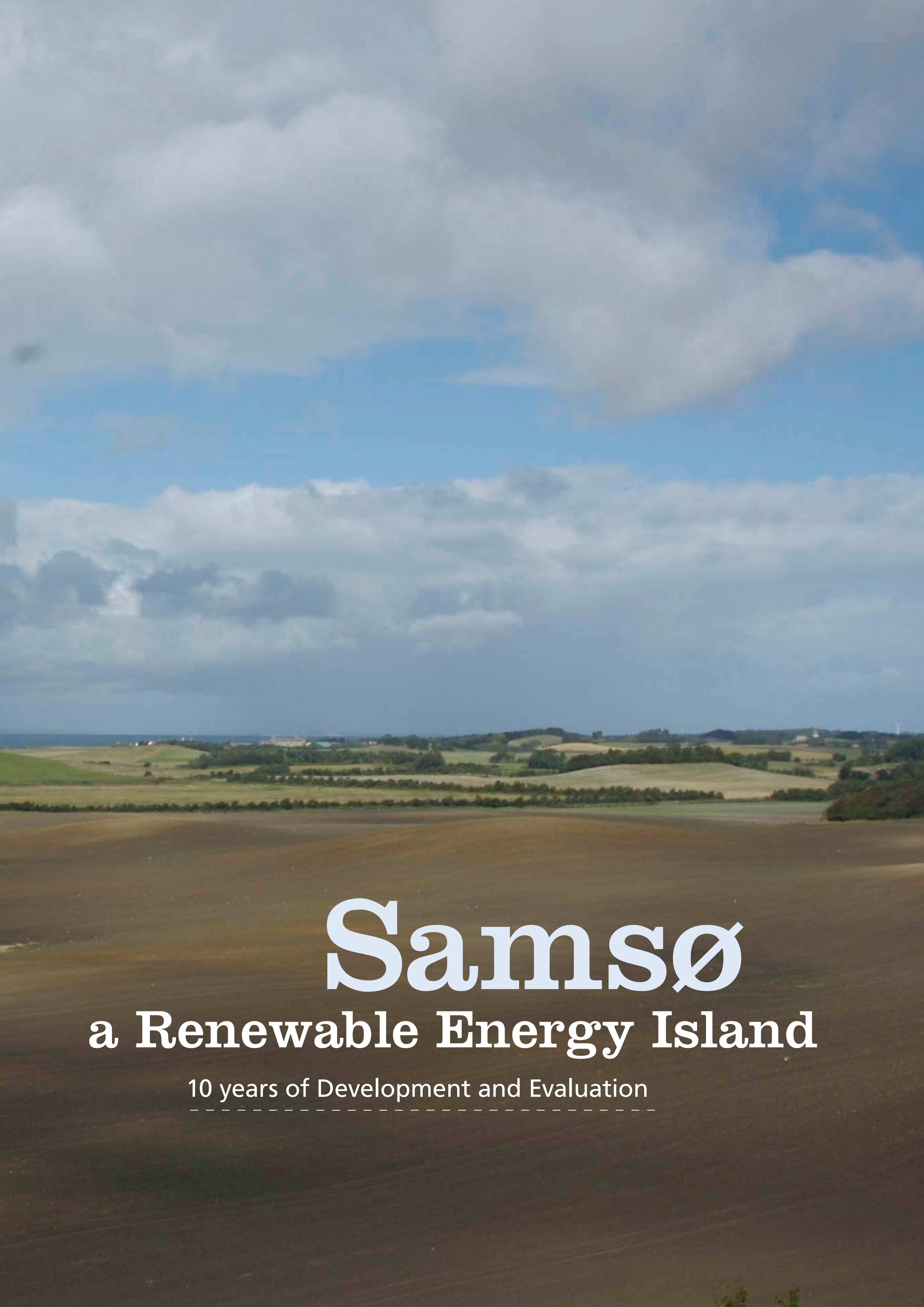

Samsø
a Renewable Energy Island

10 years of Development and Evaluation

"Think local - act local"

Søren Hermansen

Samsø - a Renewable Energy Island
10 years of Development and Evaluation

A description and evaluation of the last 10 years' work on Samsø towards 100% Renewable Energy.

PlanEnergi and Samsø Energiakademi 2007

Samsø – a Renewable Energy Island
10 years of Development and Evaluation

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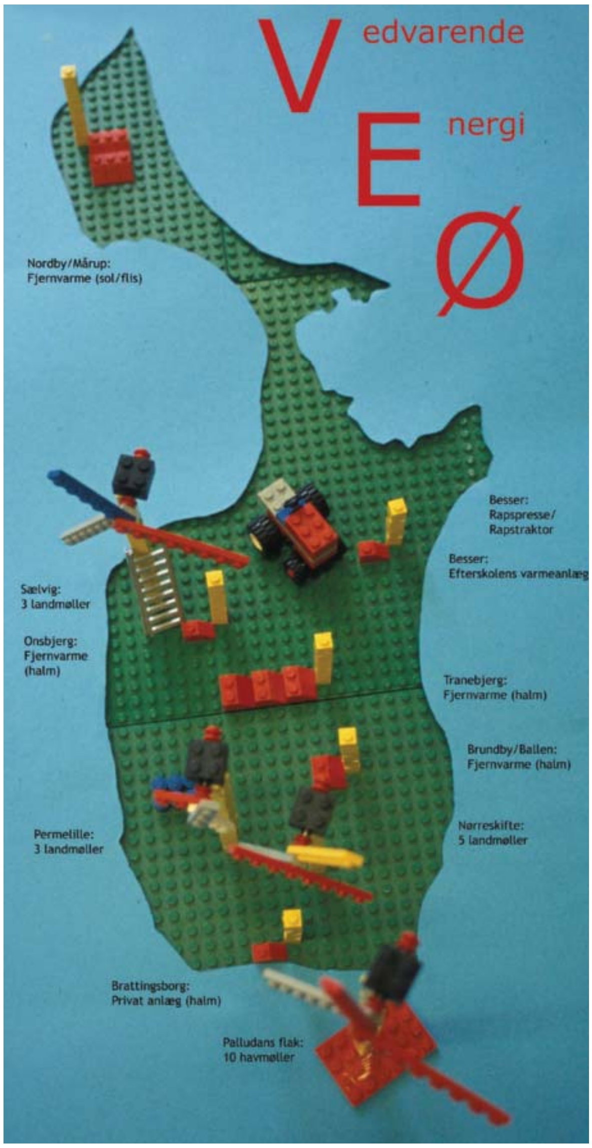
Contents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Efterskolens varmeanlæg
Sælvig:
3 landmøller
Onsbjerg:
Fjernvarme
(halm)
Tranebjerg:
Fjernvarme (halm)
Brundby/Ballen:
Fjernvarme (halm)
Permelille:
3 landmøller
Nørreskifte:
5 landmøller
Brattingsborg:
Privat anlæg (halm)
Palludans flak:
10 havmøller

Preface

The Ministry of Energy announced a competition in 1997. Which local area or island could present the most realistic and realizable plan for a 100 % transition to self-sufficiency with renewable energy? The Danish Energy Authority provided funding for the formulation of detailed plans for these transitions. Four islands and a peninsula participated in the competition: Læsø, Samsø, Ærø, Møn and Thyholm.

The background for the ministry's 1997 initiative was a report called Energy 21, which recommended an RE percent coverage of 35 % in the year 2030 for the country as a whole. With the above competition, the objective was to highlight renewable energy and study how high a percentage of renewable energy a well-defined area could achieve using available technology, and (almost) without extraordinary grants.

The competing master plans were to describe the available resources and how the transition could be made, with both technical and organizational explanations and descriptions. A priority in the ministry's competition was the reduction of energy consumption across sectors, specifically heating, electricity and transportation. Another top priority for the project was the degree of local participation. The business community, local authorities and local organizations had to support the proposed master plan to give it credibility. The technical solutions in the master plan were to draw primarily on available technology, but the master plan was also expected to envisage new ways of organizing, financing and owning the proposed RE projects. Finally, the master plan was to describe how the winner project would address its status as a demonstration and 'display window' for Danish RE technology to the rest of the world.

Samsø won the competition in October 1997. The Samsø master plan was judged the best and most likely to succeed by the Danish Energy Authority.

Since then, ten years have passed. How did the project and all its visionary ideas fare? It's time to evaluate the original master plan in terms of its implementation, to identify what was feasible and what could not be done. This evaluation will try to follow up on several different centres of focus. The evaluation is based on results up to 2005, as statistics for this year are the latest available. The conclusions made for the 2005 results will often underestimate the results to date, as the transition to RE is still underway on the island. The process has not stopped, but continues to develop and still generates many new initiatives and projects.

This evaluation is based on the energy statistics Samsø Energy Company has assembled for the years 1997, 1999, 2001, 2003 (estimates) and 2005 to follow the transition progress. Note that some of these statistics differ quite significantly from the original calculations in the master plan. The original figures must have suffered from incorrect data and other inconsistencies, which have been corrected for in the new calculations.

In the following, projects have been evaluated in terms of implementation or extent of implementation within the project period, relative to the original proposal from the master plan.

By Peter Jacob Jørgensen - PlanEnergi

1. Samsø

This description of Samsø will only encompass matters of relevance for the energy sector, for example, population figures and the economic community. The area of the island is, as of 1997, 114 km², and the island is about 26 km long and about 7 km wide at its maximum width.

1.1 Demographics

In 1997 the population of Samsø counted 4,366 people. According to the municipal prognosis, an increase in the population on Samsø was expected. A population of 4,400 people was expected in 2003. Contrary to expectations, the population dropped to 4,197 people in 2003 and has since decreased to 4,124 people in 2005.

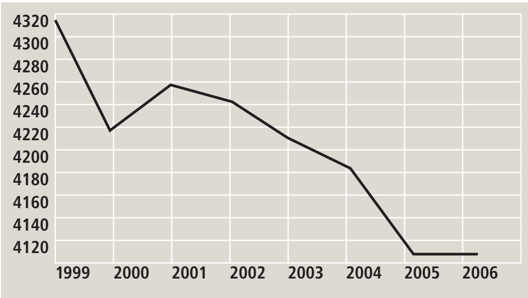


TABLE 1. Population of Samsø 1999 - 2006. Source: Statistics Denmark

The population is decreasing every year. As seen in table 1 the population decline is greater in 1999 and 2004 than in 1998 and 2005. As in other small island societies, no education is available after secondary school (age 15-16). Because of this, nearly all young people move away and only a few return to live permanently on the island. In the coming 5 - 7 years, the island baby boom kids are expected to move away, increasing the likelihood of a further decline in the population. Therefore, the Samsø Development Office is working hard to encourage new families to move to Samsø, and to create new jobs on the island.

1.2 The Economic Community

Table 2 shows the change in the number of employed islanders. This is also affected by the decreasing population. The difference between the number of jobs on Samsø and the number of working inhabitants on Samsø implies how many people commute to and from the island. In 2000 - 2003 more people commute to the island than away from the island. In 2004 and 2005 more people commute away from the island than to the island. Overall Samsø is not a place many people commute to or from, a status we share with most island communities. In October 2008*, better ferry connections to Jutland will be provided by two ferry lines. One ferry line plans to sail directly

	1995	2003	2005
Farming, fishing and extraction of minerals[1)]	401	306	288
Public administration	80	81	85
Social- and healthcare[2)]	361	387	333
Teaching[3)]	140	155	170
Production companies[4)]	220	116	115
Trade, hotels and restaurants[5)]	300	302	291
Transportation, post and telecommunication	180	147	159
Services	100	122	123
Building and construction[6)]	120	161	117
Financing and business services	100	161	150
Occupation in total	**2002**	**1938**	**1831**

TABLE 2. Number of employed individuals on Samsø.
Source: Samsø Udviklingskontor (Samsø Office of Development).

to Århus. These new connections will allow more people to commute to and from Samsø and make it possible for more people to move to Samsø. And it will probably increase energy consumption in the transportation sector.

	1998	1999	2000	2001	2002	2003	2004	2005
Population ultimo	4318	4233	4266	4251	4221	4197	4125	4124

TABLE 3. Population of Samsø. Source: Statistics Denmark.

The number and percentage of unemployed people living on Samsø is also related to the business community and its job potential. In recent years, the municipality has tried to reduce unemployment on the island.

As seen in table 3 the tendency follows the general decreasing population.

Comments on table 2:
1. Agriculture is still one of the two main business sectors on the island, lots of vegetables and fruit are exported from the island. The agricultural production also generates secondary production and goods transportation.

2. Social and health care have been rationalized and the local hospital now has limited health services.

3. Teaching. On the island there are three primary/secondary schools, two boarding schools for youths and one community college, the latter three attracting pupils from the mainland. One main reason for the increase in employment is thought to be the two boarding schools for youths and the community college.

4. Manufacturing. In 1999/2000, Samsø's pork slaughterhouse, employing 70 workers, was closed.

5. Tourism is the second main business sector. About ½ million guests stay overnight annually. While farmers are permanent residents, some of the people working with tourism do not live permanently on Samsø.

6. Building and construction. From 2000 to 2005 the land-based wind turbines and three new district heating systems were built. This increased demand in the construction trade Most of the construction work on these projects was carried out by local craftsmen. These projects finished in 2002 - 2004 with the establishment of the district heating plants in Onsbjerg and Ballen-Brundby. At the moment, most new buildings on the island are constructed by workers from the mainland, the Samsø Energy Academy being an important exception. By the end of 2008, 80 new houses will be built in Ballen mostly using workers from the mainland, and about 100 new summer cottages on 3-4 different sites will be constructed the same way. This is a shame for the development of businesses on Samsø, especially because the local craftsmen have the expertise to build houses of high quality.

'In March 2010 this is still not the case, nor is it apparent when this double connection will be feasible


2
Danfoss

2. Heating

The share of the total heat produced by renewable energy (RE) increased from about 25 % in 1997-1999 to about 65 % in 2005. During this same period there was a 10 % decrease in the heat consumption. Some possible explanations for this decline will be discussed below. All prices are excluding value added tax.

2.1 District Heating

At the beginning of the project, the municipal council opted for voluntary arrangements for all existing homes. They could accept or decline to connect to the district heating system. Only new buildings built in areas with existing or planned district heating are compelled to connect to the district heating system. In Tranebjerg this was the case in one area. In Ballen three new subdivisions have been forced to connect to the district heating system. In total about 80 houses in the heating district will be forced to join. 10 have done so and about 60 will be established by the end of 2008. One of the latest subdivisions in Tranebjerg (district plan nr. 61 from 12/12-2006, consisting of 23 houses) is without mandatory connection to the district heating system. The buildings are instead built to comply to the minimum standards for energy class 2 buildings (according to BRS 98, addition 9). The lower heat requirements make the combination of heat pumps, thermal solar and PV cells or other RE combinations more feasible.

It is very inexpensive to sign up for district heating before the plant is constructed. The consumer pays 80 Danish kroners (DKK), equivalent to 10 euros (EUR,) as a registration fee when they sign the contract. This model was introduced by NRGi in Tranebjerg and used in the remaining three district heating stations. The model is an exception to normal practice. In Denmark, a high registration fee is normally paid both when the district heating system is established as well as when connecting to existing district heating systems. In the NRGi model, the high registration fee is only paid for connecting to existing plants, typically about 36,000 DKK (about 4,700 EUR). A consequence of using this model is higher heating prices, because the repayment of investment costs is added to the price of the heat delivered. Still, the price is favourable compared to the high costs of heating by oil or electricity. The national association for energy savings 'Energisparefonden' gave a grant to heat consumers who converted from electrical heating to district heating.

The municipal council on Samsø guaranteed the mortgage loans that finance the district heating stations. Straw and wood chips for the district heating stations are produced by local farmers.

Tranebjerg

The district heating station in Tranebjerg opened in 1994. Its straw-fired boiler burns whole bales of straw. The station is owned by NRGi (at that time ARKE) and the initial investment cost was 26.3 million DKK (3.4 million EUR). The project was not subsidized by the Government.

In 1992, a few active citizens in Tranebjerg asked ARKE to re-establish a derelict district heating system. These citizens participated in the process until the new district heating station opened in 1994. In 2005 more than 90 % of Tranebjerg's heat supply, including the large institutional buildings, came from the district heating plant.

Nordby-Mårup

In 2002, the district heating plant located between the villages Mårup and Nordby opened. Here the heat is produced by burning wood chips (about 80 %), and by a 2,500 m^2 solar heating system (about 20 %). The station is owned by NRGi and the initial capital expenses were about 20.5 million DKK (2.7 million EUR). This investment was partly subsidized with a grant of about 9 million DKK (1.2 million EUR) from the Danish Energy Authority. About 80 % of the buildings in the two villages are connected to the district heating system.

At a meeting arranged by the island renewable energy organizations, a 'district heating group' consisting of citizens from the local area was defined. In 1998 the group decided to ask NRGi to establish a district heating system for the two villages. NRGi agreed to try and the planning started. It is worth mentioning that the Nordby-Mårup plant was to be the last of the

four new stations on Samsø to begin operations, but the local group felt differently about this. The local group was extremely active; amongst other activities they went from door to door talking to all potential district heat consumers in the two villages.

Onsbjerg

The district heating station is located in the south-western part of Onsbjerg and supplies about 80 houses and institutions with heat from straw. The plant opened in 2003 and the heat is produced by burning shredded straw delivered by Kremmer Jensen ApS, the owners of the plant. The initial costs were about 8.5 million DKK (1.1 million EUR), paid in part with a grant of 3 million DKK (0.4 million EUR) from the Danish Energy Authority.

The board of the Onsbjerg district heating system consists of five members from 'Kremmer Jensen ApS', two members selected by the consumers and one island council member. Changes in heat prices have to be approved by the municipal council. At the moment the price for district heating in Onsbjerg is the lowest on the island, on the same level as the price in Ballen/Brundby.

Originally, Onsbjerg was planned to be one of seven villages, pearls on a string, supplied by district heat from surplus heat from the ferries docking in Kolby Kås and Sælvig on the west coast of Samsø. 37 % of the heat demand was envisaged covered by the ferries, while the remaining heat demand was to be delivered by biogas from a thermopile system fed with biological trash and wood chips. This project was dropped in 2000 because the 52 million DKK (6.8 million EUR) in capital costs could not be raised.

Instead a group consisting of citizens from Onsbjerg, a local entrepreneur and 'Samsø Energy Company' decided to work on a smaller district heating station for the village based on a straw fired boiler. In 2002 the group was ready to sign contracts with the consumers.

Ballen-Brundby

The district heating plant is located between Brundby and Ballen and opened in 2004. The heat is produced by burning shredded straw. The station is owned by the consumers in a limited liability association and the capital costs were 16.2 million DKK (2.1 million EUR). The project received a 2.5 million DKK (0.3 million EUR) grant from the Danish Energy Authority. This was the last grant given in Denmark by the agency, as the national funding for these subsidies stopped in 2001. 232 houses and institutions are connected to the district heating system. As mentioned earlier, the number of connected houses will increase to about 290 over the coming years.

Originally the district heating system was planned to supply Ballen, Brundby, Ørby and Permelille with heat. In 1998, at a meeting with the citizens of this area in Brundby, a working group of local people was defined. The meeting was arranged by the energy organizations with the particular aim to define a group of people representing the four villages. In 1999 the group asked NRGi to establish a district heating station for the four villages. Calculations soon showed that the financing for the project for the four villages as a whole was not sound. Ørby and Permelille were too far away, causing a large heat loss from the distribution system. Finally, the number of potential district heat consumers was relatively small in these two villages.

The group accepted this verdict and was reduced to members from Ballen and Brundby. NRGi made several suggestions for the provision of Brundby and Ballen, but these were all rejected by the potential district heat consumers. Finally NRGi gave up trying to find an acceptable economic model for the project and withdrew from the planning of the district heating station in the area. This happened at the end of 2002.

The remaining members of the group and the Samsø Energy Company decided to try one more time. First all potential district heat consumers were asked to say whether or not they were interested in joining the district heating system. The consumers were promised heat prices similar to those in Onsbjerg, the cheapest on the island; 1,800 DKK (234 EUR) a year for the fixed annual payment and about 500

DKK (65 EUR) per MWh. It would be based on a co-operative model. Enough consumers were interested and the Samsø Energy Company started the detailed plans for the district heating system.
In april 2004 'Brundby-Ballen District Heating Cooperative' initiated construction and the district heating plant opened in 2005. The board of the co-operative association includes 6 district heat consumers elected at an annual general meeting, and one committee member elected by the municipal council. The heating price is approved by the municipal council, and a local administrative office is responsible for the daily administration. The plant itself is operated by Kremmer Jensen ApS. Kremmer Jensen ApS have previous experience from the operation of their private district heating plant in Onsbjerg. Both plants use the same type of boiler. The committee finds this solution both practical and most likely cheaper than hiring part-time staff.

Besser and other villages
Finally, an attempt was made to establish the last of the four planned district heating systems for the villages Besser, Langemark, Torup and Østerby, but the attempt was not successful. Some of the citizens were not interested in the project. Others had made private investments in biomass installations and other renewable energy systems.

The above project was not as straightforward as some of the other projects. The distribution piping to Østerby was relatively long and there were only a few consumers in the village. In Torup, several of the consumers had already invested in biomass solutions. In Besser, the largest of the villages, very few were interested and the same was the case in Langemark. In addition, many of the houses in Besser are vacation homes.

2.2 Individual Installations

Houses too far from the district heating systems are called houses in the open countryside, and they would not normally receive much help. If the people living in these houses are to convert to renewable energy, they will do so for financial reasons, or because of environmental concern. The decision is up to them. They can consult the local plumber or blacksmith, talk to a specialist in renewable energy (for instance NRGi), or they can contact the Samsø Energy and Environment Office and receive impartial advice about solar heating, heat pumps or biomass systems. Since no more grants for individual renewable heat installations were given after 2001/2002, it became more difficult for the energy organizations to motivate renewable energy campaigns. There are somewhat more than 2000 houses in the open countryside, 800 of which are vacation homes. Local energy organizations have initiated the following projects to ease the transition to RE.

Certification of blacksmiths, plumbing and heating services
A course led by The Danish Technological Institute was organized by active tradesmen and the energy organizations. In 1998 intensive examination and testing of the vital parts of their solar heating systems led to the approval of all participating firms. They received a certificate allowing them to install state authorized solar heating systems. Using state authorized units gave customers the right to a grant reimbursing 30 % of the initial expenses.

Energy exhibition
In October 1998, the energy organizations arranged an energy exhibition on Samsø. The exhibition was successful, with 1,600 guests attending. A key feature of the exhibition was the cooperation between local craftsmen, with local carpenters, plumbers and blacksmiths manning one booth per trade.

Energy Campaigns 1999 and 2000
Supported by the European Union's ALTERNER program and the Danish Energy Authority, the energy organizations arranged two campaigns for renewable energy installations and energy savings in the areas where no district heating was planned. These areas had about 850 regular houses and 750 vacation homes. Most of the vacation homes are summer cottages, while others are located in the villages and in farming districts. Only summer residences in Tranebjerg and Onsbjerg can be used as full-time homes, while residences on the rest of the island are strictly vacation homes.

A central element of the campaign was the open house visits to private consumers who demonstrated their own solar heating systems, heat pumps or biomass installations and shared their experiences with these installations. At these private demonstrations, small mobile exhibits explained renewable energy technology, and professionals and specialists participated to answer technical and financial questions. All island citizens were offered a private visit by a renewable energy advisor, to outline potential energy improvements and financing options for the respective household.

The renewable energy advisers visited 28 families in 1999 and 46 families in 2000; solar heating systems were installed in about 25 % of these houses in the same year or the year after the visit. 59 systems were installed from 1998 to 2000; 15 in 1998, 25 in 1999 and 19 in the first 8 months of 2000. In the 2000-campaign a special pamphlet was sent to summerhouses. This led to only two visits by renewable energy advisors, with no subsequent solar heating installations.

Energy Appraisal and Renewable Energy in Small Villages

Between November 2003 and July 2005 the energy organizations campaigned in the villages Østerby, Besser and Pillemark/Hårdmark and other houses in areas not connected to a district heating system. Little was done to promote renewable energy in these villages as the energy organizations focused on district heating systems elswhere and the offshore windmill park. The campaign was introduced to encourage the reduction of heating expenses, primarily through energy conservation for 42 interested households. Long term investments in less expensive heating based on renewable sources was discussed with the 14 consumers who showed interest.

It is worth mentioning that of the 42 houses appraised, five were heated solely by renewable energy such as heat pumps, solar heating systems, woodburners and biomass boilers. 30 of the houses were primarily oil heated. 16 of these used supplementary sources such as solar heating systems, woodburners and biomass boilers. In 17 houses, the main heat source was electrical heating supplemented by woodburners.

The energy advisers calculated 100 % renewable energy solutions for 14 houses, with interest roughly equally divided between heat pumps and wood pellet boilers was about equally divided. Additionally, some owners were interested in solar heating systems as a supplement to biomass boilers, as excessive use of wood pellet boilers would impact the local environment (in some villages the presence of many boilers would impact local emissions). Except for the few renewable energy installations already set up, we do not know how many will follow up on the recommendations and convert to renewable energy installations in the future. We do know that some will install new RE measures. The timing depends on how old their oil furnace is, and on electricity and oil prices.

In addition to the mentioned problems, the financial impact was also discussed. Installing a woodburner is a bit cheaper than installing air/water heat pumps. However, consumers tend to forget that woodburners demand storage space for wood, and in some cases a new chimney is required to match the boiler. We always point out that handling wood pellets and cleaning the boiler requires some work. These chores can be difficult for older people, and 1/3 of Samsø's inhabitants are elderly. Finally we discuss noise nuisances from the vibrating heat pumps, which can vary with compressor placement inside or outside the house.

2.3 Heat Savings

Samsø Energy Company, Samsø Energy and the Environment Office ran five campaigns targeting energy savings. The pensioner campaign was conducted with the municipality. One campaign was run in Ballen-Brundby and Onsbjerg, one campaign was associated with 'the campaign for Renewable Energy in the open countryside', one demonstrated alternative insulation materials for houses and one campaign focused on energy reductions in areas not supplied with district heating.

Pensioner project

The Danish Energy Authority gave grants to pensioners for energy saving renovations in their private houses, a program which existed for several years. The grant was 50 %, maximum 25,000 DKK (3,247 EUR) and the investments had to be 25,000 DKK (3,247 EUR) or more. The Danish Government has a general interest in energy reductions. These investments also saved public funds allocated to subsidize pensioners' heating costs. In addition, the investments improved the comfort of the houses.

Prior to the campaign launch in 1999, the grants were allocated to app. 10 households annually. In the four years from the launch, 192 households made use of the grant - app. 48 households a year.

The campaign was initiated with a letter sent by the municipality to all 444 pensioner housholds on Samsø. This letter described the available grants for investments in energy saving installations and explained where information about renewable energy installations in private homes could be found. A visit by an energy adviser was free and many pensioners applied for visits. The first year 63 households were awarded a home improvement grant.

The campaign went on for three more years and ended in 2002 when state funding ended. During the last three years of the campaign, 129 families were awarded a grant. Altogether, improvements were made to 192 houses on the island and local craftsmen increased their revenue by more than 8 million DKK (1.1 million EUR).

Brundby-Ballen and Onsbjerg

The campaign served two objectives. The first objective was to have an energy adviser assess all houses to carry out free energy appraisals, including recommended ways to save energy. The second objective was to inform people about the planning of the district heating plants, and to assess the interest in participating in such a system. The campaign was subsidized by the Danish Energy Authority, lasted five years, and ended in 2002.

113 houses in Ballen-Brundby opened their doors for energy advisers or an energy appraisal, 25 % said they would implement the energy saving improvements, while 19 % were not interested in energy saving improvements and 7 % of the appraised houses were well insulated houses with low heat consumption. 11 % of the houses were for sale, 45 % were undecided. When asked about local district heating, 49 % showed an interest in local district heating, 16 % had doubts, 6 % were not interested, 13 % did not answer the question, and 11 % of the houses were for sale.

In the spring of 2002, the citizens in Onsbjerg were offered a visit from an energy adviser and an energy appraisal. 31 houses were visited by the authorized energy adviser. Of these, 61 % expressed interest for making the energy saving improvements, 13 % of the houses were so well insulated that no further improvements were feasible. 16 % were not interested, and 10 % were for sale. 77 % expressed an interest in district heating, 7 % had doubts and 16 % were not interested.

Campaign for Renewable Energy in areas with no district heating

This campaign ran from 1999 to 2000. To increase interest in renewable energy installations, 74 houses were visited by energy advisers from the mainland. All visits by advisers started with an energy appraisal. Most of the homeowners involved received suggestions about energy saving improvements that could be implemented before or during the installation of renewable energy installations. The project was described in more detail above.

Demonstration of alternative insulation materials

The project was subsidized by the Danish Energy Authority and ran from 2001 to 2002. Key elements of the project are described in the following.

Five houses in the southern part of Samsø were used as showcases, four of which were having attics and the first floor renovated. The materials used for insulation were paper wool from Ekofiber and Heraklit linen insulation rolls. Open house arrangements were held in 3 of the houses, and and a demonstration video was produced. The fourth project was a

'straw house' under construction, which used linen rolls to insulate the roof. The finished demonstration video was distributed to all energy and environmental offices in the country.

The two largest carpentry busineses on Samsø participated in these demonstrations, and one of them subsequently invested in the equipment necessary to apply paper insulation to houses. These same two firms later joined forces to do the carpentry work for the construction of the Samsø Energy Academy building in 2005 and 2006. Here they made use of their expertise using alternative insulation materials, such as paper wool, linen rolls, and Perlite.

Energy appraisal and energy savings in small villages

From November 2003 to July 2005, free energy appraisals were offered to citizens in the villages Østerby, Besser and Pillemark/Hårdmark, none of which were connected to a district heating system without a district heating system. 32 houses joined the program. The project was subsidized by the municipality of Samsø through grants from the Ministry of the Interior and the Ministry of Health. Small campaigns were made in each village, starting with a public meeting and followed up with door to door distribution of brochures to every household offering free energy appraisals. In Besser and Hårdmark, the public meetings were organized by the local citizens' association. In the smaller village of Østerby, a group of active citizens made the arrangements for this first meeting as well as two additional meetings.

Østerby

In Østerby we had contact with almost half of the citizens. For differing reasons, six of them did not want an energy appraisal: One building was newly renovated, one was for sale, one had "free" heat supply from biomass, two already had their houses appraised in earlier campaigns, and one was only interested in learning about grants available for renewable energy installations (since 2002 this was no longer an option).

Appraisals were made in 13 of the houses.

Only three of the houses used more than 150 kWh per m^2 per year, a relatively small number considering how old the houses are in this village. 10 houses used less than 150 kWh per m^2 per year. Five of the 13 houses were strongly advised to install extra insulation. Especially the attics were insufficiently, or not at all, insulated.

The campaign had an additional benefit; a council was established in the village and three members were elected for the committee. The council arranges social activities like village dinners in the summer and Shrovetide arrangements, and they maintain the area around the village pond. At an arrangement on the national Constitution Day shortly after the campaign, Søren Hermansen from the Samsø Energy Academy gave a speech in the village.

Besser

In Besser energy appraisals were only conducted in four houses.

Pillemark/Hårdmark

12 energy appraisals were conducted in Pillemark/Hårdmark, and one house under construction also received free advice. The house under renovation used a boiler fired with wood pellets/grain for heating, with further improvements to energy consumption underway.

Heating consumption could only be estimated for 10 households and the results showed that 7 houses used less than 150 kWh per m^2 per year. The remaining three used between 150 and 200 kWh per m^2 per year. Generally the problem was inadequate insulation and the renovation of the typically old, but beautiful, doors in the village houses.

During the public campaigns for the three villages, people from other areas with no district heating contacted us. After the village campaigns, we contacted these people, asking if they were still interested in energy checks in their houses. Nine of them were. In six of these houses, less than 150 kWh per m^2 per year was used.

2.4 Heat Consumption and Heat Production, 1997-2005

Every year from 1997 to 2001, the Samsø Energy Company collected energy statistics, an important activity financed by the office itself. In 2005, this activity was financed by the Samsø Energy and Environment Office. The figures come from mainland oil companies, local wood pellets distributors, the four district heating stations, and the electric utility (which also owns and operates the district heating supplier plant in Tranebjerg).

Heat consumption 1997-2005

The total consumption fluctuates between 67,222 and 75,277 MWh (242 and 271 TJ) annually between 1997 and 2000. The amount of fuel oil imported fluctuates correspondingly.

In 2001 there is a clear change. The total consumption decreases by 11,889 MWh (42.8 TJ) from 2000 to 2001, and the amount of imported fuel oil decreases by 6,833 MWh (24.6 TJ) in the same period. One reason for the decline in total consumption is the way it is calculated. Land-based wind turbines on Samsø supply heat pumps with electricity and heating from electricity. From 2001 we chose to count this in the budget of the total heat consumption. It is assumed that the transmission loss from the local wind turbines through the offshore cable corresponds to the loss from imported electricity. Until 2001, electric heating and heat pumps were supplied by a coal-fired power plant with 40 % efficiency, including the transmission loss from the power plant to Samsø through the offshore cable. The 2001 electric heating and heat pumps would, if generated by the coal fired plant, have consumed 8,000 MWh (28.8 TJ). Additionally, the campaigns to promote energy saving seem to have been effective. The campaign directed at pensioners across 192 households appears to have been especially effective; specifically, the 8 mil DKK (1.1 mil EUR) (excluding 25 % VAT) invested in energy saving measures.

In 2001, the share of renewable energy increased from 25 % to 46 %. The RE heat supply from district heating and wood pellets increased by 2,528 MWh (9.1 TJ).

From 2001 to 2005 there are again significant changes. The amount of imported oil falls by 9,417 MWh (33.9 TJ), and the consumption of biomass increases by 12,222 MWh (44 TJ). Solar heating systems account for 1,333 MWh (4.8 TJ) from the district heating station in Nordby and 150, mostly new, private solar heating systems. One might question the difference between the decrease in imported oil (9,417 MWh/33.9 TJ) and the increase in consumed biomass consumption (12,222 MWh/44 TJ). One explanation is the transmission loss in the distribution of heat from the district heating stations. In Tranebjerg where the distribution network covers a small geograhical area, and large institutions are supplied by heat, the transmission loss is relatively small; about 10 %. In Ballen-Brundby the distribution area is relatively large, the transmission loss is just over 30 %. Both district heating systems are expanding, because legislation requires new buildings to connect, especially in Ballen. The efficiency of the boilers in the three new plants is good, 85 % for the two straw-fired boilers and even better for the plant in Nordby.

A general reason for the inexplicable fluctuations in the gross amount of oil imported to Samsø is the method and timing that oil companies use for their annual deliveries to Samsø. The island has the capacity for sizeable oil depots, as do the gas stations.

Finally, the trend of building larger houses can mean that the new houses on Samsø increase overall heat consumption. Growing prosperity and bigger homes increase heat consumption. On the other hand, some trends indicate declining heat consumption: the fall in population on Samsø, almost 200 from 1998 to 2005 (127 from 2001 to 2005); houses have become better insulated and owners have implemented measures from the energy saving campaigns.

2.5 The Future

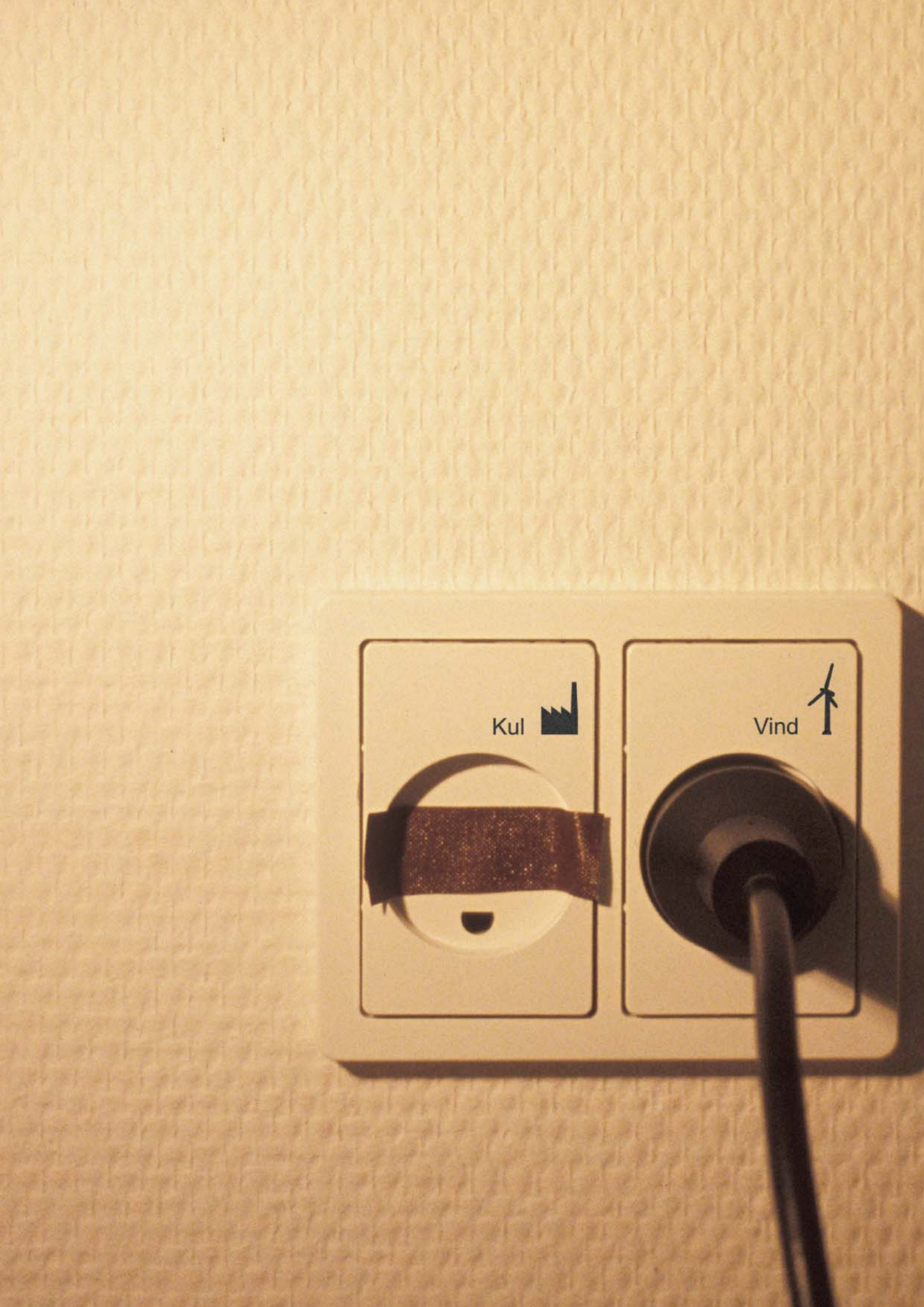
There are no special initiatives targeting the heating sector in 2006. The energy organizations have used their resources to organize new areas: one example is Samsø Energy Agency, a project co-financed by the EU. Samsø is in charge of this EU project, which also includes Energy Agencies on Iceland and Tenerife. Another example is the Danish energy service network, where Samsø is responsible for press office releases. Finally 2-3 energy island employees have worked with establishing the Samsø Energy Academy after financing was finalized. Construction plans began in the beginning of 2005, with invitations to submit tenders in September. The construction process began in October 2005 to prepare for occupation by December 2006. In 2007 no specific initiatives are planned, however people can contact the energy organizations for advice on energy savings and renewable energy installations. The same service was offered to consumers/builders asking for advice about building new 'low energy houses'. One example is the district plan number 61 consisting of 23 'low energy houses' in Tranebjerg.

Even though new buildings and home renovations (mostly when homes change hands) will lower energy consumption per square meter in the years to come, more buildings will increase the total energy consumption in the housing sector. In the coming years, 100 vacation homes and about 50 year-round houses are being planned. In addition, Samsø has just been granted permission to plan sites for 100 more summer cottages on the island.

There are significant efforts involved in attracting settlement to Samsø, and a belief that this will be successful. One trend is that modern summer cottages and vacation homes become year-round homes for pensioners when they retire and move to the island. At the same time, efforts are made to attract families with children and parents still young enough to work. To some families now working in Århus, the move to Samsø might be tempting. An improved ferry service is critical in this regard and is a priority for the municipality. The most cited reason for why families settle on Samsø is the wish to provide safer and more idyllic surroundings for the children. As technology develops, working hours and work locations become more and more flexible. As competition for competent workers increases, more firms will have to offer good and flexible working conditions, matching the employees' social and family related needs, to insure good and stable employees. The upshot of this development is an increased demand for year-round heating on Samsø.

Efforts to establish a biogas plant on the southern part of the island have been attempted several times. The local farmers are very interested in the biogas project, and a site is available near the village of Ørby. If the money can be raised, we will make an effort to establish a district heating system supplying heat for Ørby, with any excess heat going to the Ballen-Brundby district heating system. This will increase the share of renewable energy in the heating sector and improve local air quality.

Better heat pumps and more efficient boilers are expected in the future. In addition, boilers burning locally produced rapeseed oil are expected in the future.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3. Electricity

3.1 Land-Based Wind Turbines

The distribution of electricity on Samsø is managed by NRGi (earlier ARKE). There are sea cables from Jutland to a transformer station near Vadstrup, a central geographic location on the island. Consumer electricity is distributed from here to all the island consumers.

The energy island master plan in 1997 estimated the island electricity consumption to be 29,000 MWh (105 TJ). 15 wind turbines rated at 750 kW could generate this amount of electricity annually.

In 1998 the process of selecting wind turbine sites and financing construction began. It was soon obvious that there was no shortage of potential investors. In particular, farmers with potential wind turbines sites on their land were keen to invest in their own wind turbine.

The energy island organizations arranged a number of public meetings. These had two purposes: to keep the public informed and to further the positive interest this project was generating for investments in wind turbines.

To ease implementation and secure broad public support, the energy island project also proposed, in conjunction with the National Wind Turbine Association, an ownership scheme which would give all island citizens the chance to invest in the forthcoming wind turbines. This scheme was adopted and implemented by the organization running the existing shareholder wind turbines, 'Samsø Wind Energy'. This association started in 1983 with two so-called 'blacksmith wind turbines' and the pioneers from these first experiments later replaced these early models with larger, more efficient wind turbines. The ownership scheme was based on the idea of reserving shares for the general public. The owners of the wind turbine sites agreed to allocate the sites necessary to meet the general public demand for shares. At the same time, these landowners and future wind turbine owners signed an agreement to establish a fund to further other forms for renewable energy.

Samsø Municipality and the Århus County Office for Technology and Environment conducted the area zone planning for the project. The municipality suggested a distribution of wind turbines in six different clusters spread over the southern part of the island. This proposal was based on more than 40 specific applications for a turbine site on local properties. Århus County appraised this proposal, taking environmental considerations into account such as visual impact, which resulted in 10 approved turbine sites. The local debate revolved in large extent around the question of ownership. The ownership scheme reserving shares for the general public gave the debate a more constructive perspective. The psychological effect of spreading ownership also greatly improved citizen acceptance for the erection of these wind turbines. The RE-island plan estimated consumption needs and kept matters in perspective. To make Samsø self-sufficient with electricity, a total production capacity of 11 MW was necessary. This argument led to a special dispensation from the municipality allowing for the maximum turbine height to be raised from 70 meters to 77 meters. This in turn meant that fewer, larger windmills could be erected, resulting in 11 1-MW windmills across 3 clusters.

Samsø Wind Energy began the pre-sales reservation of wind turbines shares in collaboration with the energy organization Samsø Energy and the Environment Office. These initial orders reserved two wind turbine sites for 430 shareholders.

Only one manufacturer could deliver a 1-MW wind turbine with the specified height. This meant that all 11 wind turbines were delivered by Bonus Ltd. in Brande. The first wind turbine was erected and on-line in 2000. Electricity production prices are regulated by law and include a ten year fixed price agreement which is the same for all 11 wind turbines on the island. The agreement stipulates a guaranteed price of 0.60 DKK (about 8 EUR cents) for the first 12,000 full-load running hours and after this 0.43 DKK (about 6 EUR cents) until the ten year period has expired. Each wind turbine cost about 6 million DKK (about 800,000 EUR) including the grid connection and foundation.

3.2 Offshore Wind Turbines

There is no available technology on the market today that can supply the transport sector's energy needs with renewable energy. The RE-island master plan therefore suggested that this energy supply could be offset with offshore wind turbines. To compensate for the energy used in the transport sector, the plan proposed to produce an equivalent amount of CO_2 free energy.

The offshore wind turbines would need a capacity corresponding to the actual energy consumption in the transport sector, minus the energy savings to be realized in the master plan. The RE-island plan calculated that this could be produced by 15 wind turbines rated at 1.5 MW, a turbine size available in 1998.

The Samsø Commercial Council, Samsø Farmers' Association, Samsø Municipality and Samsø Energy and Environment Office joined forces and founded the company Samsø Offshore Wind Co. This was done to ensure that Samsø owned the project concessions and to involve key local partners in ownership of the offshore wind turbines. The Samsø Energy Company laid the groundwork which lead to the Samsø Offshore Wind Company. The Danish Energy Authority funded the preliminary sea floor studies and the requisite environmental studies. An executive office was established to prepare the tender calls.

Innovation in wind turbines increased dramatically in these years, such that by 2002 2.3-MW wind turbines were available. These wind turbines were briefly the largest offshore wind turbines in the world. Their size is very important for their economic viability.

The production cost per kWh is lower for larger wind turbines. But initial costs for offshore placements are much higher than land-based turbines. The land-based turbines cost about 6 million DKK (800,000 EUR) per installed MW. The offshore turbines were 10.4 million DKK (1.4 million EUR) per installed MW. The offshore turbines have an essential advantage:

Wind conditions are better at sea. There is very little landscape disturbance (a variable quantified in technical production estimates) and therefore greater production. The land-based turbines have generated 2,300 MWh (8.28 TJ) per installed MW capacity, while the offshore turbines produce 3,500 MWh (12.6 TJ) per installed MW capacity.

The 25th of April 2002 the company made the following press announcement:

- Samsø Offshore Wind Co. signs the contract
- 10 offshore wind turbines are now ordered.
- The final contract for the delivery and installation of 10 offshore wind turbines was signed April 25, and construction of the turbines and the foundations can begin.
- Investors have financed 9 wind turbines, and the last investors are signing up for the cooperatively owned wind turbine “Paludan Flak Ltd..
- The turnkey project and construction work will be carried out by ***Dredging International N.V*** together with ***Hydro Soil Services N.V.*** and ***ABB New Ventures GmbH.***
- Bonus Energy A/S delivers 10 wind turbines rated at 2.3 MW each. The wind turbines are among the largest yet produced in Denmark, with a rotor diameter of 82.4 meters.
- The monolith steel foundations will be built by Bladt Industries A/S in Ålborg. The 10 steel foundation pipes are 45 metres long and are made of 3000 metric tons of steel.
- ***SEAS Wind Energy Centre*** is the technical consultant and project coordinator for Samsø Offshore Wind until the project is finished. SEAS was the technical consultant for the Middelgrunden offshore wind turbines in Copenhagen.
- The project is part of “Samsø – Denmark’s renewable energy island”. Within a 10 year time span, the island energy will be supplied by 100 % renewable energy. The energy produced by the offshore wind turbines will offset the energy consumption in the transport sector.
- The Municipality of Samsø finances 5 of the turbines, 3 are ‘commercial’ wind turbines bought by larger investors, and the last 2 are owned by smaller shareholders, altogether about 1,500 shareholders organized in two separate companies. *The project will be finished in 2002.*
- The wind turbines are being erected 3.5 kilometres south of Samsø along the ***Paludan Flak reef.*** They will be placed in a single straight row running north-south.

3.3 Photovoltaic (PV) Cells

The RE-island master plan predicted that PV cells will play a more important role in the future. Several campaigns were envisaged that would increase investments in both the installation and production of PV cells.

The Danish Energy Authority cooperated for several years with 'Energi Midt' on a PV cell project that subsidised PV installations. The project's explicit objective was to promote the production and installation of PV installations. Three Samsø homes participated in the programme, each with 20 m² solar panels. The Samsø Energy Academy has 100 m² PV panels integrated in the roof.

The main obstacle for further expansion is the high production cost per kWh compared with more conventional production costs. PV cells appeal to the idealistic citizen more interested in the technology and self-reliance than economic viability.

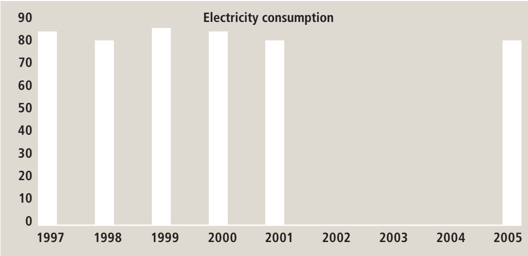
3.4 Saving Electricity

Converting electrically heated houses to other heating sources has been the primary focus in the RE-island project's efforts to save electricity. These efforts aimed to decrease the consumption of electricity used for heating purposes by eliminating electric heaters. The Danish state subsidized conversion to other heating forms. Why use such a resource intense source of energy for heating purposes? The highest rates of subsidy were awarded to conversions from electricity to biomass, solar energy or a combination of these.

Several local campaigns also promoted other electricity saving options, like low energy, long lasting light bulbs, energy efficient appliances, and improving consumption habits. A national allocation of funds to save electricity made many of these campaigns possible, and the RE-island projects used the national guidelines set up for these funds in our efforts to reach the electricity conservation targets.

Research has proven that habits can be changed, but consumer patterns also change. While some electrical products and appliances were replaced with more energy efficient models, the number of electric consumer products as well as the total consumption of electricity increased.

3.5 The Consumption of Electricity, 1997 - 2005



As seen in the diagram the total yearly electricity consumption is unchanged in the period 1997 to 2005. In spite of several national and local saving campaigns it has not resulted in decreased electricity consumption on Samsø. Even though the population is buying and using energy saving bulbs and A++ refrigerators and freezers etc., and therefore is saving electricity, the increasing use of products that use electricity negates these savings.

3.6 The Future

There is still much to be done to further the conservation of electricity. One of the most important areas is the promotion of intelligent consumption, i.e. the distribution of consumption to match supplies and the production capacity. At the moment there are two peaks a day with maximum loads, morning and evening while preparing supper and washing clothes. Consumption is generally high during the day and low at night. To meet the peak load periods, the utilities have to have a large production capacity on hand.

The excess capacity in off-peak hours can be channelled elsewhere using intelligent consumption, for example by storing excess wind-generated electricity for future use. Storage technologies such as hydrogen conversion, electric batteries and conversion into heat need to be explored in future RE-island projects. Electric cars can be charged at night, excess wind power stored by producing hydrogen, and electric heat added to the district heating systems.

The building sector can begin to implement 'smart house' solutions, where computers monitor the household energy consumption. There is still a need to focus on our consumption habits and our attitudes toward saving electricity. The widespread use of stand-by functions around-the-clock is not strictly necessary, and is one of the examples of how a simple change in consumption habits can save many kWh's annually.

4. Transportation

Transportation is both nationally and internationally a varying commodity that richer parts of the world buy on demand, using differing means of transport available for business and pleasure. Restrictions imposed to protect certain areas (primarily urban centres), rising prices, and national energy taxes seem to have very little impact on the increasing demand in this sector and the ensuing drain on energy resources. This is also the case in a small island context like Samsø, where there are very few possibilities for regulation, and these few are too costly or demanding to put into effect.

4.1 Change

In the original master plan from 1997, consulting engineers from PlanEnergi listed a number of areas which could be targeted to decrease energy consumption:

- Campaigns to promote energy efficient driving and optimize engine efficiency and tire pressures. The campaigns would target both the business community and island citizens. The potential savings: 5 - 10 %.

- Mail and food delivery to pensioners could be combined, using only one set of cars to distribute both. The potential saving: 40 %.

- Public transport overhaul: larger buses could be replaced by smaller ones in off-peak hours. More flexible bus schedules or free public transport would reduce private sector transport. Potential savings: 10 - 25 %.

- Reducing the energy consumption of tractors by improving driving techniques and engine specifications could reduce energy consumption in the agriculture sector by 30 %.

- A gradual transition to electric cars would decrease fossil fuel consumption.

The latter three intiatives in the list above were implemented in the 10-year project period

The island bus route
In 2002, Århus County and Samsø Municipality contracted a feasibility study of an overhaul of the public transit system. This study was carried out by the engineering consultancy COWI in cooperation with a local work group and an executive committee. They recommended a more flexible demand structure and that the regular buses should be substituted with handicap-friendly mini buses, except at peak demand. Both the county and municipality would save 30,000 DKK (4,000 EUR) a year. Both the local business council and a public transport working group outlined a similar proposal for the municipality's strategy plan. However, the proposal was finally rejected by the municipality in the 2007 strategy meeting.

Energy conservation in agriculture
The demand for diesel in agriculture has not declined between 1997 and 2005. Although consumption fell slightly in 2001 and 2003, the general tendency was higher consumption. Consumption in 1997 was 7,111 MWh (25.6 TJ), in 2001 6,861 MWh (24.7 TJ) and in 2005 7,333 MWh (26.4 TJ). In this 7 year period there have been several thematic meetings to focus on the potential energy savings attainable with different cultivation practices. The rather constant rate of energy use is not to be taken as a lack of interest in savings. The Samsø farmers had already implemented substantial structural changes before 1997 which still had first priority. They would be more than happy to save hours of work if they could harrow and sow in one pass. There is still potential for saving energy by improving driving techniques and engine efficiency.

In the summer of 2003, a demonstration project started a local production of rapeseed to supply rapeseed oil for the tractors and rapeseed feed for the animals. All the cattle farmers were invited to participate and three participated actively in the project. Today, two of these farmers still use rapeseed in their tractors and cars. They press the rapeseed themselves, using the oil in their converted diesel motors and the rapeseed cake to feed the cattle.

Inspired by these two pioneers and their good results, a large task force was established: the Municipality of Samsø, The Farmers Association, the Commercial Council, the local branch of a major feed company, DLG Samsø, and several private partners.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This group was very enthusiastic about introducing locally produced rapeseed oil to the local energy market in a large scale operation.

The farmers were concerned about motor durability, if the motors would last as long running on rapeseed. Could they get guarantees for their motors and for the price of rapeseed? Would it remain as cheap as diesel fuel? The rapeseed price is still a limiting factor, as rapeseed oil is subject to the same energy taxes in Denmark as diesel fuels.

The feed company DLG Samsø had the capacity to press and distribute the rapeseed oil and cake to the local market. This would save transport costs for exporting the rapeseed crop from the island, as well as transport costs entailed in the import of protein fodder that would be replaced by the rapeseed cakes. Unfortunately, this project has since faltered, as all attempts to remove the energy taxation of rapeseed oil have failed.

Electric cars

The original Energy Plan envisaged quite a number of electric vehicles in use during the project period. There was a generally optimistic consensus in 1997 in Denmark about the market potential of electric cars. Many believed that 10 % of all cars and vans would be converted to electricity in the coming ten years.

The energy consultants who formulated the energy plan asked what would happen if 50 % of the island vehicles, with their many short trips, were converted to electric propulsion. The need for electricity for these vehicles would amount to 1,611 MWh (5.8 TJ) annually. The general improvements in wind turbine efficiency and the subsequent production and export of 2,028 MWh (7.3 TJ) of electricity annually in 2005 showed that the necessary windpower capacity was available.

Unfortunately, the optimistic 1997 predictions did not prevail. The market for electric cars is almost non-existent, still waiting for better batteries and hybrid vehicles where electric propulsion can be incorporated. On its own initiative, Samsø Municipality leased four Citroën Berling electric vehicles in 1999 to service local pensioners. The four electric cars were supplemented by three petrol operated models. After a 3-year period the electric vehicles were returned, due to the following reasons:

- The service agreement with the mainland-based auto dealer did not work well. There were often problems with the batteries, and frequent maintenance meant that they were often one vehicle short.

- The 12 nurses who used the vehicles had different driving techniques, and they were often in a hurry, because of 'emergency' calls where speedwas essential. Over the 3-year period the electricity consumption of the cars was app. 3 km/kWh, corresponding to app. 1.40 DKK/km.

In the fall of 2006, the energy academy acquired an electric Citroën Saxo from the now defunct Århus county. This car has performed without problems, except for one minor instance with a loose wire.

4.2 Consumption and Traffic, 1997 - 2005

Private automobiles

From 1997 to 2003, gasoline consumption fell from 11,611 MWh/year (41.8 TJ/year) to 9,167 MWh/year (33 TJ/year) on the island. Unfortunately, this quite remarkable decline cannot be interpreted as a constantly falling level of gasoline consumption, the result of fewer trips, or more efficient cars. In 2005, fuel consumption increased to 13,472 MWh/year (48.5 TJ/year). The decline in consumption can perhaps be attributed to the fall in employment figures in the same period, while the abrupt increase cannot be explained by any major upswing in employment.

The diesel fuel consumption for private automobiles remained more constant, fluctuating between 4,278 and 4,583 MWh/year (15.4 and 16.5 TJ/year) during the years 1997 and 2005.

Buses

Diesel consumption increased from 861 to 917 MWh (3.1 to 3.3 TJ) annually from 1997 to 2005. The more flexible demand service bus system would in all likelihood have reduced this diesel demand somewhat.

Trucks/trailers/construction equipment
In 1997 and 1999, diesel fuel consumption was 5,639 MWh/year (20.3 TJ/year), in 2001 and 2003 5,444 MWh/year (19.6TJ/year) and in 2005 5,805 MWh/year (20.9 TJ/year). The variation with a decline in consumption in the middle of the period and a rise the final year does not correlate with the construction activities in the same period. From 1999 - 2004, three district heating systems were established and there was a lot of construction equipment in use. The truck and semi-heavy traffic and diesel consumption has also increased. The truck transport sector has invested in a lot of new trucks. These operate mostly off the island, and their increase in numbers is not reflected in an increase in diesel consumption if they are fuelled on the mainland.

Tractors
These are discussed in section 4.1

Ferries
Ferry traffic is the real big energy consumer. In 1997 the three ferries to Samsø consumed 25,111 MWh/year (90.4 TJ/year) which increased to 26,833 MWh/year (96.2 TJ/year) in 2005. The increasing amount of ferry departures the last few years is one of the explanations for the increasing use of fuel.

4.3 The Future

Samsø will need to develop and implement several different solutions and strategies to tackle the transport sector energy consumption, in particular implementing effective energy conservation schemes.

Energy supply

On the basis of local as well as international findings, different solutions will have to be found for the different areas. The simplest and most obvious solutions may be something like:

Private automobiles
Electric vehicles are a reasonable choice for many motorists on the island, because most trips are short. As a second vehicle, families with these needs could use very small electric cars or electric scooters. Converting more of the island diesel vehicles to run on rapeseed is still an obvious choice. Larger scale use will also entail larger scale production like the previously described project with DLG Samsø. Alternatively, a group of car owners might decide to try running their own rapeseed fuel depot.

Buses
As mentioned earlier, the municipality has already endorsed the rapeseed oil project. Converting the local buses to rapeseed should thus be a reasonable goal. The municipality can stipulate this transition the next time the bus service is tendered.

Trucks/trailers/construction equipment
These machines should be converted to rapeseed oil. The conversion of large trucks and construction equipment to rapeseed has commenced in other parts of the EU, e.g. Northern Germany (Schleswig-Holstein) and in Ireland.

Tractors
Discussed in section 4.1. The local farmers are prepared to convert to rapeseed oil given the right conditions.

Ferries
The ferries and ferry routes now servicing Samsø are changing hands and new tonnage is on its way. Suggestions for changes in energy supplies will have to be consistent with the changes underway.

Energy conservation

Concomitant with the more environmentally correct and locally based energy resources, campaigns to promote energy conservation would be appropriate, encouraging the island populace to:

- Take their bicycle or the bus to work
- Make carpools to fill up the cars
- Choose a car with good mileage
- Avoid gas guzzling 4-wheel drive RCVs
- Stop idling motors

Initiatives to promote energy conservation in the transportation sector will always be necessary and the suggestions above encompass only some of the most obvious steps, steps that are more about peoples' habits than a comprehensive technological change.


H2 Logic
drogen
TH!NK

Filling Station Concept from H2 Logic Co.
Filling Station developed by H2 Logic,
Hydrogen Car developed by H2 Logic Co. and TH!NK.

5. Tourism and Education

5.4 Samsø Energy Academy

Samsø is a tourist island. There are about 500,000 overnight bookings annually and this figure is increasing. Standard tourism is based on summer cottage rentals, camping sites, leisure boating, and hotels/bed and breakfast, etc. Tourists mention Samsø's nature and island culture as the main reason for their visit. More recently, a new trend is developing: educational or vocational tourism. Many island guests come to visit the Renewable Energy Island project.

5.2 Renewable Energy Tourism

The very first year Samsø won the Danish Energy Island status, Japanese contacts showed an interest in the project. With the announcement of the new Danish concept energy island and with perspectives from the Kyoto agreement, Japanese interest in the new energy island was to be expected. The first year, 4-500 Japanese visited the RE-island project. In the next couple of years Samsø entered several EU initiatives and joined the organization ISLENET. Europeans began to visit the island. Since then, visitors have come from almost everywhere.

There are several different kinds of visitors. The more political visitors and contacts would like to understand how the Danish energy policies have been implemented in a local context. These groups are often delegations interested in questions of organization, new forms of ownership and practical implementation. Other groups are the government professionals and private businessmen who study economic potential for growth, employment and business opportunities. Energy transition is a new growth area of great interest especially in some of the Asian countries like China, Japan and Taiwan. Some energy island tourists are also on vocational tours arranged by a firm for their employees. These ask the Energy Island project to supply technical insight and training.

University and technical college students often choose to base project studies on renewable energy in a wide variety of perspectives. They are often helped with the initial project formulations, and RE-island personnel supply information and later evaluate the project results.

The demand for seminars, courses and exhibition is increasing. After the opening of the Energy Academy, interest for the project has rocketed. This summer (2007), 30-50 persons a day participated in tours arranged during academy opening hours. Schools often visit Samsø on class visits, and many of these classes are now spending the whole day at the Energy Academy.

The final groups are more difficult to define, comprising special interest groups and grassroot organizations. These diverse groups are interested in the small-scale democratic aspects of the organization, and local participation in energy transition and development.

5.2 Education and Renewable Energy

Basic knowledge about energy is of interest to most people. But the more specific forms of energy and energy production are often uncharted territory, and many people don't understand the basic principles behind these technologies. The Energy Island project is based on broad public support. This has entailed widespread dessimation of these principles and techniques and the possibilities they represent. Public and private primary and secondary schools can now use the Energy Academy as a working laboratory. The children learn by doing. They build wind turbines, make electric coils and motors, electricity, and experiment with energy in many forms. These experiments lead to more questions from the children, and new ideas that can be tested.

With this new knowledge and experience, understanding energy contexts and connections is easier. More importantly is the improved understanding of the role each individual plays in terms of energy consumption and production.

For the older student, full-scale wind turbines, online production figures, and district heating projects based on local biomass resources can lead to project descriptions about energy balances and better utilization of our energy resources.

Hands-on models illustrate how matters interact, and new models are generated in the daily work with the pupils. This cycle of learning never ends, but acts as a constant source of inspiration and creates new, testable theories. The Energy Island project is an educational experiment with great development potential.

5.4 Samsø Energy Academy

The RE-island project is a socioeconomic development project constructed as an exhibit for the use of renewable energy in a local community. As a direct consequence of these actions, the general objective to establish a central home for the energy island project took hold. The Energy Academy is a community hall for energy concerns, a meeting place for energy and local development.

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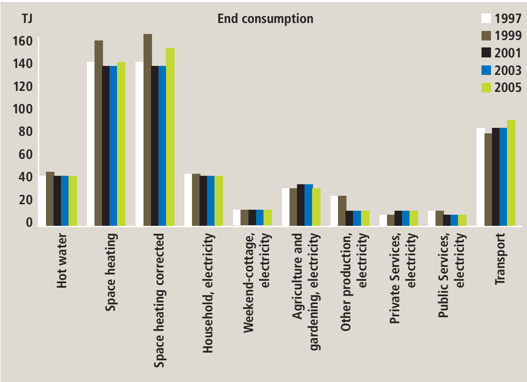
The building is erected on a large plot of land, 20,000 square metres, and the grounds are used to display experimental and small scale energy devices for educational and demonstration purposes.

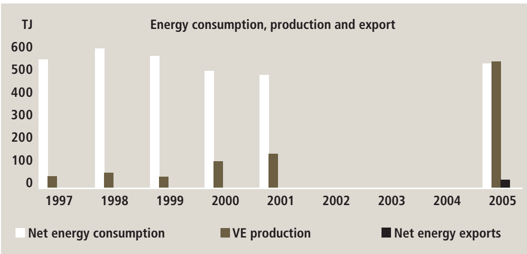
6. Environment

One of the major reasons for converting to renewable energy resources is their low environmental impact, especially on the atmosphere. This chapter will focus on the effect the transition to RE has had for Samsø.

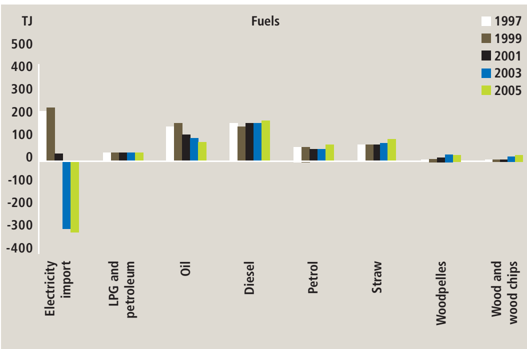
As mentioned elsewhere in this document, the energy supply systems on Samsø have undergone significant change.



The energy consumption has not significantly changed between 1997-2005, as apparent in the above figure. But the resources used to generate this energy have changed considerably, as seen below:



This diagram also shows that the RE contribution to the total consumption has risen to over 100 %, and there is thus a small surplus exported from the island. The next figure shows the change in consumption (and production) of different fuels or energy forms.



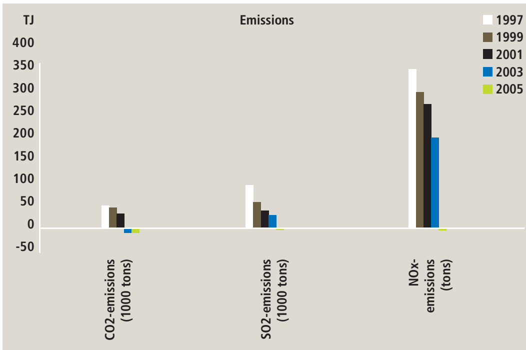
The fuel oil consumption has fallen by about 15 % from '97 to '05. This is mainly attributable to the fall in the heating oil consumption by almost 50 %, primarily due to the district heating systems based on straw, wood chips, and solar collectors. The consumption of other petro-products (in particular petrol and diesel to cars and bunker oil to the ferries) remains unchanged.

Electricity imports end in the same period and are replaced, first by land-based wind turbines and later supplemented by 10 offshore wind turbines. The consumption of biomass doubles in the course of the same period, once again in particular because of the new district heating plants.

The introduction of 11 1-MW land-based wind turbines and later 10 2.3 MW offshore wind turbines entailed a factor 100 increase in wind power production. Thermal solar heating went from a negligible contribution to an appreciable level of production, primarily due to the 2500 m² thermal panels at the district heating plant in Nordby.

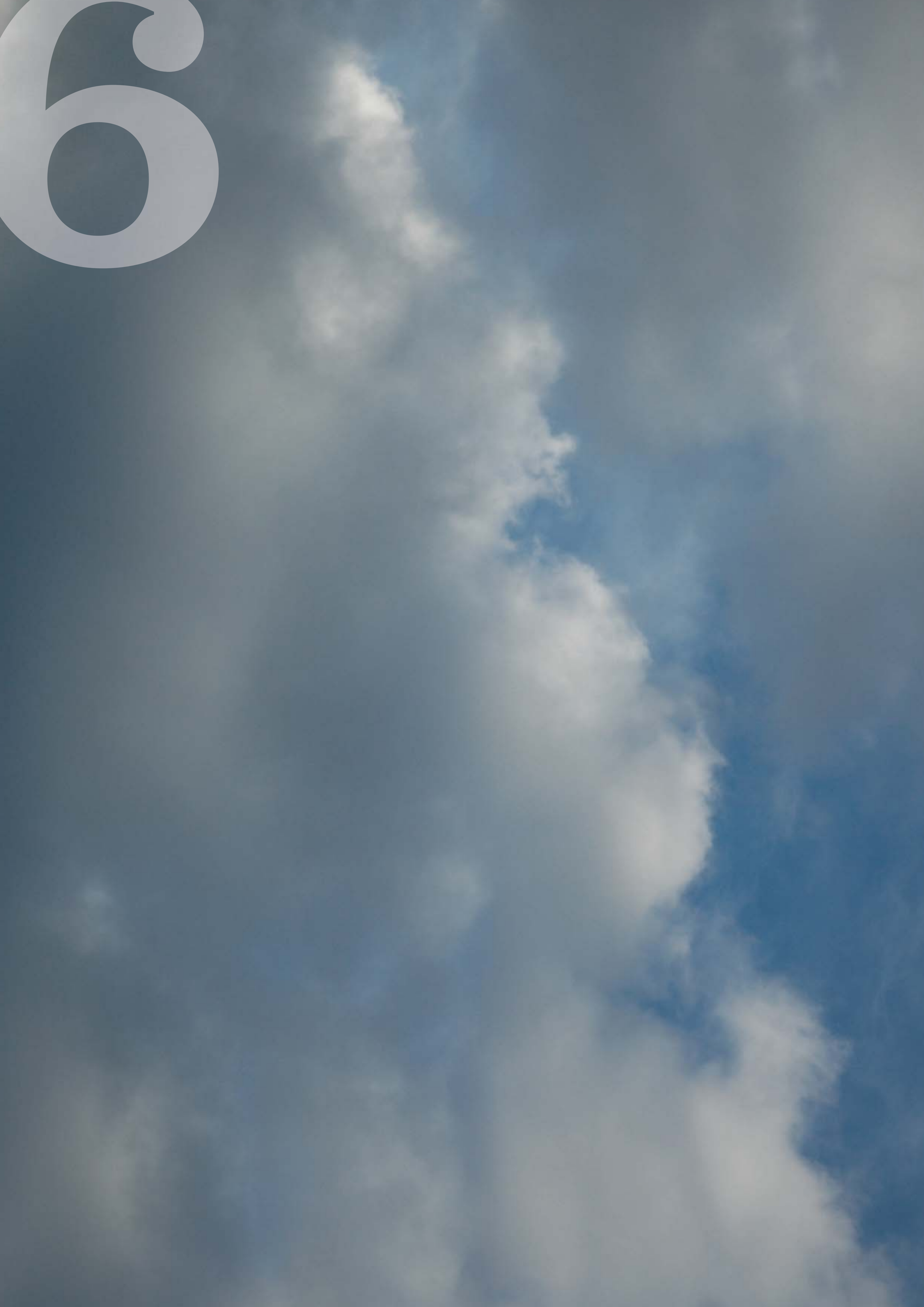
6.1 The Atmospheric Enviroment

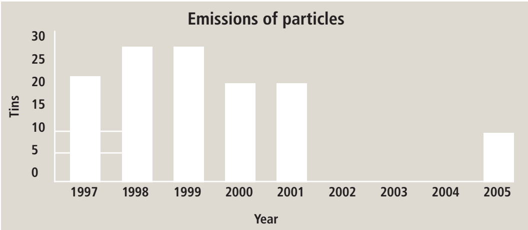
Quite clearly, changes in energy supply and consumption patterns have had profound consequences for the emission of greenhouse gases and other emissions that in one way or another are detrimental to the environment. Sulphuric oxides (primarily the dioxide SO2), nitrogen oxides



(NOx), airborne particles and carbon dioxide (CO2) will be discussed in some depth, while other emissions are diverse hydrocarbons, carbon monoxide, methane and dinitrogen monoxide.

6





The figure depicts the emission of SO2, NOx and CO2 over time

The figure above depicts the emission of SO_2, NOx and CO_2 over time.

Sulphur dioxide and nitrogen dioxides

The emissions of sulphur dioxide and nitrogen dioxide influence the acidity of the environment, both that of the surrounding land and the sea. The amount of sulphur dioxide emitted depends on the amount of sulphur in the fuel combusted, while the amount of nitrogen dioxide emitted depends on the combustion chamber and technology used. The combustion of any fuel involves large amounts of atmospheric air – more specifically oxygen – in the combustion process. But the atmosphere consists in large part of gaseous nitrogen, and a small percentage of this gaseous nitrogen is changed to NOx. The process is less dependent upon the concentration of nitrous contents in the fuel itself.

The emission of sulphur dioxides from 1997 - 2005 has fallen from 85 tons to a level below zero. The nitrogen dioxide emissions have been reduced from 340 tons to minus 10 tons. The negative figures are explained by the export of energy which spares the mainland these emissions.

These large reductions are primarily due to substantial wind power production, and benefit even mainland consumption, as exported wind-generated electricity substitutes traditional coal-generated electricity. There will not be a local reduction in the acidity levels from the smaller emissions of SO_2, and NOx, but there is a regional effect.

Particles

The table above shows a very significant reduction in the emission of air-borne particles. These results must be qualified, however, as there is some uncertainty involved in the available data. This is in part because the respective volume of consumption of the different fuels is somewhat uncertain, and in part because emissions are strongly dependent upon the smoke cleaning techniques employed, a subject not evaluated here.

Once again, the significant reductions in emission levels are to a large degree due to the wind turbines.

Carbon dioxide

The reduction of carbon dioxide emissions, the most important of the greenhouse gases, is very significant and a direct result of the energy transitions made. In 1997, Samsø's energy consumption added 45,000 tons of CO_2 a year to the atmosphere. With the described island energy transitions this emission has has decreased to less than zero, with the mainland emitting 15,000 tons less due to their imports of wind-generated electricity from the island. This large reduction in CO_2 emissions is due to the large scale development of wind power which replaces coal generated electricity on the mainland.

The apparent increase in emissions from 2003 - 2005 can be attributed to new emission data from the national office (www.energinet.dk) which are much lower than those used previously.

The conclusion is thus that the transition to renewable energy res ources had a significant positive impact on greenhouse gas emissions.

6.2 The Terrestrial and Aquatic Environment

The previous section focuses on the impact of sulphur dioxide and nitrogen dioxide emissions on the tmosphere. The decline in emissions is particularly beneficial for the terrestrial and aquatic environment. This is also the case with the air-borne particles.

They are emitted to the atmosphere, but they fall with rain over land and sea. On agricultural areas they do little harm, as they are just a little more fertilizer, which of course is uncalled for in protected nature reserves. The same is the case for the sea.

But while still in the air, these particles do represent a detrimental health hazard for all that inhale them, and a reduction in particle emissions benefits people in the vicinity of chimney and tailpipe emissions.

Cinder, slag and biomass ashes

The combustion of various solid fuels (coal and biomass) also produces ashes, slag and cinders.

This relationship has not been computed exactly, but a rough estimate suggests that the production of wind-powered electricity reduces the production of ashes and cinders by about 4,500 tons annually. On the other hand, the increased use of biomass for heating has doubled the production of biomass ashes on the island, from 100 to 200 tons annually. The national energy transition has reduced the production of cinders and ashes in the nation as a whole quite considerably, although local production of ashes has doubled.

Biomass ashes can be used as fertilizer on agricultural areas if they meet restrictions for concentrations of e.g. heavy metals. When using primarily local biomass resources, the minerals are simply recycled locally. It can also in some cases be used to produce concrete, or deposited, if no use is found for it, at a landfill site.

Other considerations

The original Samsø energy island project also envisaged the construction of a methane gas plant to extract energy from animal slurry and energy crops. This methane gas plant would not only produce a CO2 neutral electricity, but also result in lower emissions of methane gas and dinitrogen monoxide from the slurry beds, and from the fields fertilized with the de-gassed slurry. It would also reduce odour problems while spreading slurry, and reduce the loss of nitrate to the water systems in two ways: 1) by improving the utilisation ratio of the available nutrients in the slurry, and 2) by encouraging the cultivation of more perennial energy crops.

This methane gas plant has not yet been stablished,but the plans are not completely abandoned. Perhaps an improvement in the price paid for electricity generated with methane gas would make its construction feasible.The described positive environmental consequences can still be realized.

7. Economics and Employment

7.1 Economics, Public and Private Funding

In the years 2000 - 2003, 11 land-based wind turbines (altogether 11 MW production capacity) at a cost of 66 million DKK (about 8.8 million EUR) and 10 even larger offshore wind turbines with a total production capacity of 23 MW and a total investment of about 250 million DKK (about 33.3 million EUR) were established. The Danish Energy Authority contributed 7.5 million DKK (one million EUR) to the preliminary studies and project material. In the years 2001 - 2004, three new district heating plants were contracted; a total investment of 45 million DKK (6 million EUR). More specifically: 2001 - 2002, Nordby-Maarup cost 20.5 million DKK (2.7 million EUR), 2002-2003 Onsbjerg cost 8.5 million DKK (1.1 million EUR), and in 2004 Ballen-Brundby cost 16.2 million DKK (2.1 million EUR). These district heating projects received public grants from a 'From the ground up' district heating allocation fund administered by the Danish Energy Authority.

The Nordby-Mårup plant received approx. 9 million DKK (1.2 million EUR), Onsbjerg approx. 3 million DKK (400,000 EUR) and Ballen-Brundby approx. 2.5 million DKK (330,000 EUR). The relatively small grant awarded the last of the district heating plants was because it was granted the last of the allocated funds. During the same period of time, from 1998 - 2005, private homeowners and busineses invested about 15 million DKK (2 million EUR) in individual renewable energy production units – solar thermal units, biomass boilers, and heat pumps. These 300+ investors received public subsidies of approx. 3 million DKK (400,000 EUR) from the Danish Energy Authorities' different programs.

Different energy conservation investments, such as extra home insulation and window upgrades in primarily private homes in the period 1998-2005 entailed investments of app. 15 million DKK (2 million EUR), which in turn generated public subsidies for approx. 4.5 million DKK (0.6 million EUR). One subsidy program in particular, a program to help old-age pensioners make home improvements to save energy, received most of the public funding granted to these investments.

7.2 Employment

Quite obviously, the total investment of about 425 million DKK (57 million EUR) in these years generated a number of jobs. The number has been estimated to correspond to 20 man-years of employment per year in the period 1998 - 2007, an estimate including positions filled during both planning and constructing the 21 wind turbine and three district heating plants, private home investments, and the Energy Academy building itself.

Both the district heating projects and the wind turbine projects have used local contractors for the foundation work, and local machine shops and electricians for installation work, even when the main contractor has been a mainland based company. The local plumbers and blacksmiths were certified to install solar thermal units in 1998, at the initiative of the energy island project, to ensure the local employment benefits of these installations. The many new energy units also require servicing which is carried out by the local tradesmen, and the local farmers are assured better prices for their waste straw when they contract delivery to the local district heating plants.

The number of persons working with organising, planning, and communicating the Samsø Renewable Energy-Island project is also increasing. In 1998, two persons worked full-time with the project. In 2007, six people were employed. This increase in staff is a measure of the increasing interest and demand for services and facilitating the Samsø Renewable Energy-Island project. The project has succeeded in establishing a regional Energy Agency financed partly with EU funds. The rest of the Agency funding is national funding from the Danish Enterprise and Construction Authority and the Samsø Offshore Wind Co. A national energy consultancy program has posted one consultant on the island due to the energy island project, and the Danish Enterprise and Construction Authority has also financed a three year Director position for the Samsø Energy Academy. All these organizations cooperate as integral parts of the daily work done at the Samsø Energy Academy.

8. Organization and Finances

8.1 Organization in General

As a general rule, the Island Energy Project organised the larger district heating systems. An initial overview of these large projects entailed clarification on very basic accounts: budgets, environmental assessments, and local relations and special interests. These very basic details have been crucial for the viability of the projects.

8.2 The Organization and Financing of Individual Units

In 1997, individual RE units could apply for, and receive, subsidies from the Danish Energy Authority from a program available to projects nation-wide. Until 2001, solar thermal panels received a subsidy of up to 30 %, biomass boilers up to 20 %, and heat pump units up to 15 %. Homeowners with electric heating could also apply for conversion subsidies to install waterborne heating systems (radiators).

In both 1999 and 2000, the Danish Energy Authority granted the RE-island project the necessary funds to hire independent energy consultants who could offer private homeowners living outside the proposed district heating areas their assistance. The project offered homeowners a free energy appraisal of their home, pointing out possible ways to save energy, and estimating the age and efficiency of their current furnaces. Local dealers and distributors made fixed price offers for the purchase and installation of a number of specific units, and the energy consultant could therefore inform the homeowner quite precisely what it would cost to make the transition to RE. After the home call and appraisal, the consultant sent the homeowners a letter, often including an estimate of the possible savings obtainable by the transition to thermal solar heating and/or a replacement of the oil furnace with a wood pellet boiler or a heat pump unit. In 2001, all of these subsidy programs were terminated, but homeowners continued investing in individual RE units on Samsø. This is in part due to the rapid increase in fuel oil prices in the beginning to middle of the 1990's.

8.3 The Organization and Financing of District Heating Systems

The district heating projects are all organised with a high degree of citizen involvement in the project. The energy organizations arranged meetings with local citizens in the potential district heating areas, and these meetings appointed local citizen groups. These groups then participated in local promotion work and the collection of the requisite contract signatures form the individual homeowners. The financing model used is described in detail in Chapter 2. The district heating systems have different forms of ownership. Nordby-Mårup District Heating is owned and operated by the local utility company NRGi (which already owned the RE plant in Tranebjerg). Onsbjerg District Heating is owned and operated by a private investor, the entrepreneur Kremmer Jensen. Ballen-Brundby District Heating is cooperatively owned. Financing has in part been assisted by municipally guaranteed mortgages, and all three district heating systems received grants from the Danish Energy Authority's 'From the ground up' funds. There are further details in Chapter 7.

9. Samsø's Renewable Energy-Island Organizations

Samsø Energy and Environment Office was founded in 1997 with the explicit objective of promoting renewable energy and counselling island citizens who wanted to establish their own RE projects. Samsø Energy Company was founded in 1998 to implement projects, especially wind turbine and district heating projects.

These two organizations organised campaigns and meetings, both individually and collectively, from the very start of the RE-island project. This meant that joint meetings often gave both a technical and a more general version of a specific project proposal. This helped insure that the island citizens could participate actively in the preliminary processes entailed by new RE-island projects, for example joining citizen groups working with district heating projects. See the other chapters for more details about these processes.

By the end of 2005, there were three new district heating systems, 11 land-based wind turbines, 10 offshore wind turbines, and a large number of private REunits. The goal of 100 % self-sufficiency with renewable energy was more or less achieved, and the RE-island organizations were reorganized.

The Samsø Energy Company was shut down in 2005, as the larger heating and wind power projects were implemented. The two employees continued their work for the RE-island project, one as a senior consultant for the RE-island project, specifically the realisation of the Samsø Energy Academy project. The other engineer continued working for local and regional RE projects under the auspices of the new Samsø Energy Agency (SEA). SEA was founded in 2005. It is a regional energy office described in more detail in chapter 7. The same year, the former national network of energy offices received new funding in a more streamlined version, and the new Energy Service Denmark appointed an Energy Service officer to work on the energy island project in collaboration with the Samsø Energy Academy. Energy Service Denmark is also described in chapter 7.

The Samsø Energy Academy was ready for occupancy in the fall of 2006. It now houses the RE organizations Samsø Energy Agency, Energy Service Denmark, and Samsø Energy and Environment Office, the latter still being an active participant in local RE arrangements. The Energy Academy works with education and RE communication by mediating workshops, conferences and exhibitions. The Energy Academy also operates a school service which prepares educational material and confronts a large number of local and visiting school classes with a 'hands-on' learning experience. The school children learn about different kinds of energy and experiment with making them work, for example by building a wind turbine that can generate electricity.

Samsø Energy and Environment Office is co-owner of the organization Samsø Offshore Wind Co. This company was formed to coordinate the offshore wind turbine project and to retain the project concessions. The energy organizations have helped found other organizations: Samsø Landfill Biogas Co. and a number of other organized projects. These are described in the chapters relating to the energy forms involved.

1. RE, the Degree of Self-Sufficiency and Exploitation of Local Resources

– In the energy balance sheet for 2005, the RE supply meets 99.6 % of demand and the objective of self-sufficiency within a ten year period can be said to be met in full, in addition primarily fulfilled with local resources. –

The ultimate objective, to be self-sufficient with renewable energy, was extremely ambitious, and few people actually thought this possible given the short time span of ten years. In 1997, 13 % of the island energy supply was based on renewable energy, roughly equivalent to the average for the country as a whole. Waste straw was by far the most important resource used in Tranebjerg and a number of smaller units. Firewood and wind turbines made much smaller contributions.

This 100 % self-sufficiency draws on only 35 % of the local biomass resources: 67 % of the straw resources, 100 % of the wood resources, 0 % of the biogas potential and of course a great deal of wind power, which is almost unlimited. There is still room for improvement, especially with regards to the exploitation of the large biogas resources, about 145 TJ when supplemented with energy crops.

2. The Supply and Utilization of Heat

2.1 District Heating

– The widespread introduction of district heating systems is achieved to some extent, as 43 % of heat consumption is now based on district heating. –

The master plan adopted very ambitious goals for the implementation of district heating systems. Four new projects were suggested, so that the combined district heating coverage would rise from 25 % (the Tranebjerg plant) to about 65 % of the total heat supply on the island. The energy balance sheet for 1997 shows a total heat consumption at the consumer level of about 140 TJ, more than half of which derived from fuel oil. The master plan thus envisaged about 90 TJ covered by district heating systems based on renewable energy resources, produced by new 'from the ground up' district heating systems and the existing straw-based district heating plant in Tranebjerg. Connection to these new district heating systems was to be voluntary in accordance with a municipal decision to this effect. One exception was mandatory district heating connections for new subdivisions near the proposed new plants.

The planned district heating systems were:
'The string of pearls' – Sælvig/Onsbjerg/Tanderup/Pillemark/Hårdmark/Kolby/Kolby Kaas – Fuel/energy source: Surplus heat from the ferry/Biogas/Landfill gas/Woodchips
'Straw and Heatpumps' – Ballen/Brundby/Permelille/Ørby – Fuel/energy source: Straw/Heat pumps for industries
'Combined Biogas' – Besser/Langemark/Torup/Østerby – Fuel/energy source: Biogas/Energy crops/Wood chips
'Woodchip and solar thermal' – Nordby/Mårup – Fuel/energy source: Woodchips/solar thermal

Only one of the district heating systems described above was implemented as planned, 'Woodchip and thermal solar' in Nordby-Mårup. In the master plan, the net heat demand and the investment were calculated to be 21 TJ and 24.5 million Danish kroners (DKK) equivalent to 3.3 million euros (EUR). The actual heat production is on the average 19 TJ and the initial costs were about 20.5 million DKK (2.7 million EUR).

The master plan pointed out that the production of woodchips or willow saplings could be established in an environmentally ambient fashion on agricultural acreage subject to special restrictions deemed necessary to protect the groundwater, or as a product of waste treatment systems using willow beds to clean low nutrient wastewater. This has not as yet been implemented.

'The string of pearls' had a number of weak points. Some of the heat sources were rather uncertain, for example, the ferry heat and landfill gas. And the district heating system was conceived with a very long line of transmission (approx. 10 km.) for such a low volume system. This meant the investment needs were quite substantial. In 2000, this project was abandoned, and a less ambitious project to heat just the village Onsbjerg with a straw-based heating plant was established (85 connected homes as opposed to the original scheme's 530 homes). The houses in the other villages on the string of pearls are still heated individually.

Although the project was abandoned, several interesting studies were carried out. The landfill gas potential from the closed and covered waste disposal site outside of Pillemark was not abandoned with the string of pearls heating system. The disposal site does contain some gas, although much less than expected. A local attempt to generate electricity using the landfill gas was met with very little success.

The ferry heat project was supposed to make an important contribution to 'The string of pearls'. A study was carried out and it documented that utilizing the surplus heat from the ferries could be implemented in an economically feasible way. The technical installations were quite simple, but the organizational questions were much more complex: ownership, state taxes, and other concerns were so complicated that they not only represented difficult problems, but made the actual utilization of the heat surplus impracticable. Since then, the ferry line has lost its concession to the ferry route from one of the harbours on the string of pearls. If the district heating plant had been based on this ferry heat, a new operator would have complicated matters even further.

Also the **'Straw and heat pump'** system underwent change and diminution. This project was also weakened by the relatively long transmission line envisaged. Its ambitious attempt to supply very small heating markets with district heating proved unviable, a possibility the master plan did mention might arise from of more detailed studies.

The project was therefore limited to only Ballen and Brundby already in the planning phase. This reduced project met many hindrances on its way. Several project suggestions were rejected by the homeowners and only a concerted effort made the district heating system possible. The heating plant in Ballen is straw-based and produces about 18 TJ annually.

As its name suggests, this plant was to use surplus heat from two large industrial complexes on the island, the Danish Crown slaughterhouse in Ballen and the canning factory in Permelille. The slaughterhouse closed a few years after Samsø won the RE-island status, and the utilization of the surplus heat from the canning factory was only possible for the original project with its long transmission line.

The **'Combined Biogas'** plant had to be dropped altogether. The project was complicated and the homeowners in the area showed little interest, in part because a number of these homeowners had already invested in relatively new biomass and other renewable energy units.

The **'Tranebjerg plant'** was established before the RE-island project. It is straw-based and in 1997 used straw representing 47 TJ. This figure has now fallen to 41 TJ, which is primarily due to the installation of a large hot water storage tank and only to a lesser extent the result of energy conservation efforts.

2.2 Individual Heating Units

– The transition of houses in the open countryside has to some extent succeeded, as approximately half of the year-round houses have installed RE systems to meet all or part of the household heat demand. –

The RE-island project carried out a number of initiatives to promote the use of renewable energy units. Blacksmiths, plumbers and local dealers participated in courses to be certified as thermal heat tradesmen. An energy exhibition was held. Various energy campaigns and energy appraisal offers were organized, all expressly to further the use of renewable energy units in the open countryside.

The master plan envisaged the installation of about 160 solar thermal units to heat household water and supplement household heating, as well as 700 solar thermal units producing hot water alone. The plan also envisaged a number of different biomass units and household wind turbines, some of which would produce hot water.

The number of individual RE units has not been registered, but the use in particular of woodburners and wood pellet boilers, and to some extent heat pumps, has risen considerably since 1997. For example, the consumption of wood pellets has risen from practically nothing in 1997 to 21 TJ in 2005, which represents the average consumption of 300 households.

On the other hand, the more 'exotic' RE units have not been attractive and therefore do not supplement the array of possible individual solutions. No new heat producing windmills or farm-scale biogas units have been established during the project.
One measure of the success of the transition to RE is the consumption of fuel oil for heating purposes. In 1997 this was about 133 TJ and in 2005 about 74 TJ, a decline of almost 50 %. This result is quite

satisfactory, considering the loss of state subsidies for this transition in 2001/2002. Not unexpectedly, the most difficult sector to influence is the vacation home/summer cottages. Very little has changed in these houses, except for the installation of a smaller number of airborne heatpumps.

2.3 Heat Consumption and Heat Conservation

– The targeted savings of 25 % of the heat consumption has not succeeded in spite of relatively intense efforts. –

The master plan calculated the heat consumption to be about 140 TJ – at the consumer level (terminal heat consumption) – and estimated that 25 % of this could be saved by influencing consumption patterns with campaigns.

Five campaigns targeting savings on household heating were carried out. There were campaigns for old-age pensioners, energy appraisals of private homes, advice and energy calculations when installing RE units, demonstration projects for insulation materials, etc.

Almost 500 households have in one or another of these campaigns been in touch with different energy savings advisors. Far fewer have actually implemented actual energy conservation measures, either because their insulation standard has been acceptable or because the economic incentive or the amount saved has been too small.

Total heat consumption today is about 155 TJ. In other words, an increase of about 10 %. This is even more remarkable given the simultaneous 5 % decline in the island population.

Please note that these figures may be subject to a number of uncertainties, for example periodic displacement because of storage facilities for fuel oil, etc. The heat balance sheet for the Tranebjerg plant as mentioned above suggests that some energy conservation measures have been implemented, at least in this specific area.

3. Electricity, Consumption and Production

3.1 Electric Consumption and Savings

– This evaluation concludes that the conservation of electricity envisaged in the plan has only succeeded to a minor degree. –

The total consumption of electricity in 1997 was about 105 TJ, of which 18 TJ was used for heating purposes and 6 TJ was wind power from the island's 6 smaller wind turbines.

The master plan predicted higher electricity consumption due to many new heat pumps in homes, two industrial heat pump installations, more widespread electric heating in homes, and the introduction of electrically charged vans, cars and buses.

The number of heat pumps and the amount of electricity used for home heating is on the rise, but cannot be quoted exactly. The industrial heat pumps have not been built (see above) and the introduction of electric vehicles has not been a success, even though the municipal home care department leased four electric vehicles early in the project. The batteries were not good enough to give sufficient stability, and the operating costs were higher than expected.

A number of campaigns have focused on the conservation of electricity. One promoted the conservation of electricity in the agriculture sector, which was followed up with energy appraisals of the farms, including specific recommendations for potential savings. The specific results of this project have not been tallied.

The energy vision suggested a number of campaign ideas that have not yet been tested in practice. One idea was a campaign to replace home appliances, another idea was a campaign about appropriate use. Other suggestions: energy conservation advice for agriculture (partially implemented), savings in public buildings using energy advisors, and the preparation of a tactical program for energy conservation.

The consumption of electricity exclusively for heating purposes was about 83 TJ in 1997, and the master plan estimated that this consumption could be reduced to about 70 TJ after the campaigns had influenced consumption, a predicted decline in consumption of about 15 %. In 2005, the same electricity consumption was about 80 TJ. The level of savings has thus only been 3 - 4 %.

3.2 Electricity Production

– The production of electricity to match the electricity consumption on the island has been completely successful. The project has also established a wind

turbine capacity that matches the transportation energy consumption. On the other hand, other electricity production technologies have not been demonstrated on a larger scale: PV solar cells, household wind turbines and methane gas generation of both heat and electricity. –

At the start of the project, the great majority of the island's electricity consumption was imported from the mainland's large power plants and this consumption was primarily based on the coal used in these power plants. Only 5 % of the island electricity was derived from wind turbines.

The master plan proposed a production of electricity based on the replacement of the existing wind turbines, with larger units with a total capacity that would meet the island consumption of electricity. In addition, an offshore wind turbine park was suggested as a way to compensate for the energy used in the transportation sector, as it would not be feasible to convert this sector to RE within a ten year period. To supplement these sources, other techniques, in particular biogas units (both larger joint project and individual farm units), household wind turbines and PV cells would deliver electricity. While the biogas was expected to contribute appreciable amounts of electricity, the latter two were more considered of interest as exhibits for demonstration purposes.

In 2000 the 11 new 1 MW wind turbines were erected in a large scale renovation of the island wind turbines. Six smaller wind turbines were removed at the same time. The master plan suggested a terrestrial wind turbine production of 86 TJ. In 2005 this production was 100 TJ.

In 2005, 10 new 2.3 MW offshore wind turbines were erected south of Samsø. The master plan suggested a production of 260 TJ. In 2005 this production was about 285 TJ.

The Samsø Energy Academy has 100 m² PV cells integrated in the roof. This unit and the 2 – 3 other smaller units on the island do not contribute significantly to the power supply.

A couple newer household wind turbines should be erected to demonstrate the latest technologies available.

The island project has not established one or more biogas units. A single preliminary project has been carried out, but to no avail. One or more biogas plants would not only be an asset for demonstration purposes. They would also contribute with considerable amounts of electricity if built in the scale envisaged in the master plan. Hopefully, the government's new Energy Proposal will soon be passed. This bill should improve the economic returns for biogas plants to the extent that biogas proposals will merit renewed attention.

4. Transportation

– Very little has changed in the transportation sector. The postulated savings have not been met and newer means of propulsion (electricity) have not been introduced in any appreciable degree. The idea in the master plan of substituting the transportation energy consumption with wind power has on the other hand proven to be a very realistic and pragmatic solution. –

The consumption of energy for transportation was in 1997 almost 200 TJ. In 2005, this figure has risen to 210 TJ.

Almost half this consumption is used by the ferries, while the rest fuels cars, trucks, tractors and other heavy equipment. The ferries' consumption has been quite stable at about 90 – 95 TJ a year, except for one year, where it for unknown reasons fell 25 %(!), which most likely is a mistake in the data material. No apparent changes in the ferry services or resource management can explain so great a difference.

The stable rate of consumption is quite logical and to be expected, as the same ferries have been used and the ferry schedules have been more or less the same.

This consumption has been difficult to influence in any direct way, and as already explained, it also turned out to be very difficult to make indirect use of the surplus heat from the ferries (district heating: The string of pearls).

Of the 1997 consumption for the land-based transportation, about 110 TJ, the master plan anticipated savings of 5 - 10 % by improving the average mileage of the vehicles driven by trading older models for newer, more energy efficient vehicles, improved driving techniques and better car maintenance, reduced need for ploughing and other less energy intensive agricultural practises, etc.

In 2005, energy consumption for this land-based transportation was about 115 TJ, an increase of about 5 %, and this evaluation must point out that a number of the recommended projects dedicated to reducing this consumption – driving technique courses, energy management, a reorganization of the goods and courier market, etc. – have not been implemented. Only a few transportation projects have been carried out. One was a study of the possibility of revamping the bus service to make it more flexible and more energy efficient, a project which for different reasons did not get implemented. Another transport project hosted several theme days or meetings about less energy demanding ways to till the land.

There are several reasons for the lack of action on these topics. The Samsø Energy Company employees had limited resources and had to concentrate on other tasks that had higher priority. Second, these projects were difficult to finance. Traffic studies and related projects are notoriously expensive and the results are often of less import than expected.

The master plan presupposed that in the course of a few years, a lot of the daily transportation needs would use electric vehicles. Expectations of these electric cars were high, and the municipality leased four electric vehicles (Citröen Berlingo) shortly after the RE-island project started, for daily use in the home care service. These cars did not last long, primarily because the batteries weren't good enough, service too time-consuming and too unreliable. The Energy Academy has one electric car used by its personnel.

There are positive highlights. A handful of farmers are growing their own fuel, using rapeseed oil in converted diesel motors in their tractors and cars. The initiative is insignificant in light of the total energy consumption for transportation.

5. Economy

5.1 Investment and Public Subsidies

– For an average investment of about 100,000 DKK (13,333 EUR) per capita and public subsidies of about 7-8,000 DKK (1,000 EUR) per capita, the island energy supply has been transformed to 100 % RE self-sufficiency. –

The master plan set the price for the transition of the island energy system at approximately 590 million DKK (78.7 million EUR). Furthermore, the plan calculated that to ensure these investments a reasonable break-even time span of ten years, 70 million DKK (9.3 million EUR) in public subsidies would be required.

It is difficult today to calculate exactly how much money has been invested, because many citizens have invested in individual units. A qualified guess is the best we can offer; let's say 400 million DKK (53.3 million EUR). The direct public subsidies granted the district heating projects, the offshore wind turbine park and the private energy projects add up to about 30 million DKK (4 million EUR).

Both the total investment and the total subsidies have been much lower than originally predicted. This is also in part due to the many projects not yet effectuated and the projects abandoned, especially because their economic feasibility was too poor.

5.2 Local Economy and Local Savings on Fuel

– The RE-island project has had an appreciable positive effect on the local economy, as the import of fuel oil for heating purposes has fallen about 10,000 DKK per capita – money which to some extent now circulates on the island. –

As mentioned earlier, a large number of islanders are directly involved in investments in different RE units and systems. In addition, the RE-island project has an important influence on the local economy, because money used to purchase energy after the transition is more often paid to the primary producer on the island, instead of paying the mainland for fuel imports.

Two areas are paramount. Imports of fuel oil and electricity have fallen considerably. And the import of wood pellets has increased dramatically.

The master plan estimated annual savings on the purchase of fossil fuels at about 65 million DKK (8.7 million EUR). The actual savings on fuel oil, electricity and wood pellets is about 45 million DKK (6 million EUR). This is less than predicted, and can be explained in part by the continued importation of some fuel oil products, as well as the import of wood pellets from the mainland.

6. Employment

– The project has especially in the construction phase had a positive effect on the local employment. How much is difficult to estimate. –

There's no doubt about the positive effect the implementation of the RE-island project has had for local employment. The construction work on the district heating systems and the many individual heating units, especially the solar thermal units, has used local contractors and companies, and the percentage of locally employed workers is high.

On the other hand, the large wind turbine projects have not generated much local employment. The turbines, wings, and towers are all produced on the mainland and the wind turbines were also erected by special construction teams from the mainland. One local firm did the foundation work for the terrestrial wind turbines.

The number of permanent jobs is not as high as expected, as both the operation and maintenance of the turbines is handled from the mainland. One Samsø firm has signed a wind turbine service contract.

Using more biomass in the energy supply would help rectify this lack of local jobs.

7. Communication and RE Tourism

– The results of the project are communicated effectively to both the local populace and the world at large. The islanders have adopted the project and it in turn has placed Samsø on the map around the world. –

The local media have been used extensively as communication channels, both to inform about and mobilize participation in different activities, and to give general status reports about the progress of the project.

Outside the island, being Denmark's Renewable Energy Island has generated a lot of attention. And this attention has certainly not decreased as one RE project after another became a reality. Quite naturally, the project was primarily a matter of national interest in the beginning, but as the goal of 100 % RE was attained, international interest grew stronger, with much coverage in world renowned newspapers and on international TV neworks. This interest in the project has, since day one, given press coverage of the results achieved, making these results available for a broad public both at home and abroad. This access to the media has in itself generated more interest in the project. And the international interest in the project has generated a positive feedback that has reinforced local islanders' support and interest in the project.

The energy organizations have also participated in a number of international networks and initiatives with the same goals: Sustainable Energy Islands, which have given other projects access to the experiences gained in the Samsø RE project. They have hopefully been able to use them.

The latest initiative to further this communicative aspect of the project is the Samsø Energy Academy, where a number of energy technologies and energy conservation technologies are demonstrated for citizens and visitors.

Since the very beginning of the project, demand for RE vocational tourism has been considerable. Especially tourists from the Asian countries have visited the project frequently.

8. Local Involvement/Participation

– The mobilisation of the local populace and the spheres of cooperation established between local participants and interest groups has been exceptional, and a central factor to bear in mind when explaining why the project has achieved such good results. The Samsø Energy Company's staff have been acknowledged as credible 'whips' in touch with reality and what was feasible. –

An ambitious project like the energy vision for Samsø RE-island can only achieve its objectives if all local parties – citizens, authorities and the business community – embrace the projects open-mindedly and positively. A little venture capital is also a good asset.

Innumerable public meetings have been arranged during the last ten years, often with an amazing turnout. This cannot be attributed to the free coffee and cake alone. The islanders' interest in the project has been both widespread and genuine, after a little slow start with a natural touch of scepticism.

Every larger project – and in particular the district heating plants – mobilized the local citizens and this participation in most cases grew even stronger during the course of the project. And the projects embraced by positive citizens who had the tenacity to keep at it were also implemented. Where the projects met less positive responses, and there can be many reasons for this, the projects had to give up. This is the case with several district heating systems.

Many individuals have invested in RE units as a way of supporting the project.

The islanders have also participated actively and constructively in the large wind turbine projects, and some have invested considerable funds in these projects, with the expectation of a positive return at a later point in time.

The local authorities have been positive, and the Municipality of Samsø has been very engaged in the project from the beginning. The municipality and the mayor himself actively supported the process which produced the winning master plan. Several prominent members of the business community were also actively involved from the beginning, driven by the potential and possibilities in the ideas rather than focusing on the difficulties.

The municipality also exhibited a resolute ability to make decisions and run a risk, for example when deciding to finance half of the offshore wind turbines, but also by participating in different public meetings and improving the municipal track record on the RE area.

9. Environment

– This report can conclude that the transition to RE has had the predicted effect on the reduction of greenhouse gases and air polluting fractions. From the average emission of approx. 11 tons, 80 kg and 20 kg of CO2, NOx and SO2 respectively, emission per islander are now approx. minus 4 tons, minus 2 kg, and minus 1 kg. –

A principal objective of the RE-island project was a reduction of the CO2 emissions caused by the island energy consumption.

The master plan calculated the initial rate of emissions to be about 65,000 tons a year. This emission figure has since then been corrected to 46,000 tons using other baseline figures for emissions. The master plan also calculated that emissions after the implementation of the energy plan would be reduced to about -14,000 tons. These negative values derive from the export of wind power to the mainland, where it replaces electricity that otherwise would be generated with coal. The latest energy balance sheet for 2005 shows present emissions to be -15,000 tons annually. Here the master plan's predictions were right on target.

The emission of NOx and SO2 were originally calculated to be 275 tons and 70 tons respectively. These figures in the revised energy balance calculations are approx. 340 tons and 85 tons. Today these emissions are, thanks to the RE transition, reduced to -10 tons and -4 tons respectively. Here too, the mainland saves emissions because of the export of wind power from Samsø.

Particle emissions have declined by about 20 tons, from 30 tons to about 10 tons. The production of ashes and cinders will decline for the country as a whole by 4,500 tons annually because of the implementation of the national RE plan.

The construction of a methane or biogas plant would have meant considerable improvement for several important environmental parameters: less slurry odours, less methane gas and laughing gas emissions, and less nitrogen loss. Until the biogas plant is established, these emissions will continue.

10. Summary and Conclusion

To sum up, the project must be deemed almost completely successful. The primary objective has been achieved: 100 % self-sufficiency with renewable energy is attained using local resources, at the same time totally removing the emission of the greenhouse gas CO2 and other air pollutants. One of the explanations for this success is the mobilization of the local populace and their subsequent adoption of the project.

On the other hand, the conservation objectives have not been met in the heating or the electricity sector. Transportation has not been reduced or transformed to renewable energy.

The project has been a colossal task for such a small society, and they even finished on schedule. Could the same be done in all of Denmark? The table below shows that this task will be more difficult for several reasons. First, the national energy consumption per inhabitant is 25 % higher than the level on Samsø. Secondly, the national area resources that can be used to produce biomass are only one-third of the area Samsø has at its disposal. The wind resources per inhabitant for the country as a whole cannot match Samsø's potential.

The task will not be easier for the country as a whole. If Samsø is considered an integral part of the Danish energy supply system, and thus bound to deliver its share of the country's total energy consumption as RE, this change of perspective leads to different conclusions:

	Energy consumption MJ/Capita	Area resource hectares	Energy comsumption MJ/hectar
Samsø	130	2,8	50
Denmark	160	0,8	200

- If Samsø is to contribute correspondent with its area, RE production must be increased fourfold compared to the present level

- If Samsø is to contribute correspondent with its population, RE production must be increased by 25 %

In both cases, a substantial increase in production compared to the present. These considerations are in no way meant to detract from the success of the Samsø project. They merely attempt to bring the challenge of the national transition to RE in the proper perspective.

One essential conclusion can be made. If Denmark wants to make this same transition to RE, very substantial conservation efforts will be necessary to reduce the amount of energy needed. Samsø's experience certainly shows that these savings do not appear out of nowhere. It will take a lot of hard work, and both economic incentives and penalties to make it happen! On the other hand, one kWh saved is worth much more than one produced. It doesn't need service checks!

A direct transfer of the Samsø results to the whole of Denmark would mean that the transition of Denmark to an RE based energy supply system would cost about 670 billion DKK (89 billion EUR). This investment would save the country about 60 billion DKK (8 billion EUR) annually and thus be paid off in 11 years, not a bad return given the seriousness of the problems involved!

Ideas for following up on the reduction of energy use on Samsø – the continuous road toward a sustainable society.

The success of the restructuring of the energy supply to 100 % renewable energy (RE) and the demonstration of a range of different REtechnologies on Samsø, is mostly due to the citizens' participation. That will also be crucial in a follow-up project and must be encouraged in order to ensure local ownership and durable solutions in the long run.

Samsø has a good size for making full-scale experiments and new energy solutions. Moreover Samsø has become widely known and it is a good showcase for emerging solutions. This offers opportunities to combine know-how with show-how in order to generate a multiplier effect. This brand should be exploited to attract venture capital to pursue new, slightly larger, and perhaps more demanding experiments in full scale. An example would be the electrification of transportation and the necessary infrastructure to do so.

The follow-up on the energy project, Samsø Version 2.0, will focus on those parts of the energy consumption that are still problematic, and still have considerable room for improvement, while trying to involve new energy technologies with significant potential in the demonstration palette. The follow-up will still focus on energy, but now wider, including the more comprehensive topic: sustainability.

Restructuring of agriculture to organic farming and biogas production

- One or more biogas plants based on energy crops (nitrogen binding, such as grass-clover, alfalfa, etc.) and possibly manure can create many positive effects and opportunities.

- Samsø gets biogas on the RE demonstration palette in line with solar and wind energy. Cultivation of clover can leverage a gradual shift to a larger organic production in agriculture. This will facilitate good crop rotation, and help produce a good and efficient organic fertilizer.

- Clover contributes to a self-production of nitrogen for fertilization. It can reduce the need for commercial fertilizers and hence the very large indirect energy consumption in conventional agriculture. Clover enhances the carbon binding in soil and reduces the greenhouse effect – it acts as a carbon sink.

- Due to large exploitation of straw for energy purposes on Samsø, less carbon is returned to the soil. A production of clover can counteract this negative effect. A sale of clover for biogas production provides the basis for a reasonable profit margin for the crop and at the same time an economically viable biogas production.

- Biogas can be used for combined heat and power generation or for transportation purposes. Biogas can also be used for new demonstration projects: e.g. production of methanol or hydrogen for transportation.

- On a larger scale Samsø can show the world how efficient conversion to organic production could be conducted in practice, with biogas technology as the focal point and heart of the system, and focussing on: energy production, self-sufficiency regarding fertilizers, and increased carbon binding in soil (carbon sink).

The combination of these factors can result in a number of synergies that reach far with regard to RE self-sufficiency and a sustainable agricultural production. Based on this vision one or more biogas plants could be established, either as farm plants or communal plants, possibly with a conventional and an organic line. Energy crops will be the primary biomass. Also other biomass could be used: animal manure, organic waste, and the shared use of landfill gas.

Energy savings - how to make that exciting?
Without very large savings on both heating and electricity (not to mention transportation!), it will be very difficult to achieve the necessary reduction targets for emissions of climate gases nationally and globally. And without substantial savings and efficiency measures, the renewable resources will only cover a smaller part of the consumption rate. A saved kilowatt-hour is worth more than a manufactured kilowatt-hour, especially in the long term. It does not need maintenance, and it has in principle an infinite lifetime! Therefore, savings are important, and we should also in this field try to use Samsø's unique position to show the rest of the world how savings can be achieved in practice.

The recently implemented growth package showed that with the right funding and the proper motivation of individuals, large sums are channelled into energy. On Samsø a great share of the growth package has actually been used for replacing windows and insulating houses, etc. A good user economy is a prerequisite, and work is needed to secure grants for energy saving measures. National, regional, EU, and local funding should be exploited. Savings are not visible, and thus not so interesting and exciting to invest in, compared to physical REinstallations. Savings should therefore be promoted with as much public attention as possible. Competitions can be initiated, with as much media coverage as possible (TV, radio, articles), between individuals, neighbourhoods, or villages.

- Continuing information campaigns.
- Training / education of especially children.
- Contests used to make savings visible – make it fun to save.
- Who does what, why, and how? Saving methods described and illustrated.
- The widest possible media coverage, to get a large multiplier effect.

Transportation

With Samsø's wind resources and infrastructure, it is natural to try to focus on electric cars for transportation. The distances are short, and daily trips can in most cases be covered by today's batteries. In addition, batteries can to a certain extent – limited by the island size – serve as storage for wind power when the wind blows. In this field Samsø could serve as an experiment of how to configure a smart power system. Extended transportation on the mainland could be covered by gasoline-driven (or hybrid) shared cars located in the mainland port of Hou.

A cooperative should be attempted between Stakeholders with an interest in demonstrating a transportation concept on a manageable scale. The Samsø brand could be used to demonstrate the system's progressive development, performance, and impact toward the outer world. Also in this area cooperation with the media should be established to demonstrate the process. Public institutions must be involved as the first to invest in electric vehicles. Without a locomotive, it will be hard to achieve momentum.

Establish a system for charging / replacing batteries

Establish a service system. Use batteries as storage for wind power. Demonstrate the system through the media (TV).

Prominent projects – large and small

The exposure in Samsø's media makes it possible to develop and demonstrate large and small solution models and nerdy ideas, and those projects initiated should try to tell a story with an overarching message of a more sustainable future. Various project ideas can be undertaken in collaboration with the direct stakeholders, not least Samsø's own citizens. All of the following ideas can have a greater or lesser effect. Some are more relevant to other communities, but are included for completeness.

- **Intelligent power system**
  Smart meters and smart electric loads in combination with differentiated tariffs. Stakeholders: electric utilities, manufacturers of electrical goods and other items. Sail on ferries and recycling of surplus heat from the ferries. Systems already exist, but must be tested in practice. Not easy but possible. Stakeholders: the ferry company, the municipality, district heating companies, and others.

- **Campaigns on a personal level**
  Eat-less-meat campaign and decrease your indirect energy consumption significantly. Produce your own meat – chicken and pigs in the backyard. Buy meat from nature conservation areas – conserve nature with cattle and sheep. Stakeholders: citizens, municipality, health authorities, etc.

- **Other biomass**
  Hemp production for edible oil, fibres for new materials, and residues for biogas production. Willow for chips or wood pellets, purification of water, productive shelterbelts. Seaweed, gathered or grown, for energy and fertilizer. Biomass from maintenance of the countryside for biogas and recycling of nutrients. Crops, say fodder kale or radish, for nutrient capture and energy. Stakeholders: agriculture, health food, the municipality, industry, etc

- **Heat from water cooling of wind turbines**
  Water cooling as an alternative to air cooling. Stakeholders: Wind Power Industry and others.

- **Landfill and organic waste**
  Utilization of landfill gas together with a biogas production. Separation at the source of organic waste in order to achieve a good resource utilization and nutrient circulation. Stakeholders: biogas company, municipality, citizens, and others.

- **Continue for yourself!**
  Even the slightest initiative or project that results in a decrease of energy or resources is interesting. Please tell others about it!

Samsø Energy Academy and PlanEnergi,

Conversion Table

k (kilo) = 1,000 = 10^3
M (mega) = 1,000.000 = 10^6
G (giga) = 1,000.000.000 = 10^9
T (tera) = 1,000.000.000.000 = 10^{12}

Conversion - Energy Units:
1 kWh (1 kilowatt hour) = 3.6 MJ
1 MWh (1 megawatt hour) = 3.6 GJ
1 GWh (1 gigawatt hour) = 3.6 TJ

1MJ (1 mega joule) = 0.278 kWh
1 GJ (1 giga joule) = 0.278 MWh
1 TJ (1 tera joule) = 0.278 GWh

Calorific value:
1 l petrol = 9.1 kWh = 32.9 MJ
1 l gas/diesel = 10 kWh = 35.9 MJ
1 l fuel oil = 10.9 kWh = 39.2 MJ
1 m^3 biogas (65 % methane)= 6.5 kWh = 23.3 MJ
1 kg straw = 3.9 kWh = 14 MJ
1 kg wood chips = 2.9 kWh = 10.5 MJ
1 kg wood pellets = 4.945 kWh = 17.9 MJ

Place:	Samsø	Number of inhabitants	4331
Year:	1997		
Unit:	TJ		

Energy balance, Samsø 1997

Fuel

Electricity import	LPG and petroleum	Oil	Diesel	Petrol	Straw	Woodpellets	Wood and wood chips	Solar heat	Wind	Biogas	Total	Name
	2,8										2,8	Gas cookers
												Electricity cookers
												El Water heaters
												El-radiators
								0,1			0,1	Solar heating plants
									5,6		5,6	Wind mills
99,0											99,0	Imports, electricity
											0,0	Exports, electricity
												Lightings
												Refrigerating machines
												Motors, etc.
						1,6					1,6	Wood pellet boilers, indiv.
		132,1									132,1	Oil boilers, indiv.
												Heat pumps, indv.
					5,5						5,5	Straw boliers, indv.
							5,5				5,5	Wood boilers, indv.
					46,2						46,2	Tranebjerg, straw
		0,8									0,8	Tranebjerg, oil
												Tranebjerg, consumption
											0,0	Nordby-Mårup, sun
											0,0	Nordby-Mårup, wood chips
											0,0	Nordby-Mårup, oil
												Nordby-Mårup, consumption
											0,0	Onsbjerg, straw
											0,0	Onsbjerg, oil
												Onsbjerg, consumption
				41,8							41,8	Cars petrol, small
			16,0								16,0	Cars diesel, small
			3,2								3,2	Busses
			20,3								20,3	Trucks/contractor machines
			25,6								25,6	Tractors
			90,4								90,4	Ships
99,0	2,8	133,0	155,4	41,8	51,7	1,6	5,5	0,1	5,6	0,0	496,5	Total
21,4	0,2	9,8	11,5	3,0	0,0	0,0	0,0	0,0	0,0	0,0	46,0	CO2-emissions (1000 tons)
50,5	0,0	12,5	14,6	0,9	6,7	0,0	0,1	0,0	0,0	0,0	85,3	SO2-emissions (tons)
52,5	0,3	13,3	236,2	30,5	4,7	0,1	0,5	0,0	0,0	0,0	338,1	NOx-emissions (tons)
					117,4		9,8			145,1	272,3	Local ressources
					44%		57%			0%	21,0%	Utilisation% of local ress.

Plant

Name	Efficiency % Electricity	Process	Heat	Electricity grid	District heating grid	Electricity grid ex plant	Electricity grid to consumer	D.H-grid ex plant	D.H-grid to consumer	Final consumption Hot water	Space heating	Space heating, corrected	Household, elctricity	cottage, elctricity	and gardening, elctricity	production, elctricity	service, elctricity	Services, elctricity	Transport
Gas cookers			38										1,06						
Electricity cookers			44	97		-5,99	5,81						2,06	0,50					
El Water heaters			90	97		-1,64	1,59			1,43									
El-radiators			100	97		-7,72	7,49				7,49	7,48							
Solar heating plants			100							0,06	0,01	0,01							
Wind mills	100					5,62													
Imports, electricity	100					99,00													
Exports, electricity	100																		
Lightings		50		97		-16,18	15,69						2,34	0,57	1,29	0,38	1,37	1,91	
Refrigerating machines		150		97		-11,80	11,45						8,27	2,03	0,77	1,50	4,60	0,00	
Motors, etc.		85		97		-61,17	59,34						12,99	3,18	11,96	9,17	4,37	8,77	
Wood pellet boilers, indiv.			70							0,20	0,94	0,93							
Oil boilers, indiv.			70							16,19	76,31	76,23							
Heat pumps, indv.			250	97		-0,11	0,11			0,05	0,22	0,22							
Straw boliers, indv.			60							0,58	2,72	2,72							
Wood boilers, indv.			60							0,58	2,74	2,74							
Tranebjerg, straw			84					38,79											
Tranebjerg, oil			95					0,79											
Tranebjerg, consumption					80			-39,59	31,67	5,54	26,13	26,10							
Nordby-Mårup, sun			100					0,00											
Nordby-Mårup, wood chips			100					0,00											
Nordby-Mårup, oil			90					0,00											
Nordby-Mårup, consumption					70														
Onsbjerg, straw																			
Onsbjerg, oil																			
Onsbjerg, consumption																			
Cars petrol, small		20																	8,36
Cars diesel, small		25																	3,99
Busses		33																	1,05
Trucks/contractor machines		33																	6,69
Tractors		33																	8,43
Ships		38																	34,36
Total						0,0	101,5	0,0	31,7	24,6	116,6	116,4	26,7	6,3	14,0	11,0	10,3	10,7	62,9
CO2-emissions (1000 tons)	10,61 tons/inhabitant					10,61 tons/inhabitant, deegree day corrected													
SO2-emissions (tons)	19,70 kg/inhabitant					19,70 kg/inhabitant, deegree day corrected													
NOx-emissions (tons)	78,06 kg/inhabitant					78,05 kg/inhabitant, deegree day corrected													
Local ressources	13,0% Renewable Energy					13,0% Renewable , deegree day corrected Energy													

Electricity import	LPG and petroleum	Oil	Diesel	Petrol	Straw	Woodpellets	Wood and wood chips	Solar heat	Wind	Biogas	
216	68,5	74	74	73	0	0	0	0	0	0	CO2-emission factors (ton/TJ)
0,51	0	0,094	0,094	0,022	0,13	0,015	0,015	0	0	0	SO2-emission factors (ton/TJ)
0,53	0,1	0,1	1,52	0,73	0,09	0,09	0,09	0	0	0,2	NOx-emission factors (ton/TJ)

Place:	Samsø	Number of inhabitants	4318
Year:	1999		
Unit:	TJ		

Energy balance, Samsø 1999

Fuel												Plant	Efficiency %					Electricity grid		D.H-grid		Final consumption									
Electricity import	LPG and petroleum	Oil	Diesel	Petrol	Straw	Woodpellets	Wood and wood chips	Solar heat	Wind	Biogas	Total	Name	Electricity	Process	Heat	Electrity grid	District heating grid	ex plant	to consumer	ex plant	to consumer	Hot water	Space heating	Space heating, corrected	Household, elctricity	cottage, elctricity	and gardening, elctricity	production, elctricity	service, elctricity	Services, elctricity	Transport
	2,4										2,4	Gas cookers			38										0,91						
											0,0	Electricity cookers			44	97		-5,96	5,78						2,05	0,50					
											0,0	El Water heaters			90	97		-1,80	1,75			1,57									
												El-radiators			100	97		-8,50	8,24				8,24	8,88							
								0,2			0,2	Solar heating plants			100							0,14	0,04	0,04							
									5,5		5,5	Wind mills	100					5,50													
101,9											101,9	Imports, electricity	100					101,93													
											0,0	Exports, electricity	100																		
												Lightings		50		97		-16,60	16,10						2,33	0,56	1,36	0,37	1,38	2,05	
												Refrigerating machines		150		97		-11,81	11,45						8,25	1,99	0,81	1,50	4,63	0,00	
												Motors, etc.		85		97		-62,64	60,76						12,95	3,13	12,61	9,13	4,40	9,42	9,42
						8,2					8,2	Wood pellet boilers, indiv.			70							1,00	4,73	5,10							
		148,4									148,4	Oil boilers, indiv.			70							18,18	85,70	92,38							
												Heat pumps, indv.			250	97		-0,12	0,12			0,05	0,24	0,26							
					5,5						5,5	Straw boliers, indv.			60							0,58	2,72	2,93							
							5,5				5,5	Wood boilers, indv.			60							0,58	2,74	2,96							
					47,0						47,0	Tranebjerg, straw			84					39,49											
		0,8									0,8	Tranebjerg, oil			95					0,81											
												Tranebjerg, consumption					80			-40,29	32,24	5,64	26,59	28,67							
											0,0	Nordby-Mårup, sun			100					0,00											
											0,0	Nordby-Mårup, wood chips			100					0,00											
											0,0	Nordby-Mårup, oil			90					0,00											
												Nordby-Mårup, consumption					70														
											0,0	Onsbjerg, straw																			
											0,0	Onsbjerg, oil																			
												Onsbjerg, consumption																			
				40,4							40,4	Cars petrol, small		20																	8,08
			16,0								16,0	Cars Diesel, small		25																	4,00
			3,2								3,2	Busses		33																	1,06
			20,3								20,3	Trucks/contractor machines		33																	6,70
			25,6								25,6	Tractors		33																	8,45
			72,4								72,4	Ships		38																	27,51
101,9	2,4	149,2	137,5	40,4	52,5	8,2	5,5	0,2	5,5	0,0	503,4	Total						0,0	104,2	0,0	32,2	27,8	131,0	141,2	26,5	6,2	14,8	11,0	10,4	11,5	55,8
16,7	0,2	11,0	10,2	2,9	0,0	0,0	0,0	0,0	0,0	0,0	41,0	CO2-emissions (1000 tons)		9,5 tons/inhabitant				9,70 tons/inhabitant, deegree day corrected													
17,3	0,0	14,0	12,9	0,9	6,8	0,1	0,1	0,0	0,0	0,0	52,2	SO2-emissions (tons)		12,1 kg/inhabitant				12,43 kg/inhabitant, deegree day corrected													
34,7	0,2	14,9	209,0	29,5	4,7	0,7	0,5	0,0	0,0	0,0	294,3	NOx-emissions (tons)		68,2 kg/inhabitant				68,51 kg/inhabitant, deegree day corrected													
					117,4		9,8			145,1	272,3	Local ressources		14,3% Renewable Energy				14,7% Renewable , deegree day corrected Energy													
					45%		57%			0%	21,3%	Utilisation% of local ress.																			

Electricity import	LPG and petroleum	Oil	Diesel	Petrol	Straw	Woodpellets	Wood and wood chips	Solar heat	Wind	Biogas	
164	68,5	74	74	73	0	0	0	0	0	0	CO2-emission factors (ton/TJ)
0,17	0	0,094	0,094	0,022	0,13	0,015	0,015	0	0	0	SO2-emission factors (ton/TJ)
0,34	0,1	0,1	1,52	0,73	0,09	0,09	0,09	0	0	0,2	NOx-emission factors (ton/TJ)

Place:	Samsø	Number of inhabitants	4266
Year:	2001		
Unit:	TJ		

		Hot water	Space heating	Household, elctricity	cottage, elctricity	and gardening, elctricity	production, elctricity	service, elctricity	Services, elctricity
El opr:	0,155	2,4	11,5	21,05	5,98	24,33	12,49	11,0	15,19
El:	0,361	1,4	6,7	29,3	7,436	18,64	7,279	14,7	12,28

Energy balance, Samsø 2001

Fuel												Plant	Efficiency %					Electricity grid		D.H-grid		Final consumption									
Electricity import	LPG and petroleum	Oil	Diesel	Petrol	Straw	Woodpellets	Wood and wood chips	Solar heat	Wind	Biogas	Total	Name	Electricity	Process	Heat	Electrity grid	District heating grid	ex plant	to consumer	ex plant	to consumer	Hot water	Space heating	Space heating, corrected	Household, elctricity	cottage, elctricity	and gardening, elctricity	production, elctricity	service, elctricity	Services, elctricity	
	2,1										2,1	Gas cookers			38										0,80						
												Electricity cookers			44	97		-5,87	5,69						2,00	0,51					
												El Water heaters			90	97		-1,48	1,43			1,29									
												El-radiators			100	97		-6,96	6,75				6,75	6,82							
								0,7			0,7	Solar heating plants			100							0,53	0,13	0,13							
									97,6		97,6	Wind mills	100					97,57													
3,6											3,6	Imports, electricity	100					3,57													
											0,0	Exports, electricity	100																		
												Lightings		50		97		-16,39	15,90						2,27	0,58	1,40	0,22	1,83	1,66	
												Refrigerating machines		150		97		-12,33	11,96						8,04	2,04	0,84	0,87	6,15	0,00	
												Motors, etc.		85		97		-57,74	56,01						12,62	3,20	12,99	5,32	5,85	7,62	9,42
						14,6					14,6	Wood pellet boilers, indiv.			70							1,79	8,45	8,54							
		107,1									107,1	Oil boilers, indiv.			70							13,12	61,87	62,52							
												Heat pumps, indv.			250	97		-0,37	0,36			0,16	0,74	0,75							
					5,5						5,5	Straw boliers, indv.			60							0,58	2,72	2,75							
							5,5				5,5	Wood boilers, indv.			60							0,58	2,72	2,75							
					48,9						48,9	Tranebjerg, straw			84					41,08											
		0,9									0,9	Tranebjerg, oil			95					0,84											
												Tranebjerg, consumption					80			-41,91	33,53	5,87	27,66	27,95							
											0,0	Nordby-Mårup, sun			100					0,00											
											0,0	Nordby-Mårup, wood chips			100					0,00											
											0,0	Nordby-Mårup, oil			90					0,00											
												Nordby-Mårup, consumption					70														
											0,0	Onsbjerg, straw																			
											0,0	Onsbjerg, oil																			
												Onsbjerg, consumption																			
				32,9							32,9	Cars petrol, small		20																	6,59
			15,4								15,4	Cars diesel, small		25																	3,85
			3,1								3,1	Busses		33																	1,02
			19,6								19,6	Trucks/contractor machines		33																	6,45
			24,7								24,7	Tractors		33																	8,14
			93,9								93,9	Ships		38																	35,67
3,6	2,1	108,0	156,6	32,9	54,4	14,6	5,5	0,7	97,6	0,0	476,0	Total						0,0	98,1	0,0	33,5	23,9	111,1	112,2	25,7	6,3	15,2	6,4	13,8	9,3	61,7
0,5	0,1	8,0	11,6	2,4	0,0	0,0	0,0	0,0	0,0	0,0	22,6	CO2-emissions (1000 tons)		5,31 tons/inhabitant				5,33 tons/inhabitant, deegree day corrected													
0,1	0,0	10,2	14,7	0,7	7,1	0,2	0,1	0,0	0,0	0,0	33,1	SO2-emissions (tons)		7,75 kg/inhabitant				7,79 kg/inhabitant, deegree day corrected													
1,0	0,2	10,8	238,0	24,0	4,9	1,3	0,5	0,0	0,0	0,0	280,8	NOx-emissions (tons)		65,82 kg/inhabitant				65,86 kg/inhabitant, deegree day corrected													
					117,4		9,8			145,1	272,3	Local ressources		36,3% Renewable Energy				36,3% Renewable , deedree day corrected Energy													
					46%		56%			0%	22,0%	Utilisation% of local ress.																			

Electricity import	LPG and petroleum	Oil	Diesel	Petrol	Straw	Woodpellets	Wood and wood chips	Solar heat	Wind	Biogas	
142	68,5	74	74	73	0	0	0	0	0	0	CO2-emission factors (ton/TJ)
0,03	0	0,094	0,094	0,022	0,13	0,015	0,015	0	0	0	SO2-emission factors (ton/TJ)
0,28	0,1	0,1	1,52	0,73	0,09	0,09	0,09	0	0	0,2	NOx-emission factors (ton/TJ)

PlanEnergi 2003

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z	AA	AB	AC	AD	AE	AF
1	Place:		Samsø		Number of inhabitants				4247										El 2001	0,361	samlet	98,1	1,4	6,7		29,3	7,436	18,64	7,279	14,7	12,28	
2	Year:		2003																El:	0,5	Samlet	94,2	0,7	3,4		29,3	7,436	18,64	7,279	14,7	12,28	
3	Unit:		TJ																													
4													**Energy balance, Samsø 2003**																			
5	Fuel												Plant	Efficiency %					Electricity grid		D.H-grid		Final consumption									
6	Electricity import	LPG and petroleum	Oil	Diesel	Petrol	Straw	Woodpellets	Wood and wood chips	Solar heat	Wind	Biogas	Total	Name	Electricity	Process	Heat	Electrity grid	District heating grid	ex plant	to consumer	ex plant	to consumer	Hot water	Space heating	Space heating, corrected	Household, elctricity	cottage, elctricity	and gardening,	production, elctricity	service, elctricity	Services, elctricity	Transport
7		2,1										2,1	Gas cookers			38										0,80						
8													Electricity cookers			44	97		-5,87	5,69						2,00	0,51					
9													El Water heaters			90	97		-0,75	0,72			0,65									
10													El-radiators			100	97		-3,52	3,42				3,42	3,42							
11									0,7			0,7	Solar heating plants			100							0,53	0,13	0,13							
12										377		377,0	Wind mills	100					377,0													
13	-280											-279,9	Imports, electricity	100					-279,9													
14												0,0	Exports, electricity	100																		
15													Lightings		50		97		-16,39	15,90						2,27	0,58	1,40	0,22	1,83	1,66	
16													Refrigerating machines		150		97		-12,33	11,96						8,04	2,04	0,84	0,87	6,15	0,00	
17													Motors, etc.		85		97		-57,74	56,01						12,62	3,20	12,99	5,32	5,85	7,62	
18							22,0					22,0	Wood pellet boilers, indiv.			70							2,70	12,71	12,71							
19			85,8									85,8	Oil boilers, indiv.			70							10,51	49,55	49,55							
20													Heat pumps, indv.			250	97		-0,52	0,50			0,22	1,03	1,03							
21						5,5						5,5	Straw boliers, indv.			60							0,58	2,72	2,72							
22								5,5				5,5	Wood boilers, indv.			60							0,58	2,72	2,72							
23						48,9						48,9	Tranebjerg, straw			84					41,08											
24			0,9									0,9	Tranebjerg, oil			95					0,84											
25													Tranebjerg, consumption					80			-41,91	33,53	5,87	27,66	27,66							
26									3,6			3,6	Nordby-Mårup, sun			100					3,60											
27								10,6				10,6	Nordby-Mårup, wood chips			100					10,60											
28			0,3									0,3	Nordby-Mårup, oil			90					0,29											
29													Nordby-Mårup, consumption					70			-14,49	10,14	1,77	8,37	8,37							
30						8,3						8,3	Onsbjerg, straw			88					7,30											
31			0,1									0,1	Onsbjerg, oil			90					0,09											
32													Onsbjerg, consumption					75			-7,39	5,55	0,97	4,58	4,58							
33					33,0							33,0	Cars petrol, small		20																	6,60
34				15,5								15,5	Cars diesel, small		25																	3,87
35				3,1								3,1	Busses		33																	1,02
36				19,6								19,6	Trucks/contractor machines		33																	6,48
37				24,8								24,8	Tractors		33																	8,18
38				93,0								93,0	Ships		38																	35,34
39	-280	2,1	87,1	156,0	33,0	62,7	22,0	16,1	4,3	377	0,0	480,4	Total						0,0	94,2	0,0	49,2	24,4	112,9	112,9	25,7	6,3	15,2	6,4	13,8	9,3	61,5
40	-39,7	0,1	6,4	11,5	2,4	0,0	0,0	0,0	0,0	0,0	0,0	-19,2	CO2-emissions (1000 tons)		-4,52	tons/inhabitant			-4,52	tons/inhabitant, deegree day corrected												
41	-8,4	0,0	8,2	14,7	0,7	8,2	0,3	0,2	0,0	0,0	0,0	23,9	SO2-emissions (tons)		5,63	kg/inhabitant			5,63	kg/inhabitant, deegree day corrected												
42	-78,4	0,2	8,7	237,1	24,1	5,6	2,0	1,4	0,0	0,0	0,0	200,8	NOx-emissions (tons)		47,29	kg/inhabitant			47,29	kg/inhabitant, deegree day corrected												
44						117,4		9,8			145,1	272,3	Local ressources		100,3%	Renewable Energy			100,3%	Renewable, deegree day corrected Energy												
45						53%		164%			0%	28,9%	Utilisation% of local ress.																			
46																																
47	Electricity import	LPG and petroleum	Oil	Diesel	Petrol	Straw	Woodpellets	Wood and wood chips	Solar heat	Wind	Biogas																					
48	142	68,5	74	74	73	0	0	0	0	0	0	CO2-emission factors (ton/TJ)																				
49	0,03	0	0,094	0,094	0,022	0,13	0,015	0,015	0	0	0	SO2-emission factors (ton/TJ)																				
50	0,28	0,1	0,1	1,52	0,73	0,09	0,09	0,09	0	0	0,2	NOx-emission factors (ton/TJ)																				

PlanEnergi 2005

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z	AA	AB	AC	AD	AE	AF
1	Place		Samsø		Number of inhabitants				4125																							
2	Year:		2005																													
3	Unit:		TJ																													
4													**Energy balance, Samsø 2005**																			
5	Fuel												Plant	Efficiency %					Electricity grid		D.H-grid		Final consumption									
6	Electricity import	LPG and petroleum	Oil	Diesel	Petrol	Straw	Woodpellets	Wood and wood chips	Solar heat	Wind	Biogas	Total	Name	Electricity	Process	Heat	Electricity grid	District heating grid	ex plant	to consumer	ex plant	to consumer	Hot water	Space heating	Space heating, corrected	Household, elctricity	cottage, elctricity	and gardening,	production, elctricity	service, elctricity	Services, elctricity	Transport
7		1.8										1.8	Gas cookers			38										0.68						
8													Electricity cookers			44	97		-5.83	5.66						1.99	0.50					
9													El Water heaters			90	97		-1.50	1.45			1.31									
10													El-radiators			100	97		-7.06	6.85				6.85	7.39							
11									0.5			0.5	Solar heating plants			100							0.40	0.10	0.11							
12										386		386.3	Wind mills	100					386.3													
13	-286											-285.7	Imports, electricity	100					-285.7													
14												0.0	Exports, electricity	100																		
15													Lightings		50		97		-16.29	15.81						2.26	0.57	1.39	0.22	1.82	1.65	
16													Refrigerating machines		150		97		-12.26	11.89						7.99	2.03	0.83	0.87	6.12	0.00	
17													Motors, etc.		85		97		-57.39	55.67						12.54	3.18	12.91	5.29	5.82	7.57	
18							21.3					21.3	Wood pellet boilers, indiv.			70							2.61	12.30	13.27							
19			73.8									73.8	Oil boilers, indiv.			70							9.04	42.62	45.97							
20													Heat pumps, indv.			250	97		-0.25	0.24			0.11	0.50	0.53							
21						5.5						5.5	Straw boliers, indv.			60							0.58	2.72	2.94							
22								5.5				5.5	Wood boilers, indv.			60							0.58	2.72	2.94							
23						40.5						40.5	Tranebjerg, straw			84					34.02											
24			0.2									0.2	Tranebjerg, oil			95					0.19											
25													Tranebjerg, consumption					80			-34.21	27.37	4.79	22.58	24.35							
26									4.2			4.2	Nordby-Mårup, sun			100					4.20											
27								14.5				14.5	Nordby-Mårup, wood chips			100					14.50											
28			0.0									0.0	Nordby-Mårup, oil			90					0.00											
29													Nordby-Mårup, consumption					70			-18.70	13.09	2.29	10.80	11.65							
30						14.8						14.8	Onsbjerg, straw			88					13.02											
31			0.1									0.1	Onsbjerg, oil			90					0.09											
32													Onsbjerg, consumption					75			-13.11	9.84	1.72	8.11	8.75							
33						18.0						18.0	Cars petrol, small			88					15.84											
34			0.0									0.0	Cars diesel, small			90					0.02											
35												0.0	Busses					75			-15.86	11.89	2.08	9.81	10.58							
36					48.5							48.5	Trucks/contractor machines		20																	9.70
37				16.5								16.5	Tractors		25																	4.12
38				3.3								3.3	Ships		33																	1.09
39				20.9								20.9	Total		33																	6.90
40				26.4								26.4	CO2-emissions (1000 tons)		33																	8.71
41				96.2								96.2	SO2-emissions (tons)		38																	36.56
42	-286	1.8	74.1	163.3	48.5	78.8	21.3	20.0	4.7	386	0.0	513.1	NOx-emissions (tons)						0.0	97.6	0.0	62.2	25.5	119.1	128.5	25.5	6.3	15.1	6.4	13.8	9.2	67.1
43	-36.6	0.1	5.5	12.1	3.6	0.0	0.0	0.0	0.0	0.0	0.0	-15.2	Partikel-emissions (tons)		-3.69 tons/inhabitant				-3.59 tons/inhabitant, deegree day corrected							1.0787 (deegree day correction factor)						
44	-9.4	0.0	1.7	0.1	0.0	3.7	0.0	0.0	0.0	0.0	0.0	-3.8	Local ressources		-0.93 kg/inhabitant				-0.83 kg/inhabitant, deegree day corrected													
45	-62.8	0.1	3.7	32.7	3.6	10.2	1.5	1.4	0.0	0.0	0.0	-9.6	Utilisation% of local ress.		-2.34 kg/inhabitant				-2.04 kg/inhabitant, deegree day corrected													
47						117.4		20.0			145.1	282.5	Local ressources		99.6% Renewable Energy				98.6% Renewable , deegree day corrected Energy													
48						67%		100%			0%	35.0%	Utilasation% of local ress.																			
49																																
50	Electricity import	LPG and petroleum	Oil	Diesel	Petrol	Straw	Woodpellets	Wood and wood chips	Solar heat	Wind	Biogas																					
51	128	68.5	74	74	75	0	0	0	0	0	0	CO2-emission factors (ton/TJ)																				
52	0.033	0.012	0.023	0.00045	0.00044	0.047	0.002	0.002	0	0	0	SO2-emission factors (ton/TJ)																				
53	0.22	0.065	0.05	0.2	0.075	0.13	0.069	0.069	0	0	0.2	NOx-emission factors (ton/TJ)																				

Source material

Energistyrelsen (The Danish Energy Authority – Ministry of Transport & Energy)
PlanEnergi (consultancy firm)
Samsø Kommune (The Samsø Municipality)
Samsø Udviklingskontor (The Samsø Office of Development)
Århus Amt (Århus County)
Region Midtjylland (Mid-Jutland Region)
Samsø Havvind A/S (Samsø Offshore Wind Co.)
Samsø Vedvarende Energi ApS (Samsø Renewable Energy Ltd., owned by Samsø Municipality)
Samsø Vindenergi (Samsø Wind Energy)
Paludan Flak (shallow reef offshore)
DK Vind (DK Wind)
NRGi (utility company)
Kremmer Jensen (owner of Onsbjerg district heating plant)
Ballen-Brundby Fjernvarme (Ballen-Brundby District Heating)
Samsø Erhvervsforum (Samsø Commercial Council)
Samsø Landboforening (Samsø Farmers' Association)
Vandværkskontoret på Samsø (The Waterworks Office on Samsø)
Q8
Statoil
OK Benzin (OK Petrol)
Shell
DLG and SAK Samsø (energy suppliers and feedstuff companies)
Samsø Hus og Have (Samsø House and Garden, energy supplier)
Samsø Linien (The Samsø Line)
www.energinet.dk
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DMU report 442 (National Environmental Research Institute)