there are the biggest depression areas in Poland. The region lies in the river basin of Vistula and it is full of lakes (there are around 450 lakes bigger than 1 ha in size). The highest point in Pomerania is Wieżyca (329 m above sea level). There are also two national parks. The most precious is the Slovinian National Park, which was in 1977 added to the list of UNESCO World Biosphere Reserves.

Gdańsk is the capital and the biggest city of the region with 461 600 inhabitants. With two other cities – Gdynia and Sopot – it composes the Tri-city agglomeration. Gdynia is a dynamically developing city holding a modern port established in 1926. Sopot is a seaside resort, centre of culture and national capital of summer with a modern services sector. The combined population, nearly 750 000 inhabitants, amount to 33 % of the population of the region.

Foreign investments in Pomerania are particular in the production of paper, electronics, food, furniture, means of communication, cosmetics and packaging.

2.5 Sweden/Blekinge

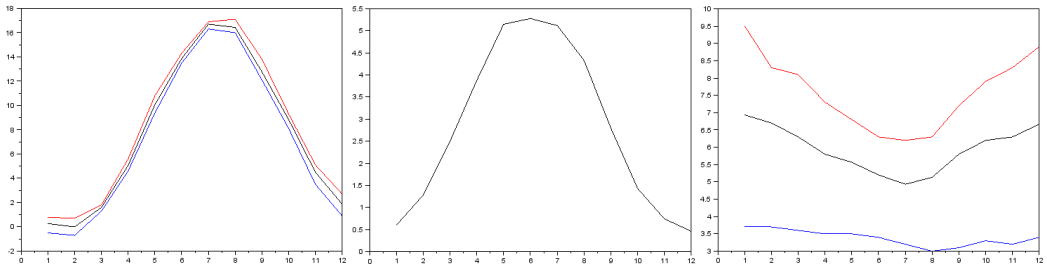

Figure 5: Over-all climate data as reported from the weather stations in Hanö, Ronneby and Ungskör.

Data from the ret-screen database, http://www.retscreen.net/.

The left diagram shows monthly temperatures, minimum, maximum and average in °C. The middle diagram shows monthly values for the insolation to a horizontal surface, kWh per day and per m². In this case, you will observe that all three stations report the same monthly means for the insolation. The rightmost diagram shows monthly values for the wind speed, m/s.

Blekinge covers an area of 2 941 km² and has a population of 153 000, 52.0 persons/km². The population is concentrated along the south coast were also the 4 cities in the county are located.

Going from the north border, at an altitude about 130-170 m above sea level, towards the Baltic Sea coast in the south, several landscape types can be observed. The northern part is dominated by forests but one can also find lakes and some low mountains. Here the forests consist mainly of conifer trees. Then follows the mosaic landscape where forests are still common but mixed with open farmland. Closer to the cost the farmland dominates the landscape and here one finds areas with good fertile soil and many deciduous trees. The southern coast is very broken and surrounded by a vast archipelago, especially in the eastern part, outside of which there are also larger islands with year around population. Blekinge has quite a mild climate due to its location along the Baltic Sea coast. The northern parts has a climate more like the inland north of Blekinge, it's colder and there is normally more snow during the winter.

The capital of Blekinge is Karlskrona, the most eastern city. The other cities are Ronneby, Karlshamn and Sölvesborg. In the northwest corner is the municipality of Olofström.

Economic development is comparatively good, primarily in the manufacturing and automotive industries. The most rapid development occurs primarily in Karlskrona and Karlshamn, but also the other regions are beginning to see a brighter future. The county has gone from an economy characterized by industry to a more modern knowledge and information society with a large element of private services.

2.6 Sweden/Skåne

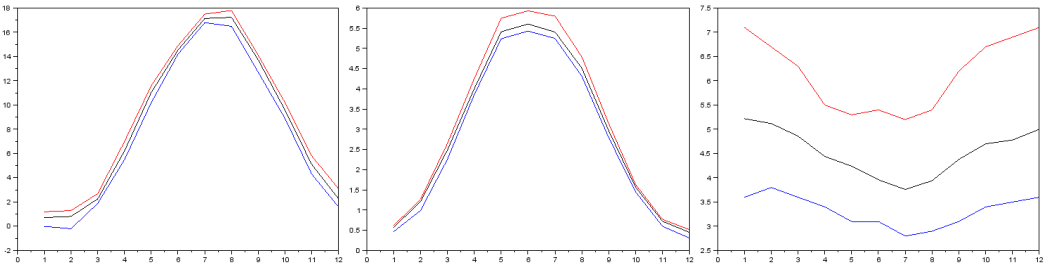

Figure 6: Over-all climate data as reported from the weather stations in Lund, Helsingborg, Falsterbo, Sturup and Skillinge.
Data from the ret-screen database, http://www.retscreen.net/.

The left diagram shows monthly temperatures, minimum, maximum and average in °C. The middle diagram shows monthly values for the insolation to a horizontal surface, kWh per day and per m². The rightmost diagram shows monthly values for the wind speed, m/s.

Skåne covers an area of 11 027 km². In comparison to other Swedish regions, Skåne is densely populated. 13 percent of the total population of Sweden live in Skåne yielding a population density about 113.3 persons/km². The population is growing by over 10 000 persons every year.

Almost half of the land is farming land. Land covered by forest is just 30 percent which is less than in any other region in Sweden. Only Stockholm has a higher percentage of built-up areas. Unlike the rest of Sweden, there are only a few remaining natural grasslands and wetlands.

The biggest cities are Malmö, Helsingborg, Lund, and Kristianstad. Biggest is Malmö with 270 000 inhabitants and directly connected to Copenhagen by the ten-year old Öresund Bridge. The bridge has had a huge economic impact of the Öresund region and led to a more integrated labour market between Malmö and Copenhagen. On average, the population of Skåne is younger than in the rest of Sweden.

The region holds approximately 41 000 workplaces with at least one employee. The largest private companies are Peab, Tetra Laval, Posten, Skanska and Sony Ericsson. With around 2 000 employees, E.ON AG belongs to the 15 biggest employers.

The majority is employed in the service sector and only 14 percent are employed in manufacturing or mining industries. However, it is important to remember that although employment in heavy industries is decreasing, it is still an important part of the economy. In 2008, there were over 5 000 employees working in the energy, water and environmental sector.

2.7 Sweden/Småland

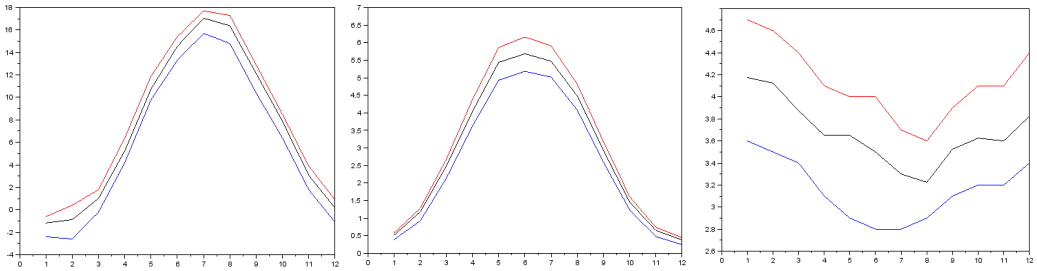

Figure 7: Over-all climate data as reported from the weather stations in Jönköping, Kalmar (2 stations) and Växjö.
Data from the ret-screen database, http://www.retscreen.net/.

The left diagram shows monthly temperatures, minimum, maximum and average in °C. The middle diagram shows monthly values for the insolation to a horizontal surface, kWh per day and per m². The rightmost diagram shows monthly values for the wind speed, m/s.

Kronobergs län is 9 426 km² whereof 9.4 km² are lakes. The population amounts to about 185 000 whereof the total work force is 95 000. The county is split in eight communes ranging from 8 000 inhabitants to 84 000 and the over-all population density is 20 persons/km². The unemployment rate is 9.5 % and is un-evenly distributed over the communes ranging from 7.2 % up to 13.8.

Kronoberg is densely forested and is a centre for wood-based small- and large-scale industry like joineries, furniture manufacturing, saw-mills and pulp- and paper industry. The majority of the forest land (about 80 %) is private owned with a mean size of the individual farms about 50 hectares. These relatively small lots (as compared to Northern Sweden) affects the technologies and the practices used in silviculture and are partly an explanation to the relatively large number of small entrepreneurial companies in the area. 22 % of the workforce is employed in industry, wood-based industry dominant followed by small-scale mechanical industry.

Use of RES in the regions

To following sections bring up only some of the installations from the different regions. The aim is to bring up the most important types of RES in each region and to summarise them. Detailed data can be found in the state-of-the-art reports from the individual regions but the aim here is only to put forward some of the most prominent examples from the regions. Total production capacity is related to the number of inhabitants in the region so as to give an indication of the importance of the different types of RES and if they may, for example, contribute significantly to the economy of the region.

3.1 Guldborgsund

The state-of-the-art report for Guldborgsund accounts for 25.6 MWh/p·year as compared to the average Danish energy consumption 40.5 MWh.

The use of renewable energy began in Guldborgsund area in the early 1980 s. The main driving forces were local initiatives launched by the former Storstrøm County, the six municipalities that are now merged into Guldborgsund Municipality and NGOs, civic initiatives, etc.

Wind power and biomass are the main resources, utilized in the municipality. Biomass has been and are used in many different technologies: Straw-and wood-fired heating systems, both individual and collective heat supply, combined heat and power on straw, biogas plants and in waste incineration.

3.1.1 Wind – 10.4 MWh/person

The total wind power installed on-shore amounts to 66.3 MW, basically all installed before 2000. 2010, the land-based wind mills produced a total of 111 GWh corresponding to a total capacity factor 19.1 %. In 2003, a major off-shore wind park was taken into operation comprising 72 turbines, each 2.3 MW. The total production from this park amounted to 526 GWh in 2010, corresponding to a total capacity factor of 36 %.The difference is significant and clearly demonstrates the advantage with off-shore based wind power production.

3.1.2 Biogas – 0.45 MWh/person

The two major biogas plants Nysted and Nykøbing – both using agricultural waste and manure for substrate – produce altogether approximately 28 GWh of electricity (7 GWh) and heat on an annual basis.

3.1.3 Solar thermal – 0.1 MWh/person

As for solar energy, the focus of interest is on large collective solar heating plants. In the autumn of 2011 a large solar heating plant was put into service in Væggerløse in connection with Sydfalster Varmeværk. The solar heat plant consists of 966 solar panels, each 12.5 m², and thus a total of 12 000 m² of solar panels, which are expected to produce about 6.2 GWh of heat on an annual basis.

3.2 Mecklenburg

The state-of-the-art report for Mecklenburg accounts for 31.5 MWh/p·year as compared to the average German energy consumption 47.8 MWh.

Renewable Energy Sources are established in Mecklenburg-Vorpommern mainly because of the Ministry of Environment. The ministry actively promoted RES from 1999 to 2006 before it was merged with the Ministry of Agriculture and the explicit and trendsetting support of RES grew to the level of support that was required by the German state policy.

As a result of the geographical and demographic conditions in Mecklenburg-Vorpommern, wind energy is the most established RES in MV, followed by solar and bioenergy. The fourth RES relevant for MV is geothermal energy. No other forms have been established on a significant level so far.

3.2.1 Wind – 1.5 MWh/person

The total installed wind-power production capacity in Mecklenburg-Vorpommern 2010 was no less than 1 549 MW in 1 356 installed turbines. The mean turbine size thus becomes 1.1 MW. The total production in 2008 amounted to 2 590 GWh yielding a capacity factor of 19.1 %. Until 2020, plans are not only to expand the land-based wind power by almost 700 GWh but also to install a total capacity corresponding to 6 850 GWh of off-shore wind farms. These will be large-scale turbines ranging basically from 3 – 6 MW.

3.2.2 Biogas – 0.65 MWh/person

While the use of solid biomass for energy was dominant to biogas in 2005, 252 GWh compared to 112, the picture has changed and in 2008 the situation was instead that solid biomass accounted for 287 GWh and biogas had advanced to 859. Until 2020 a further expansion of biogas utilisation up to 1 500 GWh is expected while the solid biomass will remain at a low level, 430 GWh.

The total biogas production in 2010 was already 1 100 GWh to which come another almost 95 GWh from biogeneous waste. The expansion is based on two foundations: Some of the expansion is in large-scale plants equipped with upgrading equipment and aimed to feed gas into the fossil-gas pipeline system, the other part of the expansion is expected in the small-to-medium size sector including farm-scale plants.

3.2.3 Geothermal – 0.04 MWh/person

There are three geothermal plants in Neustadt-Glewe, Waren and Neubrandenburg and the related engineering competences bring Mecklenburg-Vorpommern into a top position in Germany.

The state government has promoted geothermal energy so far by initiating two dedicated projects "*Opportunities of current production from hydrothermal geothermal energy*" and "*Regional centres of health industries based on thermal resources in Mecklenburg-Vorpommern*".

Concrete actions aiming to use deep geothermal energy have been limited to a further technical extension of existing plants after 1990. The high drilling risk and the necessary infrastructure for heat consumption (i.e. the demand for district heating systems) are the most relevant arguments against a development of new sites.

However, already the existing sites contributed a total of 61 GWh in 2008 and an expansion to 280 GWh is anticipated until 2020.

3.2.4 Solar PV – 0.02 MWh/person

Mecklenburg-Vorpommern has very good conditions for using solar energy, for electricity as well as for thermal use. Solar cells are manufactured in Wismar and Greifswald and there are also dedicated research activities connected to the centre of promotion and education in Wietow. The development activities related to solar energy use can be further.

Thus, it is no surprise that the use of solar energy has been largely extended here over the last years. In total, solar panels with a total capacity 388 MW have been installed in Mecklenburg-Vorpommern since 1992 providing 28 GWh during 2008. In 2010, Germany's largest individual plant was installed in MV, with 25 MW power capacity. Current prognoses for the state aim to an annual production of about 150 GWh from 2020 on. Still, solar energy use is on an average level in comparison with other German states

3.3 Klaipeda

The state-of-the-art report for Klaipeda accounts for ????? MWh/p·year as compared to the average Lithuanian energy consumption , 24.3 MWh.

The Klaipeda region is leading in Lithuania in terms of use of RES in electricity production (as compared to installed capacity). The region hosts 41 power plants (253 total in Lithuania) with a total installed electrical power capacity 126.6 MW (378.9 MW total in Lithuania) and two of these are biomass fired, both having 1.5 MW turbine capacity. There are also dedicated heating plants and the total thermal capacity in the region is 147.4 MW (525.5 MW total in Lithuania) whereof about 100 MW is biomass fired.

Biogas is also of importance with the two plants in Dumpiai and Glaudenai.

3.3.1 Wind – 0.18 MWh/person

Klaipeda has the best wind resources in Lithuania due its geographical location close to the Baltic Sea. The first wind power projects were started in 1993. However, and due to the absence of proper legislation, the first wind turbine was installed only in 2002 in Skuodas. For the moment in Klaipeda region there are 19 wind power plants of total capacity 118.7 MW. Lithuanian legislation separates wind power installations in two ranges: small scale wind turbines with a maximum capacity up to 350 kW and large scale installations exceeding this limit.

The main future expansion of RES is expected in the form of off-shore wind parks.

3.3.2 Biomass CHP – 0.05 MWh/person

The two small-scale, biomass-fired CHP-plants CHP (each with a 1.5 MW turbine) are already in operation and will approximately produce 18-20 GWh of electricity per year, corresponding to approximately 0.05 MWh/person and year. The new plant planned in Klaipeda with its estimated capacity of 120 GWh of electricity will radically change the picture, but it is still only in the planning stage.

3.3.3 Landfill gas – 0.01 MWh/person

The Glaudenai landfill gas plant is one of the few installations making use of landfill gas in the present study. The biogas production in Dumpiai is more of a conventional installation in direct conjunction with a wastewater treatment plant.

3.4 Pomerania

The state-of-the-art report for Pomerania accounts for ????? MWh/p·year as compared to the average Polish energy consumption, 31.0 MWh.

The Pomeranian Voivodeship is supplied with electricity from a source located in the region and by energy transfer from the national system of high voltage power lines 400 and 220 kV. The total share of renewable energy in the overall energy balance is low and does not exceed 4%.

3.4.1 Wind – 0.06 MWh/person

Unfortunately there are development barriers related especially to limited possibilities for connection to the power grid. Other factors which are slowing down the development are lengthy procedures related to planning and to environmental impact assessment. This has delayed the expansion of wind power in the region though The Voivodeship has a fairly favourable climate for wind power development because of the location in the Baltic sea coast strip. In 2011 the total energy produced from wind in 21 power stations in Pomerania amounted to 141 GWh corresponding to 0.06 MWh/person.

3.4.2 Biogas - < 0.01 MWh/person

The potential for biogas production, possible to obtain from animal manure from the larger farms, is estimated at about 43.5 million m^3 of biogas per year. The technical potential of biogas production from the manure is 27.4 million m^3 of methane per year. The greatest technical potential of biogas production from animal manure is on the poultry farms, and then on the pig farms and cattle farms. The total potential thus amounts to some 190 GWh/year, corresponding to 0.08 MWh/person. However, today only a very minor portion of this potential is used.

3.5 Blekinge

The state-of-the-art report for Blekinge accounts for 47.7 MWh/p·year as compared to the average Swedish energy supply, 63.7 MWh.

The supply of biofuel has increased significantly if compared to the supply 1990. The county has a well-developed energy infrastructure. The grid and the regional network is the backbone of this infrastructure. One reason for this is the high capacity for transmitting electricity from the power station in Hemsjö in Olofström municipality and the oil-fired condensing power plant in Karlshamn. The power cable to transfer electricity to and from Poland is also part of this infrastructure.

Because of the industry structure of the region – the presence of a large pulp mill – black liquor is one major source of energy in the regional energy balance. The pulp mill delivers surplus heat to the district heating grid.

3.5.1 Biomass – 7.5 MWh/person

In Sweden it is common build new CHP plats using biomass, mostly wood chips. The electricity certificate system (green certificates) gives an incentive for these investments. As more heat is produced in the CHP plant it also stimulates the expansion of the district heating distribution networks.

As one example, a new CHP plant is built in Bubbetorp north of Karlskrona. The new district heating will replace energy mainly from oil-fired boilers and electric heating. The local electricity will be produced to replace imports, including from coal power plants. Conservative estimates show a reduced load on the environment. The new plant reduces air emissions to less than one fifth of what is emitted today.

Wood pellets are today an attractive alternative to oil heating in private houses and users of energy. It's often enough just to replace the oil burner with a pellets burner. Pellets are a high quality fuel, easy to handle and requiring a minimum of time for operation.

3.5.2 Hydropower – 0.5 MWh/person

The rivers flowing from north to south across Blekinge are extensively used for small scale hydro power. The production was 76 GWh during 2008. Many of the plants are old and there are many closed down mills and power stations that could be renovated and reopened. Building new dams is hardly a realistic alternative. The financial issue in combination with the difficulties to get permission makes it almost impossible, but only restoring and re-opening old and already existing installations might significantly increase the production capacity.

3.5.3 Wind – 0.3 MWh/person

With the location along the Baltic coast the wind conditions very good and suitable for wind energy development. The best wind conditions are along the cost and in the archipelago but there is also a number of areas with natural preservation status as well as many dwellings, both permanent and summerhouses. The navy and the air force have also put restriction on big areas limiting the number of sites where permission can be obtained. But there still are available sites and a number of projects are on-going. The production was 17 GWh in 2008 but has increased to 49 GWh during 2010 and the development continues.

The most interesting project is "Blekinge Offshore". The project intends to build 500 * 5 MW turbines 10 – 20 km south of Sölvesborg. Fully developed this park is estimated to produce 8 TWh per annum, i.e. 5 % of today's Swedish electricity consumption.

3.6 Skåne

The state-of-the-art report for Skåne accounts for 30.0 MWh/p·year as compared to the average Swedish energy supply, 63.7 MWh.

The region has much installed wind power compared to other regions in Sweden. Wind power plants are present in 26 out of 33 communes. Skåne is also well up front with respect to deep geothermal heat production where the district heating system in Lund is a good example, making use of an aquifer at 700 m as one of its major sources for production.

Like in Blekinge, there is again pulp production in Skåne providing a huge source of bio-based energy in the form of black liquor.

3.6.1 Biomass – 3.3 MWh/person

The district heating systems are well developed in Skåne. District heating networks are deployed not only in the cities and municipality centres but also in other, smaller localities. District heating is the dominating source for heating in the residential sector and has an increasing part also in the single-family housing sector. Anyhow, district heating networks are local, as generally in Sweden. Potentials for increased effectiveness have been identified by connecting district heating networks

in different parts of Skåne together. Pre-studies of such actions have been performed but any important measures in this direction have not yet been implemented.

It should also be mentioned that waste as a fuel is an important part of the RES infrastructure. In Skåne, waste fractions (MSW) provide district heating amounting to almost 1/3 of that produced by solid biomass.

3.6.2 Biogas – 0.3 MWh/person

Skåne is the region in Sweden where biogas production is most prominent. Today, biogas buses are common and in many towns, including Malmö, Helsingborg and Kristianstad, almost all the buses are gas powered. While today's annual production is a mere 334 GWh, the ambition is to bring this up to 3 TWh until 2020.

It is planned that all public buses in Skåne shall run on biogas by 2020. The number of gas-fuelled buses in the regional public transport operator's fleet is today 687 out of a total of 1034. The public city buses in all main cities in Skåne are today fuelled by gas, in some cities exclusively biogas and in others a blend of biogas and fossil gas.

Today approximately 1-2 percent of private cars are running on biogas in Skåne. To increase that number the accessibility to fuelling stations is a vital aspect. Today there are 15 public gas stations in Skåne and four filling stations for buses (bus depots). One problem is that the demand per filling station is still too low (about 1 GWh/year), which means that the investment cost for filling stations still is high in relation to the demand.

Conclusions and comments

From a climate and natural resources point of view, the regions in the South Baltic are similar. There are no major rivers with high heads for large-scale hydropower, the insolation is limited, the bedrock cannot provide high-temperature geothermal heat, average wind speeds range from about 3.5 to 7 m/s with a summer minimum in July/August and the daily temperatures range from just about 0 to almost +20 °C over the year.

At the same time, the states (Denmark, Germany, Lithuania, Poland and Sweden) have significantly different standards of living as is also reflected in the energy consumption. Using the household energy consumption as an over-all measure, one finds Lithuania 5.6 MWh/person at the bottom followed by Poland (6.4), Germany (8.8), Sweden (9.4) and Denmark taking the lead at 10.3 MWh per person and year.

Also the gross energy consumption vary within wide ranges, Lithuania 24 MWh/person, Poland 31, Denmark 40, Germany 48 and Sweden 64, and the same pattern is seen also in the gross electricity consumption ranging from about 2 MWh/person in Lithuania to 16 MWh/person in Sweden.

Now it must be said that the energy statistics provided by the European Federation are a bit ambiguous and to some extent contradictory. The publication *EU Energy in figures*, 2012 issue, available from ec.europa.eu/energy/publications/doc/2012_energy_figures.pdf, is the general

source of information for the numbers on state level but as will be found if you go to the "*Country profiles*" pages there are a number of misprints and internal contradictions in the tables. In this report, the tables have been interpreted using a critical mind and some values have been adjusted so as to make total sums fit and alike, but the result is that for the reader who wants to double-check the base data from the original publication it may be hard to reproduce the exact numbers presented in this report. However, the over-all picture still stands.

4.1 Guldborgsund – special conditions

Looking at the individual regions it is clear that Guldborgsund in Denmark is well up front producing an annual surplus of wind-based electricity. There are of course two reasons for this: First the community of Guldborgsund is small so even a modest amount of renewable energy will, when distributed over the population, give a very high number. Second the commune is situated on an island with intensive agriculture and apt possibilities for off-shore wind power. Hence it is not surprising that the use of biomass (i.e. straw from agriculture) and wind electricity form a basis in the local energy system.

But there are also external factors that need be taken into account. The Danish fossil gas pipeline network is not available in Guldborgsund, so as opposed to the main part of Denmark, gas is not an alternative but local energy solutions must be sought. A second major driving force has been state subsidies and support schemes for RES investments. When such schemes have been in effect, then investments into the relevant technology have taken place but in between these times, the rate of build-up of RES has been low.

4.2 Mecklenburg – active planning

In Germany as a whole, the decision to phase out nuclear power has put extra pressure on the energy sector. However, looking at Mecklenburg-Vorpommern, there has also been a long-time awareness that the electricity production and distribution systems need revising. The actions that have been taken in the Mecklenburg region include an overview and upgrading of the main grid so as to make room for distributed and intermittent power producers. In combination with planning efforts to assign areas for wind energy, on land as well as off shore, this has provided for a rapid expansion of wind-power production capacity.

Another part of the German energy politics at state level is the promotion of biogas production in connection with agriculture. Again, there are concrete plans for a future expansion and it is interesting that this development will follow two different lines. One of the tracks is to promote large-scale biogas plants with advanced upgrading and dedicated to inject the biogas thus produced into the fossil gas pipelines. The second track of development is to promote small-to-medium-scale biogas plants at individual farms. The second, farm-scale biogas, has been the backbone in the rapid expansion of biogas use in Germany during the last years and it is interesting that the local authorities are now taking measures also to promote large-scale production.

4.3 Polish Pomerania – huge resources

The over-all geography in Mecklenburg-Vorpommern is not radically different from that in the neighbouring Polish Pomeranian region, but the total, installed wind power production capacity is. To some extent this comes back to the active planning and promotion of wind power that has taken place in German Pomerania while, in Polish Pomerania there are (have been?) problems with the connection of new wind mills to the power grid. This has delayed the expansion of wind power in Pomerania, though the natural conditions are favourable.

Though the current use of renewable energy sources in Polish Pomerania is very small, only about half of the Polish average, resources is available and plans are to expand the use of biomass and the production of biogas, together with wind power production.

4.4 Klaipeda – biomass and wind

In the Klaipeda regions, resources are mainly biomass and wind but the expansion has not yet started to any major extent. As for wind-power, the legislation has been unclear with respect to feed-in tariffs and there have also been ambiguities with respect to planning permissions and land rights. New laws are now coming into effect and it is expected that the favourable wind conditions along the coast line will attract wind-power investors.

Biomass is used mainly for heat production and the total share of biomass in the heating sector amounts to about 112 MW out of a total of 147 MW in the region. This puts Klaipeda far up front in the country with respect to RES in the heating sector, though there is still a way to go when it comes to replacing fossil gas with biomass in the CHP sector.

4.5 Skåne/Blekinge – biomass and industrial

In Sweden as a whole, the main use of RES is in the form of forest residues used in small-scale district heating systems and in large-scale CHP-plants. The two southernmost regions Skåne and Blekinge are no exceptions though also wind-power is rapidly expanding in both regions.

However, there is one other system solution that is common in Sweden, and that is the integration of process industries with the district heating systems. Surplus heat is then sold from the process industry and delivered into the district heating network, giving an income to the company and saving operational costs for the community. Such win-win constructions are common country-wide and there are also examples in the Skåne/Blekinge region where pulp-and-paper industries (for example Nymölla) deliver heat to the nearby communities (Bromölla in the case of Nymölla).

4.6 Over-all conclusions

It is clear from this report that the development of renewable energy is not limited by the access and availability of resources but that state legislation (like for wind power in Klaipeda) and technicalities (like the access to the grid in Polish Pomerania) are major obstacles.

With land-based wind power, the capacity factor is about 19-20 % but this can be almost doubled with off-shore installations. Today's experiences from off-shore installations are indicating that there are no technical hindrances.

The use of residues from agriculture (straw in Denmark, manure for biogas in Germany) and from forestry (wood chips in Sweden) is well established or heat and for CHP-production and there is no reason whatsoever not to make full use of these resources an any region.

It is also clear that even in smaller rivers with limited heads (like in Blekinge) may hydropower produce a significant amount of energy. From the case studies it is also clear that such small-scale hydropower installations can also contribute to the conservation of cultural assets – and not only to the energy balance.

Finally, one may conclude that also in the South Baltic, geothermal energy (like in Mecklenburg-Vorpommern and in Skåne) may provide significant amounts of renewable energy even in regions where it might not be the first thing that comes in mind.