Short and medium-term scenarios for the three pilot islands (Samsø, Orkney, Madeira)

Smart Island Energy Systems - H2020 Project SMILE Deliverable 8.2

Marczinkowski, Hannah Mareike; Østergaard, Poul Alberg

Publication date:
2018

Document Version
Publisher's PDF, also known as Version of record

Link to publication from Aalborg University

Citation for published version (APA):
Marczinkowski, H. M., & Østergaard, P. A. (2018). *Short and medium-term scenarios for the three pilot islands (Samsø, Orkney, Madeira): Smart Island Energy Systems - H2020 Project SMILE Deliverable 8.2*.

H2020-LCE-2016-2017

EUROPEAN COMMISSION

Innovation and Networks Executive Agency

Grant agreement no. 731249

SMILE

Smart Island Energy Systems

Deliverable D8.2

Short and medium-term scenarios for the three pilot islands

Document Details

Due date	31-12-2018
Actual delivery date	26-12-2018
Lead Contractor	AAU Plan (Aalborg University, Department of Planning)
Version	Final rev0
Prepared by	Hannah Marczinkowski (AAU Plan)
Input from	AAU, SK, SE, EEM, LIBAL, CES
Reviewed by	RINA-C
Dissemination Level	Public

Project Contractual Details

Project Title	Smart Island Energy Systems
Project Acronym	SMILE
Grant Agreement No.	731249
Project Start Date	01-05-2017
Project End Date	30-04-2021
Duration	48 months

The project has received funding from the European Union's Horizon 2020 research and innovation programme under Grant Agreement No 731249

Table of Contents

Keywords, Acronyms

AAU	Aalborg University
BESS	Battery Energy Storage System
CES	Community Energy Scotland
CHP	Combined Heat and Power plant
Dx.y	Deliverable y from WP x
DH	District Heating
DSM	Demand Side Management
EEM	Electricity Company of Madeira (Empresa De Electricidade Da Madeira Sa)
EV	Electric Vehicles
HP(s)	Heat pump(s)
JP	Jet Petrol
LBG/CBG	Liquefied/Compressed Biogas
LPG	Liquefied Petroleum Gas
N/A	Not available (data)
PES	Primary Energy Supply
PV	Photovoltaic
RE(S)	Renewable Energy (Source)
RAM	Região Autónoma da Madeira
V2G	Vehicle To Grid
WP	Work Package

EnergyPLAN – modelling tool for the analysis of the whole energy system by identifying and exploiting technologies and synergies across sectors (also referred to as smart energy systems) by AAU; more details in D8.1
Load curve – is a chronological chart that illustrates the variation in electricity or other energy demands
Self-consumption – electricity that is produced from renewable energy sources, not injected to the distribution or transmission grid or instantaneously withdrawn from the grid and consumed by the owner of the power production unit
Smart charging – charging techniques, which do not follow the normal plug and charge paradigm

1 Introduction

In this report, we present the outcome of *Task 8.2: Establishing and simulating short- and medium-term (high-RE) scenarios for the three pilots*, which is in the scope of the SMILE project work package WP8. The Smart Island Energy System (SMILE) project combines the forces of a number of partners to investigate smart island energy systems for three pilot islands – Samsø in Denmark, the Orkney Isles in the United Kingdom and Madeira in Portugal.

The three pilot islands Samsø, Orkney and Madeira are all investigating ways of becoming carbon neutral, though local conditions differ widely. While the electricity grid of the Orkney Isles and Samsø are connected to the rest of the United Kingdom and Denmark respectively, Madeira is an isolated stand-alone system. Samsø and the Orkney Isles also both have significant heat demands, while Madeira has a warmer climate. In terms of population, they range from Samsø with 3,700 inhabitants via Orkney with approx. 21,000 inhabitants to Madeira with about 250,000 inhabitants, influencing demands and available resources per capita.

All islands present unconventional energy systems shaped by their surroundings: Samsø has been undergoing a decade-long transition after winning a competition of being Denmark's officially designated renewable energy island. The Orkney Isles are characterised by a large number of wind turbines and offshore testing facilities, and Madeira lies far off the European continent and stands out in European terms with great solar potential. These islands are therefore sites with good potentials for renewable energy production, which is addressed within the SMILE project.

This report describes the future scenarios (short-term, i.e. up to five years, as well as medium-term, i.e. up to 15 years) which include the demonstration projects in the three pilot islands in the perspective of a shift from energy systems relying on fossil fuels to energy systems relying highly or exclusively on renewable energy sources. In particular, this report presents:

- Chapter 2 gives a clarification and outline of the contents and aims of WP8 in order to establish the framework for this deliverable and the future energy system models. For this, a quick review of D8.1 is presented.
- Chapter 3 presents the future scenario creation in general and for the individual pilots. Therefore, the phases of RES integration are presented and the pilot islands classified in their terms. Furthermore, the islands are discussed individually in terms of the relevant energy system changes planned or necessary to establish high RE scenarios. Thus, Chapter 3 contains energy system overviews and their modification from the reference year 2014/2015 to the short- and medium-term.
- After presenting the islands separately, a comparison allows for the evaluation of similarities and differences in Chapter 4. This Chapter sums up the main data resulting from the reference models in comparison to the future scenarios and gives an overview of the applied data and results. Additionally, it allows for a validation and discussion of the before presented models of Samsø, Orkney and Madeira.
- Chapter 0 briefly concludes the deliverable D8.2 with a short summary on outcomes and discussion.
- In the Appendix, both the results of short- and medium-term scenarios as well as for comparison also the reference models are attached in the form of the EnergyPLAN data sheets including all system inputs and outputs for the three islands.

While the scenarios in D8.2 are made with great care, taking trends and plans into consideration, the development of short- and medium-term scenarios for the three pilot islands only provide one set of realistic pathways among many plausible. While the final scenarios inevitable will deviate from actual development paths, they do include the most relevant technologies for the three islands. The work presented can therefore be well used to evaluate the existing trends and plans, as well as reflect on ongoing work towards the most sustainable future. In this regard, the individual ideas behind the SMILE project are included, evaluated and discussed.

2 Clarifications

This Chapter presents the framework of WP8 with its tasks and deliverables for this report. First, a short review of WP8 with its objectives, tasks and deliverables is presented, before revising D8.1 briefly to explain its role in D8.2. This is to clarify the description and plan versus the realization of task 8.2. Besides this, further explanatory information, such as an introduction to the modelling tool EnergyPLAN, can be found in D8.1.

2.1 Review of WP8

Within the Framework of the SMILE project, the main goal of WP8 is to analyse and present the pilot islands' energy systems and the impacts, strategies and energy market designs associated with the demonstration projects. The details of its objectives, tasks and deliverables are listed below.

The main objective of WP8 is to investigate potential development pathways towards high-RE energy systems for the three pilot islands taking into consideration the energy systems impacts of the demonstration projects and their role in such high-RE scenarios. Primary focus is on the short- and medium-term. Secondly, the WP will investigate the energy market structures and policy strategies that impact and are impacted by the transition process in the three pilot islands. This will be achieved through meeting the following objectives:

- Establishment of reference energy systems simulations models of the three pilot islands,
- Establishment of short and medium-term (5-15 years) high RE scenarios for the three pilot islands,
- Establishment of recommendations for market design structures to support the transition to high-RE energy systems in the three pilot islands,
- Establishment of policy strategies to support the transition to high-RE energy systems in the three pilot islands.

Resulting from the second bullet point, Task 8.2 aims at: Establishing and simulating short- and medium-term high-RE scenarios for the three demonstrators looking specifically into Orkney, Samsø and Madeira respectively.

Task 8.2 takes its starting point in the reference models developed in Task 8.1. Starting in these reference models, future scenarios are developed which include the demonstration projects, potentially a larger deployment of the demonstration projects and in general a shift from energy systems relying on fossil fuels to energy systems relying highly or exclusively on renewable energy sources. The focus of the scenarios is on the short-term (up to five years), however in order to ensure that short-term measures are aligned with longer-term requirements, a medium-term perspective is also addressed.

The scenarios take into consideration a) case-specific end-use savings potentials, b) case-specific renewable energy resource availability and c) case-specific potential energy conversion shifts (e.g. individual oil or gas boilers to heat pumps (HP) or district heating (DH)). The scenarios consider as an integrated part the extent to which the systems should or could rely on interconnection to the mainland or be self-sufficient. Reducing or limiting the amount of import and export is therefore aimed for – also as this indicates the ability of the systems to balance themselves – and not rely on the balancing capability of surrounding energy systems.

The activities on the individual demonstrators are handled and coordinated in parallel as the work involve similar tasks for different geographic areas – though different starting points and renewable energy options result in scenarios of varying complexity and composition.

Dependencies on other tasks:
Input: Task 8.2 is dependent on Task 8.1 as well as partner inputs regarding general development path and partner inputs and deliverables on specific SMILE technologies.

Output: Task 8.2 will provide relevant contribution to T8.3, T8.4 and T8.5 about scenarios on the pilot islands. Furthermore, the output can contribute to the demonstrator islands, but also other islands worldwide in the framework of replication activities, and their long-term planning towards a sustainable future by providing suggestions and technical models as a base for discussion and development.

For alignment, the years 2022 and 2030 are chosen for the short- and medium-terms to present the future energy systems of the demonstrator islands. These years present the foreseeable changes by the end of the SMILE project (April 2021), as well as give an idea on the future in longer term, yet also foreseeable.

2.2 Review of D8.1

Deliverable D8.1 presents the result from the corresponding Task 8.1, which focuses on establishing and modelling reference scenarios for the three demonstrator islands. This is approached in an hourly resolution for a whole reference year from January 1st to December 31st. This way, differences of seasons, weekdays and daytimes are considered. This is important when analysing present and future energy scenarios characterised by a strong or increasing connection between sectors and by increasing shares of fluctuating renewable energy-based productions. The reference models are generally defined through the existing energy systems and available data related to it at the time of the Task 8.1. Depending on the availability of data at the different pilot islands, the reference models are created.

Task 8.2 is in close relation to the Task 8.1 and building upon it, as it uses the resulting reference models for future simulation. A reference of high quality is therefore of importance, and the validation and consequences of this is presented in D8.1, Chapter 4 and 5.

The software used for the hourly simulation of supply and demand for a complex energy system is EnergyPLAN, developed at Aalborg University. This model is presented in further detail in D8.1. Task 8.1 resulted in the presentation of three EnergyPLAN models, one for each demonstrator island in SMILE. The respective local partners reviewed these models to ensure that they represent the islands to the best extent possible.

While these are referred to as the reference models – presenting the various reference energy systems for a specific recent year – the future models developed under Task 8.2, present the paths and possibilities of high-RE scenarios for Samsø, Orkney and Madeira. While based on the reference models, they further include the respective technological additions as part of SMILE (see deliverables D2.1, D2.2, D2.4, D3.1, D3.2 and D4.1-D4.6). Furthermore, probable future changes in the energy systems besides the SMILE approaches are adapted at the same time. The result is a second and third set of three EnergyPLAN models that are presented in the following. Next to the reference models of D8.1, the D8.2 includes short-term future models of 2022 and medium-term models for the year 2030.

3 Regional Demonstrators’ Future Energy System Models

The future energy system models – or scenarios – rely on the reference models from D8.1. Therefore, these are briefly recapitulated in the presentation of each demonstrator island, before the SMILE approaches and possible future changes are adapted to model the scenarios for 2022 and 2030. The general approach is presented in the following, before presenting the islands separately afterwards. The structure of each presentation includes the following:

- Reference energy system layout
- SMILE demonstration project(s) and impacts
- Short-term changes in the respective energy systems (until 2022)
- Medium-term changes in the respective energy systems (until 2030)
- Overview of results: tables and diagrams with key indicators regarding energy supply and demand
- Discussion of further potential changes towards 100% RE systems

The structure is kept at a comparable level, yet due to the individual characteristics of each island, different changes are applied in each of them. The following Chapter 4 presents the results of the different islands in a comparable way to see similarities and options from and for Samsø, Orkney and Madeira.

3.1 General approach

As mentioned above, the task and deliverable 8.2 address the short- and medium-term developments for the demonstrator islands, which results in the model years of 2022 for short- and 2030 for medium-term scenarios. For the aim of high-RE scenarios, further developments beyond 2030 are introduced and discussed, but not modelled in D8.2. The only exception is Samsø, since it reaches a high share of RE in the medium term, while Orkney and Madeira would only reach this level most likely after 2030.

As also described before, the future scenarios created in D8.2 are based on the reference scenarios developed under task 8.1 and presented in D8.1. For the creation of the future scenarios, the references were used to the best extent and with the fewest modifications possible. These updates may include technical data, such as updated technology costs or adjusting specific values in the model, which have been found incorrect. Hence, the future scenarios have the same energy system set-up, keeping the framework conditions the same and simple, while focusing on the changes in the technical aspects. By this, the SMILE demonstration projects are in focus, as well as possible technical changes to the energy system, such as new capacities or efficiencies. With this simplified approach, certain possible changes are neglected, such as potential changes in weather conditions, demography and unforeseeable changes in production or consumption. In relation to this, the temporal distribution profiles for heating and electricity are kept the same, unless specifically changed due to a certain technical modification. Again, this strengthens the understanding of the changes we do see instead of looking into possibilities we do not see yet.

Furthermore, the future scenario creation is based on today’s understanding of technologies including its current characteristics as well as projections. Potential new inventions cannot be included, but this could be kept in mind for long-term considerations. The existing plans and strategies from the demonstrator islands also have a large impact on the scenarios, as they present most likely changes and potentials for the individual islands. Therefore, these are realized to a large extent in the future models. In similar terms, updated statistics (since D8.1) influence the creation of the scenarios. These things are verified and elaborated by the partners on the respective islands.

Finally, next to the business-as-usual conditions and trends as well as the existing plants, the future scenarios are influenced by the experience and common practices at AAU regarding the planning of energy systems. This entails for example the integration of energy sectors instead of approaching the electricity sector alone.

Therefore, the future scenarios sometimes go well beyond what is suggested in SMILE, especially in the 2030 scenarios.

Focus in the scenario development is on the best technical integration of energy systems with a view to establishing environmentally benign high-RES scenarios. Costs are also considered but only secondarily. Costs are based on general technology and fuel costs and may not reflect actual local costs for implementing technologies on the different islands and in the different time horizons.

The general approach for the future island scenarios targets the increase in the RES share in the total energy system's primary energy supply (PES). While this can be compared to the RES share in the electricity sector, the whole system balance is in focus for WP8. In line with the renewable aspect, fossil fuels, but also biomass should be limited to the maximum or to a sustainable level respectively. This goes hand in hand with the target of reducing CO_2 emissions, and combined aligns with the EU climate targets[1]. While costs play a secondary role in the scenario making, its reduction should nonetheless also be aimed for. Finally, the aim should be to minimize losses in the entire energy system. The large extent of these losses are illustrated in the respective Sankey diagrams in D8.1 and in the respective sections in D8.2

Beyond these global basic guidelines for smart energy systems, islands have further criteria to aim for in future energy systems. Due to either being limited by the (inexistence of a) transmission line or by importing fuels and products to an often higher price than on the mainland, islands should aim for the reduction of imports and dependency on such. Instead, local products should be used for the local systems to the largest sustainable extent possible, including using otherwise exported or curtailed electricity directly in the local grid. For this, the integration and balancing of energy sectors becomes important.

The integration of RES into an energy system, island or not, can be defined by three major steps. These are explained in the following and are used to describe the current and possible future situation of the SMILE islands in terms of RES integration. By this, the different statuses of the islands clarify the different approaches taken for creating their future short- and medium-term scenarios. The following three phases can be considered in terms of implementing RES technologies:

"The ***introduction phase****: This phase represents a situation in which no or only a small share of renewable energy is present in the existing energy system. The phase is characterized by marginal proposals for the introduction of renewable energy, for example, wind turbines integrated into a system without or with only a small share of wind power. The system will respond in the same way during all hours of the year, and the technical influence of the integration on the system is easy to identify in terms of saved fuel on an annual basis.*

The ***large-scale integration phase****: This phase represents a situation in which a large share of renewable energy already exists in the system, for example, when more wind turbines are added to a system that already has a large share of wind power. In this phase, further increases in renewable energy will have an influence on the system, which will vary from one hour to another, depending, for example, on whether a heat storage is full or whether the electricity demand is high or low during the given hour. The influence of wind power integration on the system, and thereby the calculation of the fuel saved on an annual basis, becomes complex and requires a detailed calculation with hourly simulation models.*

The ***100 percent renewable energy phase****: This phase represents a situation in which the energy system has been or is being transformed into a system based 100 percent on renewable energy. The system is characterized by the fact that new investments in renewable energy must be compared not to nuclear or fossil fuels, but to other sorts of renewable energy system technologies. These technologies include conservation,*

---

[1] By 2020: reduce CO_2 by 20% and increase RES share to 20% of all consumed energy; by 2030: reduce CO_2 by 40% and increase RES share to 27% (compared to 1990)

efficiency improvements, and storage and conversion technologies, as well as the use of smart grids (electricity, district heating, and gas). The influence on the system is complex, not only in terms of differences from one hour to another, but also regarding the identification of adequate conversion and storage technologies as well as the smart operation of grid infrastructures." [1]

With the definition of the three phases, the SMILE demonstrator islands are classified in different stages as seen in Table 1. As presented in detail in D8.1, Samsø is furthest ahead in terms of self-sufficiency and supply through RES. With the reference model having a RES share of almost 60%, Samsø is classified as being in the second phase of RE-integration, aiming for the third phase: 100% renewable energy. It can be said that Samsø achieved the first level of RE-introduction already in 2007. This is shaping the evaluation of technologies and creation of the short- to medium-term scenarios in D8.2.

Likewise, Orkney and Madeira have 17% and 11% RES share in their respective reference models, classifying them to still be in the RE-introduction phase as of 2014. Consequently, the next step is to reach a large-scale RE-integration, before working on the 100% target. For D8.2, the short- and medium-term scenarios therefore aim at a RES share of the PES of 50%. This is characterized by the expansion of RES, such as wind and PV capacity, instead of a focus on integration and balancing, as would be the case afterwards. The technologies considered for these steps are presented in the overview in Table 1, where the blue lines frame the phases in focus for D8.2.

Table 1: The SMILE islands and the phases of RES integration/implementation

Phases	RE-Introduction	Large-scale RE-Integration	Towards 100% RE
Example energy system	*Small share of RE, no problem integrating, direct fuel reduction*	*Existing large share of RE, system influence and interference time-dependent due to large share of intermittent RE*	*Transformation into 100% RE-based system, complex comparison of various technologies requiring balance, sector integration, optimized biomass utilization*
Samsø (from Reference / Large-scale to 100% RE)	Wind turbines, biomass and solar DH, indv. heating with biomass and electricity **25+% RES share** (2007)	More PV, wind turbines and indv. heating with biomass, electric and solar thermal, savings **60% RES share** (2015)	SMILE: BESS, DSM, PV Short/Medium-term: update DH, Biogas plant, LBG/CBG, EV, RES, HP **100% RES share?** (2030)
Orkney (from Reference / Introduction to large-scale RE)	Wind turbines, electric heating **17% RES share** (2014)	SMILE: BESS, TES, HP, EV Short/Medium-term: More PV, wind turbines, wave and tidal capacity, savings, more HP and TES, hydrogen, electrolyzer **50% RES share** (2030)	*Discussion to include in medium term:* DH (biomass or electric), TES, CHP, HP, savings, synthetic fuels, EV **100% RES share** (?)
Madeira (from Reference / Introduction to large-scale RE)	Hydro, wind, PV, autonomy **11% RES share** (2014)	SMILE: PV, DSM, BESS, EV Short/Medium-term: More PV, wind turbines, hydro and pump storages, geothermal **50% RES share** (2030)	*Discussion to include in medium term:* District cooling, CHP, solar thermal and TES, DSM, BESS, EV, savings **100% RES share** (?)

Short- to medium-term (2015-2030)

Scenarios of 2022 / 2030

Long-term (2030-?)

3.2 Samsø

The energy system of Samsø is presented with the reference model based on 2015 data. Recapitulating, the island in connected with a 40 MW transmission line to the national grid, but barely utilizes this for import since the electricity demand can be supplied by 94% through local renewables, such as the 24.4 MW wind turbines and 1.3 MW PV plants. With further heat demand being supplied with a large share of biomass, both individual and district heating wise, the island Samsø already has a high RE-share of 60% of the PES. The rest of the heating is supplied by electricity and oil, as is the transport sector. Here, the dependency on fossil fuel is still at 99%, since only a small number of EV exist and the main consumers – the ferries connecting Samsø to Denmark – run on oil, but also more and more on gas, currently natural gas.

Compared to the other SMILE islands, Samsø is the smallest and with the highest RES share (60%) and the comparably lowest CO_2 emissions (28.5 kt). The biomass heating share is 69% in the reference model with 35% of the heat supplied through four DH grids. The electric heating share is at 11% and the electric transport share at 1%, hence with room for improvements, especially with 78% of the local electricity being exported.

In SMILE, Samsø therefore addresses the possibility of employing more local electricity on the island. For this, some further RE capacity is installed, but with the help of SMILE partners LiBAL and RouteMonkey with their smart controls and a BESS, also unused existing capacity can be better integrated. This is tested in the scope of a local marina, which is both used by locals and tourists, which make up an important contribution to the local economy. Here, new PV capacity is planned to be smartly used and stored to decrease the dependency on imports, as well as the addition of HP further contributes to this local test scope. If successful, this idea could be spread to the other marinas on Samsø, as well as be replicated on other islands.

The expected outcome is a reduction of imports by shaving the local marina's peaks, increase the usage of fluctuating renewable electricity locally, and thereby decrease the island's dependency on others. Looking further ahead, the improved utilization of local RE becomes important when more electric heating and EVs are introduced.

The smart controlling of heat production via HPs further opens up the possibility to reduce the operation of biomass boilers. While biomass heating is renewable, it is not an optimal use of a storage fuel, and the biomass could alternatively enable the production of biogas for other uses – e.g. for running one of the ferries such as the natural gas-run *Prinsesse Isabella*. The overall goal of Samsø is therefore the reduction of imports by using more otherwise exported electricity, reducing further biomass consumption in the heating sector and aiming at an eventually fossil fuel free and CO_2 neutral island. This is modelled from a technical perspective in the following.

3.2.1 Short term scenario 2022 for Samsø

The short-term scenario of Samsø focusses on the year after which the SMILE demonstration is installed and running, next to some other minor updates in the energy system by 2022, based on communication with SMILE partners on Samsø. To illustrate the impact the Ballen Marina demonstration can have, Figure 1 reminds us of the distribution of electricity demands by sectors, including the demand of the Ballen Marina specifically. With only 0.4% of the total electricity demand of 25.5 GWh, the marina presents a small consumer, which consumed 105 MWh in 2015, mostly in the summer. This demand and its hourly distribution of 2015 forms the base of the SMILE demonstration scenario.

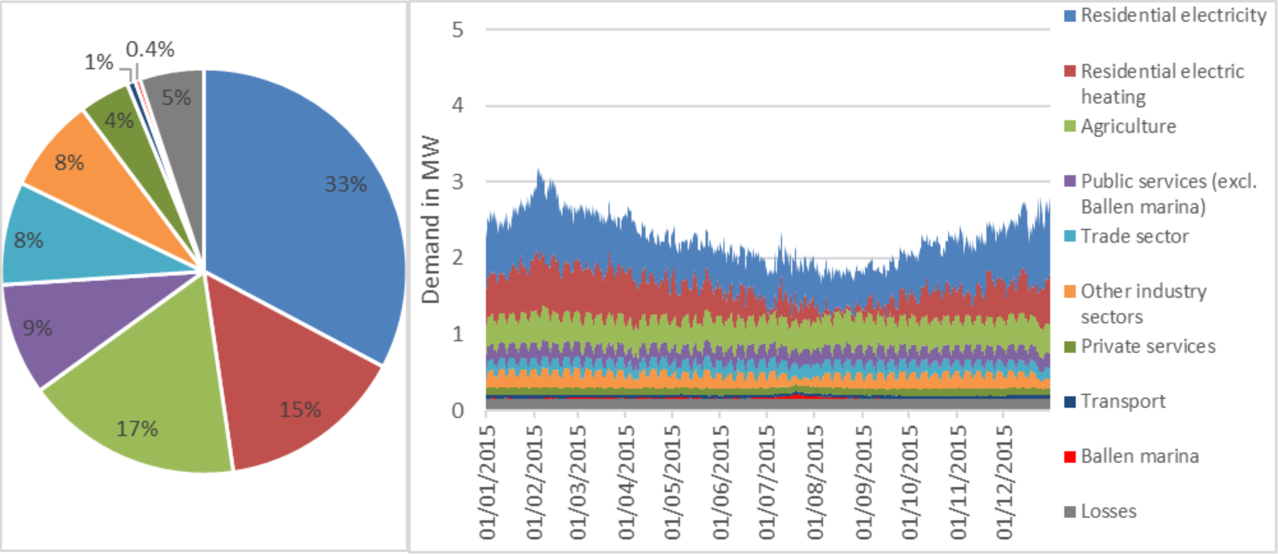


Figure 1: Electricity demand on Samsø, 2015

For Ballen Marina, a BESS of 240 kWh capacity and 50 kW power is selected to be tested and therefore analysed in the following. This is to be charged with a new local installation of 60 kW PV capacity[1]. To ensure a long lifetime of the battery, it is charged to a maximum of 90% of full capacity and discharged to a minimum of 10% of the full capacity, hence 80% or 196 kWh storage capacity is used for the simulations. Any potential excess electricity is injected into the national electricity grid, available for other users on Samsø, or on the mainland. Considering the small share of the marina of the total island consumption, the impact can be expected to be minor.

Figure 2 presents the results of combining the BESS with the usable capacity of 0.196 MWh and the PV simulation of 0.06 MW with local radiation data. As it can be seen, the demand at the marina surpasses the production from PV especially in the winter, when not a lot of PV production is modelled, as well as in the summer, when the demand and the marina peaks due to the summer holiday tourists. Nonetheless, the calculation shows that the PV production of about 69 MWh can – to a large share – be directly used (43%) or stored in the BESS for later use at the marina (38%), while some of the remaining production (14%) can be used other places on Samsø and the rest is lost (5%) in the charging and discharging processes.

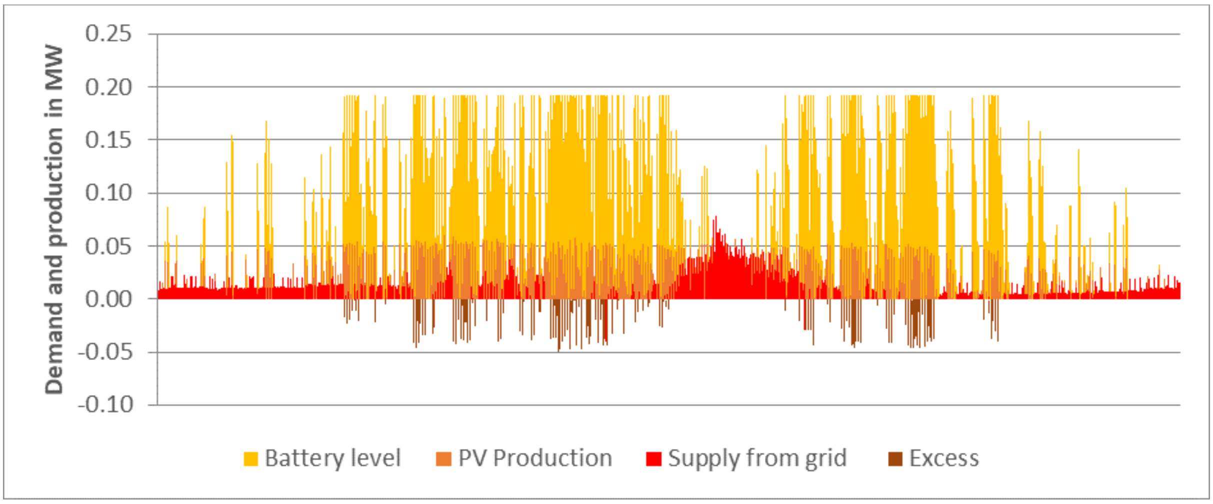


Figure 2: Electricity demand and production at Ballen Marina with BESS and PV

---

[1] Tender pending in December; planned installation March 2019; potential expansion in the future not excluded

The impact of the Ballen demonstration can be integrated in the EnergyPLAN reference model by adapting the total remaining electricity demand and by adding the excess PV production as supply available for other uses. In EnergyPLAN, this simulation reduces the import on Samsø by 10 MWh and increases the export by 40 MWh. If there would not be so much wind power already, the excess PV from Ballen Marina could have been integrated almost to the full extent locally (0.01 GWh increase in exports compared to 0.07 GWh increase of RE production – otherwise no visible impact on the system).

The focus of SMILE – besides the BESS demonstration – lies with HPs. The installation of a single HP at the harbour master's buildings, however, impact the energy system of Samsø only to a negligible extent. Instead, the following presents the updates and upgrades in the Samsø energy system until 2022, before presenting the overall 2022 scenario results.

At the Samsø municipality, the idea of building a biogas plant has been around for some time. Until 2022, this is to be realized, mostly contributing to the fuel demand of the ferries, which supply Samsø. As presented in D8.1, the fossil fuel consumption for ferries lies at around 52 GWh annually, besides the 47 GWh of oils for road transport. With biogas, the fossil fuel demand of the ferries can be reduced, and potentially also some of the road transport in the future. According to Samsø municipality, the biogas plant is supposed to produce 30 GWh by 2022 – in future potentially more – and therefore requires a large amount if biomass, which explains the increase in biomass in Table 2. With a 90% efficiency, the final input to the gas sector is 27 GWh annually.

Furthermore, the boiler at the oldest DH plant in Tranebjerg on Samsø is reaching the end of its lifetime. By 2022, it is therefore expected to be replaced by a HP. This way, the large amount of excess electricity production from wind and PV can be used to supply this DH grid. Due to limits on the operation over the year caused by low winter resource temperatures in this 1 MW_{el} air-to-water HP, it will be supplemented by an alternative boiler, explaining why biomass is still consumed in this sector even after the installation of the HP. However, this is kept to a minimum, similar to the existing oil-based back-up systems, with the help of a 2.6 MWh thermal energy storage (TES) allowing for the HP to increase its operation in time of wind even without a heat demand. As a recent (SMILE related) study shows [2], an increase in the size of the TES results in only minor improvements for the energy system. Due to the uncertainty of availability and willingness for a large TES, a small one of 3x4 m (38 m^3) is chosen. Larger TES capacity would increase the HP production slightly, reducing the biomass consumption by a similar minor share.

Otherwise, some minor improvements in the energy system are expected due to recent trends and strategies. This includes the increase of wind capacity by a minor share through the installation of a few small-scale turbines (five 6 kW turbines), which tend to be installed at the private level, as well as some further PV installations. These are either privately or installed on public buildings, where the trend of the recent years suggests the total capacity to reach 1450 kW. This new capacity would increase the export and decrease the import, but the following two updates oppose this trend again. First, an increase of EVs is expected by 2022 with twice the amount compared to the reference model 2015, which equals about 100 EVs. Secondly, the effort of the energy academy and some external causes would lead to an uptake of HP at private buildings, resulting in a replacement of oil-based heating by electricity-based heating.

The results of the scenario 2022 measures combined reduce the CO_2 emissions by 22% (6.2 out of 28 kt annually) compared to the reference scenario and increase the RES share from 59.5 to 69%. Furthermore, the fuel consumption on Samsø is reduced by 7.4 GWh; with oil consumption -6.5 GWh, natural gas consumption -23 GWh and biomass consumption +21 GWh. Even though the electricity demand for transport and heating increases, the amount of imported electricity can remain the same (1.5 GWh), with the electricity export even decreasing (from 87.5 to 84.8 GWh). The details can be found in Table 2 next to the results of updating the scenario to 2030, which is explained in the next section.

3.2.2 Medium term scenario 2030 for Samsø

In the following, a scenario is presented with realistic changes to Samsø's energy system by the year 2030. For this, the local energy strategy and current trends are used as guidelines, as well as ambitious energy goals as targets [2], [3].

Similar to the case of the oldest DH grid in the centre of Samsø, the other three smaller DH plants will need to be changed or expanded within the medium term. Due to the still high amount of excess electricity and the scarcity of local natural resources, large HPs are considered for this. By keeping the existing boilers for peaks, HP support and backup, the HPs can be operated to run entirely on excess electricity from RES. This resulting total HP capacity of 2 MW is furthermore supported by additional TES, in total 7.8 MWh in addition to the existing solar heat storage tank. Depending on the available excess RE electricity on Samsø, the amount of heat produced from HPs depends on the increase of electricity consumption in the other sectors. Hence, if the number of EV increases, the HP production might be reduced to avoid increasing electricity imports.

At this point, a sensitivity study of additional RES capacity is applied, looking into an increase of wind and PV capacity under the condition of limiting the critical excess electricity production (CEEP), which results from the combination of production, demand and transmission line. Other conditions influencing the choice are a limit to the export, a reduction of the import as well as the fuels. At this point, large RES capacities can result in large amounts of excess electricity, so an increase of wind and/or PV capacity with a total of 10 MW is suggested. The combination of both results in the lowest import of 0.7 GWh annually. This, however, increases again with the increase of EVs.

Another effect the HPs have is the reduction of fuels – mostly biomass – in the heating sector. This is an important aspect in regards to the increased production of biogas, which is suggested to cover more of the transport fuels in the energy system of Samsø. By 2030, an expansion of biogas production by 50% is considered. From the original production in 2022 of 27 GWh the production increases to 40.5 GWh annually, with a total biomass requirement similar to the 2022 scenario due to the previous reductions in biomass as heating fuel.

The next aspect is the improvement of the transport sector. Next to the increase in local biogas, which is mostly used in the ferries, the road transport is considered to be further electrified. This is modelled in two steps, first with an uptake to 1,000 EVs and second up to 2,000 EVs, representing all the personal vehicles. From 2022, where the number of EVs is estimated to be 100, this increases also the electricity demand in transport ten-fold and about 20-fold respectively. With the higher efficiency of electric compared to internal combustion vehicles, the total energy demand, however, decreases. While the first increase of EVs causes the import to increase by 0.4 GWh, the second causes an increase of another 0.5 GWh, even though the steps are very similar in demand changes. Otherwise, the otherwise exported electricity supplies the new electricity demand, hence, it decreases by 2.4 GWh and again by 2.2 GWh.

With the steps mentioned so far, the RES share surpasses the 80% mark and the CO_2 emissions have been more than halved, but the oil consumption is still at 50 GWh annually. To reduce this further, by 2030 HPs should replace the individual boilers still using oil, reducing the CO_2 balance by annually 3 kt. After this step, the remaining fossil fuel consumption is found in the transport sector (and the minor industry demand, which is not further addressed).

One option to lower the remaining fuel consumption in transport and integrate the still high RE export is through electrolysers and hydrogen production as fuel replacement. Through cooperation with Orkney and possible knowledge transfer, a similar set-up can be considered for Samsø. With a 1.5 MW electrolyzer capacity 3.3 GWh of oil can be replaced while reducing the export by 2 GWh. In total, by then, the RES share reaches 85% and the CO_2 emissions are below 10 kt compared to the reference model with 59.5% and 28.5 kt_{CO2}.

3.2.3 Overview and discussion for Samsø

The final results of the short- and medium-term scenarios presented in Table 2 are including the increase of RES capacity through PV solely. Even though an increase of 10 MW RES with wind turbines would result in similar outcomes, the electricity from PV is better integrable in the energy system and potentially easier realized regarding space demand and potential NIMBY opposition in the population. In the following, this is discussed besides other aspects of the Samsø energy system going towards a 100% RE system.

Table 2: The annual energy supply and demands on Samsø – reference, short- and medium-term

		2015 Reference	2022 SMILE (BESS, PV), HP, biogas	2030 HPs, EVs, PV, H2
	Supply (GWh)			
⬜	Wind onshore	27.5	**27.6**	27.6
⬜	Wind offshore	80.9	80.9	80.9
⬜	PV	3.1	**3.4**	**26.9**
🟧	Solar collectors, indv.	0.4	0.4	0.4
🟧	Solar collectors, DH	1.0	1.0	1.0
🟨	Biomass	52.2	**73.3**	**74.2**
🟫	Oils	89.0	**83.5**	**36.0**
🟫	Gas (natural), LPG	23.4	**0.4**	0.4
	Total PES	*279.0*	***272.0***	***249.2***
	Demand (GWh)			
⬜	Electricity for heating	3.8	**6.8**	**14.3**
⬜	Electricity for transport	0.2	**0.3**	**6.0**
⬜	Electricity for electrolyser	0	0	**2.1**
🟧	Biomass for DH plants	26.3	**17.5**	**3.3**
🟧	Biomass for indv. boilers	25.8	25.8	25.8
🟧	Biomass for biogas	0	**30**	**45**
🟧	Oil for indv. boilers	12.5	**11.6**	**0**
🟥	Gas for industry	0.4	0.4	0.4
🟩	Diesel for ferries	29.4	**25.4**	**11.9**
🟩	Diesel for cars	35.1	**34.5**	**20.1**
🟩	Petrol for cars	12.0	12.0	**4.0**
🟩	Gas for ferries	23.0	**0**	**0**
🟩	Biogas for ferries	0	**27**	**40.5**
🟩	Hydrogen for cars	0	0	**1.7**
	Results/System indicators			
	RES share of PES	59.5%	**69.0%**	**85.3%**
	RES share of electricity prod.	437.1%	**391.1%**	**324.3%**
	Imported electricity	1.5 GWh	1.5 GWh	**1.8 GWh**
	Exported electricity	87.4 GWh (78%)	**84.8 GWh (76%)**	**93.4 GWh (69%)**
	CO_2 emissions on island	28.5 kt	**22.3 kt**	**9.7 kt**
	Electric heating share	11.4%	**24.1%**	**60.2%**
	Bio heating share	68.7%	**56.3%**	**38.5%**
	Electric transport share (incl. H2)	0.5%	**1.1%**	**23.4%**
	Bio transport share	0%	**27.0%**	**40.6%**
	Total system costs	16.5 M€	**17.0 M€**	**15.6 M€**

All details from the scenarios, including input and output specifications can be found in Appendix 7.1.

Potential sensitivity aspects to consider: The combination of both 10 MW wind and PV would result in the additional 25 GWh electricity exported (0.2 GWh critical), while reducing the import by less than 1 GWh and increasing the RES share by 1.3%-points to 86.6%. This excess electricity could also increase the DH HP production if its production is linked to the excess, but only by a minor share. Another important aspect to further improve this scenario could be for example heat savings, reducing the electricity and fuel demand for boilers, which could be important if the biomass would need to be reduced further.

To address the remaining fossil fuels in transport, a further extension of the biogas plant or a replacement of remaining fuels with electro- or biofuels could be considered. These might have to be imported if a realistic scope is too big for an island the size of Samsø and should otherwise include the limited amount of biomass and the excess fluctuating electricity. In Figure 3, the remaining fossil fuel can be noticed as the main remaining point for improvement. Finally, further smart controlling and management of various demands could improve the energy system of Samsø to reach the final target of a 100% RE, so further exploration and integration of solutions such as presented in SMILE is recommended.

The concluding Figure 3 presents a comparison of the different scenarios through Sankey diagrams. Different to the graphic from D8.1, the fossil fuels are illustrated darker to mark a difference between fossil and bio fuels. Additionally, the number of nodes and connection between sector increases as interconnections and balance options are pointed out.

Most interesting may be the growth in losses from 2015 to 2022, but that can be related to the local biogas production, which has an efficiency of 90% besides the engines' (in)efficiencies in the transport sector. Regarding this, it must be noted, that the production and transportation of the alternative fossil fuels are by far worse, except that they are not presented in this local image of the island's energy system. For the replacement of the last amount of fossil fuels are alternative fuels needed, as explained above, which can also further reduce the total amount of losses in the system. Next to the further increase of the RE share (currently 85%) should the reduction of losses be addressed in the future by more efficient heating and transport options.

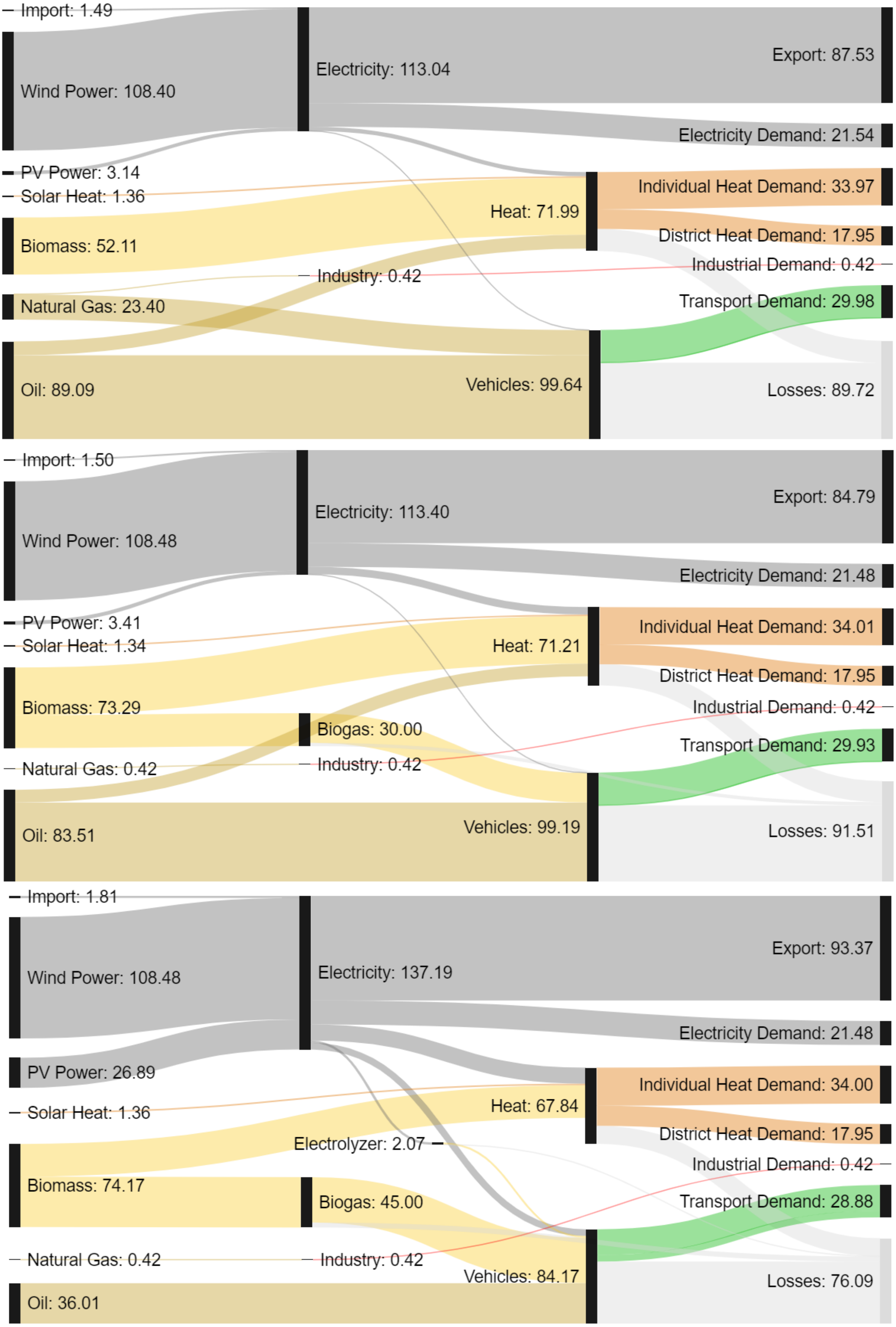


Figure 3: Sankey diagrams of Samsø 2015, 2022 and 2030

Figure 4 illustrated the fuels and results of the various scenarios, presenting oil, gas, biomass and electricity demands and resulting CO_2 emissions and annual system costs. While the SMILE demonstration can only barely be made out, also the 2022 scenario shows only minor updates in total fuel consumption with the production of biogas. Through the approach of the transport sector with EVs as well as electrifying more of the heating sector, the final scenario presents a large drop in fuel consumption and CO_2 emissions.

Despite the high EV share and a biogas plant beyond the current plans implemented by 2030, the medium-term scenario still requires 36 GWh of oil, which must be replaced with biofuels or other synthetic fuels in similar quantities. Further research is recommended for the best alternative technologies in the heavy transport sector to make Samsø finally reach the 100% RE share for the energy system. As Figure 4 further suggests, the development until now could be made with a reduction of annual costs, so a continuation of this should be economically feasible.

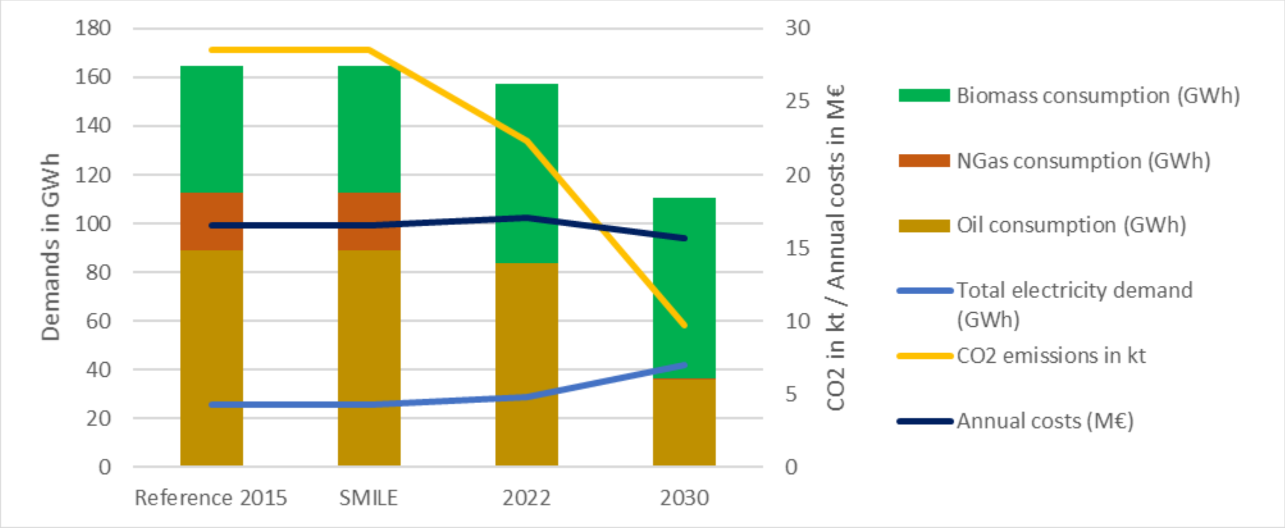


Figure 4: Scenario comparison of demands and resulting CO_2 emission and costs for Samsø

3.3 Orkney

In D8.1, the energy system of Orkney is presented with the reference data from 2014. The main island ("Mainland") is connected with two submarine cables with a total capacity of 40 MW to mainland Scotland, and the minor inhabited islands around Mainland are connected to it with smaller transmission line capacities. The total capacity of wind turbines (48.3 MW) and PV (1.3 MW) can supply the majority of the islands' electricity demand: only 7% of the demand is imported and some power must be supplied by the local power plant (27%). With the heat demand further relying to a large extent on electricity, the total RES share of the PES reaches 17.6% for the reference model. A large part of the heat is still relying on oil, as is the industry and transport sector. Despite the relatively high amount of electric vehicles compared to other regions in the UK or Europe, its share is still estimated at only around 0.1% of the road and marine transportation (0.2% of the road transport).

In the reference model of Orkney, the CO_2 emissions are at 186 kt annually, resulting in a similar amount per capita as on Samsø. The biomass share, however, is much smaller with 1% of the modelled heat sector for 2014, while the electric heating share is at 44%, resulting in a still high share of fuel poverty in the area. With a current export share of 32% of the local RE production and no existing DH grid yet, there is room for many improvements.

To address the option of more efficient heating in combination with otherwise curtailed or exported electricity, the SMILE demonstration project on Orkney focuses at new domestic heat installs at currently 45 planned households, as well as include electric transport through more EV charging stations. Both options include smart planning and operation, meaning taking into account the temporality of excess of renewable electricity production and the potential demands. This is tested in one of the zones of Orkney, which encompasses some of the mainland island and most of the northwestern situated ones. However, in D8.2, as was the case for D8.1, the whole island and its energy system is modelled.

By integrating RE in a smarter way, the local energy can be used locally and benefit both the heating and the transport sector. Furthermore, this can reduces the import of electricity or otherwise at the power plant produced electricity if demands can be shifted to hours of excess production. This reduces the island's fuel use and CO_2 emissions, as well as reduced electricity exchange and/or curtailment. An increase in self-sufficiency is the overall goal and is presented in the following through a technical approach including the SMILE demonstration.

3.3.1 Short-term scenario 2022 for Orkney

For the 2022 scenario, documents from Orkney, such as the SMILE deliverable D2.1 or the EV strategy [5], as well as UK statistics [6] were studied and used, some of it extrapolated. The details of the basic model are found in D8.1.

The short-term scenario for Orkney addresses mainly the private customers and households and their electricity and heating, while the measures for the industrial sector are introduced afterwards. Within the electricity sector, the RE production from wind and marine energy plays a role, as well as the consumption of electricity in the heating and transport sector. As Figure 6 shows, the share of domestic heating is 16% of the total electricity demand, while the transport was at merely 0.05%. However, this number has been increasing since the reference model of 2014, as can be expected from Figure 5. By 2017, the share is at about three times the amount of 2014 and in the short-term perspective of 2022, the share is even assumed to ten-fold.

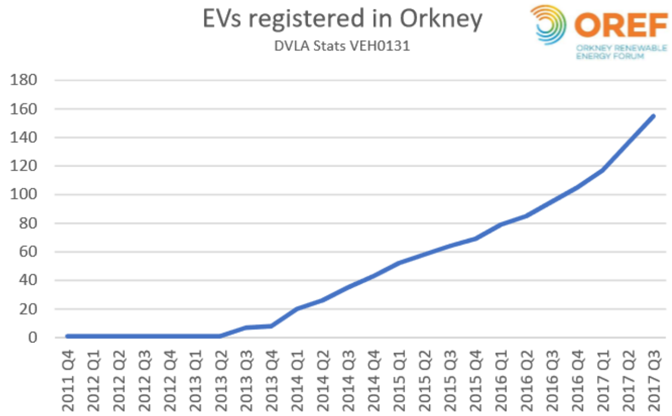


Figure 5: Registered EVs in Orkney

As Figure 6 further shows, electric heating also makes up a large share of the heating sector with 44% of demand supplied with HP or electric boiler as of 2014, which is 16% of the demand in the total electricity demand. The details presented in D8.1 indicate that electricity forms the largest share, while also oil and coal form important parts of the current heating supply. With the SMILE demonstration project, both the electricity demand and the heat supply are therefore effected.

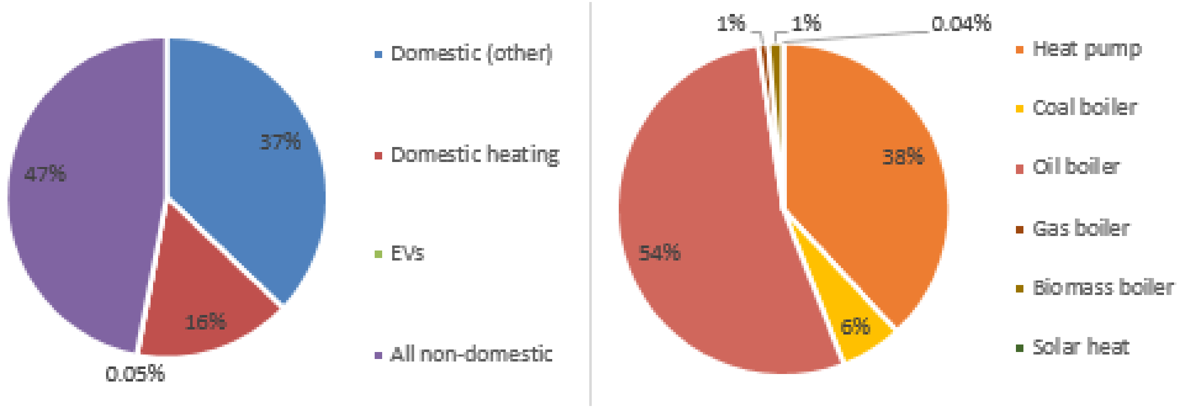


Figure 6: Electricity (155 GWh) and heat demand (124 GWh) on Orkney 2014

The 45 heat installs introduced to the heating sector, which are presented in Table 3 (cf. D2.1) to be installed on Orkney as part of SMILE are of a total capacity of 234 kW_{el}. With an average annual heat demand of 15 MWh per household[1], these would produce up to 675 MWh heat with electricity, replacing heat production from fossil fuels. Additionally, heat storage of a total capacity of 2,000 kWh is added.

The resulting impact on, on the one hand, CO_2 emissions can therefore be connected to the reduction in heating oils, while the HPs, on the other hand, increase the total electricity demand, causing a reduction in exported electricity. By keeping both heating systems in the houses – both HPs and oil boilers – the production depends on available excess electricity, while a complete replacement of oil boilers with HP would reduce the oil consumption more while the electricity demand (incl. import) would increase. In the 2022 scenario, both heating units are kept as it represents the SMILE demonstration more closely.

---

[1] Average heat demand applied for both Orkney and Samsø

Table 3: Overview of SMILE demonstration project on Orkney (based on D2.1)

Load type	**No**	**kW**	**kW total**	**kWh storage**	BESS
Domestic heat installs type 1 (PCM & TES)	15	5.6	84	65 (975)	-
Domestic heat installs type 2 (HP, PCM & TES)	15	5	75	65 (975)	-
Domestic heat installs type 3 (HP & TES)	10	5	50	65 (650)	-
Domestic heat installs type 4 (BESS, HP, TES)	5	5	25	*"100-300l + 500-1000l"*	3.6kW/7.5kWh$_{el}$ (total 18/37.5)
All heat installs	**45**		**234**	**~2,000**	
EV smart slow chargers	30	7	210		
Industrial load	1	500	500		
TOTAL			**944**		

Adding more EVs, even though smart charged, adds to this reduction of export and CO_2 because of the shift from transport oils to electricity. Furthermore, an increase of import happens due to inevitable temporal mismatches between RE production and charging. In the short-term scenario of 2022, 33% of the total expected EV fleet of 500 vehicles is expected to be able to use smart chargers, while the remaining demand is charged normally, modelled via dump charge. The charging and total storage capacities are based on typical EV Nissan Leaf specifications, which is the most common EV on Orkney.

The impacts of a few heat installs and EVs are of very small extent (1%) in the energy system of the whole Orkney, but generally suggest an increase in RE capacity if import and export are not to grow. Both ideas are scaled up to a higher penetration in the 2030 scenario below.

Besides the above presented heat installs and EV demonstrations by 2022, further development is to be included in the short-term scenario of Orkney. As presented in D2.1, the curtailment is addressed with "*domestic heat installs, EV smart charging and large industrial load*", meaning the hydrogen production facility at the Orkney-based European Marine Energy Centre (EMEC). "*SMILE will help implement the smart control of switching between the two generators and the local grid to maximise generation and hydrogen production*" with the local RE. Through "*smart control of the switching and storage system, including the existing electrolyser*", more of the excess electricity from local RE can be integrated in the local energy system. [7]

This has been increasing in importance in the recent months, since the EMEC's test side of tidal energy is to be further integrated into the energy system of Orkney, adding more fluctuating electricity to the already inflexible grid. The 500 kW electrolyzer on Eday [8], as well as one of 1 MW on Shapinsay [9], will be included in the short-term scenario, as will be the tidal energy capacity of 2 MW[1] and the wave energy capacity of 7 MW [6],[10]. Both these marine energy production sites are partly in test mode and were therefore not included in the reference model for 2014. In the short-term towards 2022, both marine energy technologies are part of the Orkney energy system. With the existing hydrogen storage of several tanks adding up to 1,250 kg, a total storage capacity of 42 MWh is added to the system and the final potential annual energy from hydrogen for transport is defined as 1.66 GWh, based on the 50 t of hydrogen expected to be produced each year [11].

Based on the statistics from DBEIS [6], additional wind power and PV capacity is further added to the energy system. By the latest update to the statistic for 2017, the wind and PV capacity on Orkney increased by 0.4 MW and 0.03 MW respectively per year since 2014. Comparing to the reference model, the total wind capacity of Orkney is estimated to increase with 4.5 MW and PV with 0.2 MW by 2022.

---

[1] Even though the installed capacity is 4 MW, the scenarios are made with 2 MW since this was the peak production recorded until now and because tidal energy is still under development and is considered with limited outcome

Regarding RES share and CO_2 reduction, these additional RE capacities have the biggest impact from the changes made since 2014. Furthermore, the import could be reduced by 27% to present only 5% of the total electricity demand (before 7%), even though the demand increased. The export of electricity is also reaching a slightly different level with 36% of the total RES production (before 32%), even though the total export increased by 14 GWh (28%). All the scenario 2022 data can be found in Table 4.

3.3.2 Medium-term scenario 2030 for Orkney

For the medium-term scenario of Orkney, likely changes up until 2030 are included. The EV strategy from 2018 influenced the transport aspects of the scenario [5], while the latest SMILE research paper[1] presents some of the ideas affecting the heating sector.

With a focus on banning the sale of diesel and petrol cars by 2032 in Scotland [5], Orkney is on the way to increasing the use of EVs to a maximum around the year 2030. As it is uncertain if there will be other future technologies and alternative fuels available, the most anticipated vehicles are stated to be EVs as of now. However, this opens up the opportunity of storage through V2G connections. The Orkney Electric Vehicle Strategy [5] states that the "*Envisaged Future of Orkney's +10,000 vehicles being electric will represent up to 500 MWh of battery storage*" if every EV was to be supplied with larger battery capacity (50 kWh) as might be expected for the future. Therefore, for the 2030 scenario, 80% of the road transport[2] is modelled to be relying on EVs with V2G balancing the electricity import and export to the best extent possible and by allowing to supply the grid via a standard 10 kW capacity per car of battery to grid connection [12]. This is estimated to be possible with a EV share of 20%, which results in the maximum V2G capacity of 33,400 kW. The total EV battery capacity is estimated to be at 350 MWh since not all the EV battery capacities are expected to reach 50 kWh.

While the increase of EVs results in higher imports (+7.5 GWh), the additional V2G options limit this again (-3.2 GWh). With the following proposals to increase the hydrogen production further and install HPs by 2030, the import might need to be answered with new RE capacity nonetheless. Hydrogen production as an alternative fuel in the energy system of Orkney is already established in the 2022 scenario. By 2030 it is deemed likely to double this production, hence 3.3 GWh of hydrogen to be replacing fossil fuels. This requires now a total of 4.2 GWh electricity, which can be mostly meet by local RE.

To improve the heating sector of the island, DH is further proposed to be implemented in the largest town on Orkney, namely Kirkwall. The studies of both the Scottish Heat Map [13], as well as the Heat Roadmap Europe [14] suggest large heat densities in the center of Kirkwall. With the selection of this central heat demand, 33% of the current heat demand on Orkney could be covered with DH. Due to the still large amounts of excess electricity, a HP is to supply this DH grid, as well as a biomass boiler as a supplement and back-up. In the following, the HP is to operate only at hours with excess electricity, while a full-load operation could also be modelled. However, due to the target of keeping imports as well as the electricity production from the local fossil-fueled power plant or similar at a minimum, this is not further pursued. The alternative of using the HP not only during hours of excess electricity but at full-load is discussed at the end of this chapter.

The DH grid is modelled by moving the individual heating demands to this centralized solution, resulting in less fuels needed for individual coal, oil, gas and biomass boilers. Since the exact types of buildings and boilers are not known, all of them are reduced by 33%, except already electrically heated houses. The final share of DH in the heating sector is therefore 19%. The impact of DH for Orkney ranges from the reduction of CO_2 by 3-4 kt annually, to reduced fuel consumption at individual buildings and in total, as well as a reduction in the overall system costs.

---

[1] *Evaluation of Electricity Storage versus Thermal Storage as part of two different Energy Planning Approaches for the Islands Samsø and Orkney*; Submitted to Energy; Nov. 28th, 2018

[2] 16,700 vehicles

If the heating sector is to further develop towards renewable heat, the remaining boilers are to change to biomass or HP as alternatives. While this, on the one hand, increases the RE share beyond 30%, it also increases both electricity demand and/or biomass consumption. The potential for biomass on Orkney is unknown, therefore, additional RE capacity based on wind, sun or water is presented. The results of the combination of 2030 aspects with additional 10 MW tidal and 10 MW PV capacity are presented in Table 4, while a sensitivity study of alternative capacities is discussed afterwards. This 20 MW combination, though – with the modelled energy system – results in the least critical excess production while reducing the import, fuel and CO_2 the most. The details are listed in the last column of Table 4.

3.3.3 Overview and discussion for Orkney

The following presents a presentation and comparison of the main scenarios for Orkney, from reference over SMILE to short- and medium-term changes. The details from the EnergyPLAN models are further added in the Appendix, where the data for Orkney can be found in section 7.2.

Further included is a discussion of aspects included in the creation of the scenarios as well as of ideas for the long term. Table 4 shows all input and output specifications of the three models for Orkney, which is illustrated in Sankey diagrams in Figure 7 below. This illustrates that one of the main focus, namely the fossil fuel consumption, is changing the most. Instead of using these, electricity replaces some of the corresponding demands.

Table 4: The annual energy supply and demands on Orkney – reference, short- and medium-term

		2014 Reference	2022 SMILE (HP, TES, EV), H2, EMEC	2030 EVs, DH, HP, Tidal, PV
	Supply (GWh)			
⬜	Wind onshore	149.7	**163.6**	163.6
⬜	PV	1.2	**1.4**	**10.6**
⬜	Tidal	0	**7.4**	**44.2**
⬜	Wave	0	**2.9**	2.9
🟧	Solar collectors, indv.	0.1	0.1	0.1
🟨	Biomass	2.0	2.0	**69.1**
🟫	Oils	598.8	**592.9**	**425.6**
🟫	Gas (natural), LPG	94.5	**83.8**	**35.5**
🟫	Coal	21.1	21.1	**12.6**
	Total PES	*878.2*	***882.8***	***767.9***
	Demand (GWh)			
⬜	Electricity for heating	15.3	**15.5**	**21.2**
⬜	Electricity for transport	0.1	**0.8**	**27.0**
⬜	Electricity for electrolyser	0	**2.1**	**4.2**
🟧	Biomass for indv. boilers	2.0	2.0	**54.6**
🟧	Biomass for DH	0	0	**23.5**
🟧	Oil for indv. boilers	76.0	**75.2**	**0**
🟧	Gas for indv. heating	1.4	1.4	**0**
🟧	Coal for indv. heating	8.5	8.5	**0**
🟫	Gas for power plant	93.1	**82.4**	**35.5**
🟥	Oil for industry	176.8	176.8	176.8
🟥	Coal for industry	12.6	12.6	12.6
🟩	Diesel for boats	228.0	228.0	228.0
🟩	Diesel for cars	75.1	**69.8**	**12**

🟩	Petrol for cars	36.1	**36.0**	**2**
🟩	Hydrogen for cars	0	**1.7**	**3.3**
🟩	Jet fuel for airplanes	6.9	6.9	6.9
	Results/System indicators			
	RES share of PES	17.6%	**20.3%**	**38.0%**
	RES share of electricity prod.	97.5%	**111.2%**	**113.5%**
	Imported electricity	10.8 GWh	**7.9 GWh**	**3.8 GWh**
	Exported electricity	48.9 GWh (32%)	**62.6 GWh (36%)**	**46.0 GWh (21%)**
	CO_2 emissions on island	186.0 kt	**182.2 kt**	**124.9 kt**
	Electric heating share	43.8%	**44.3%**	**56.8%**
	Bio heating share	1.1%	1.1%	**43.1%**
	Electric transport share (incl. H2)	0.1%	**1.7%**	**28.5%**
	Bio transport share	0%	0%	**0%**
	Total system costs	57.7 M€	**61.7 M€**	**59.6 M€**

Alternative RE capacity in the future further includes wind power, as well as wave power, based on the existing installations. Further wind capacity is not chosen since its additional capacity would increase the already extensive fluctuations between windy and non-windy hours. Wave power, on the contrary – though at same potential capacity – has a very limited effect on reducing imports or fossil fuel consumption. Further, wave power is still comparably expensive at the same capacity of wind or PV. PV is a technology much underestimated, yet comparably inexpensive with RE production during times when there is usually demand for electricity (daytime). Tidal power is furthermore chosen – even though it might be most expensive – due to its great results regarding import and fuel reduction at the same capacities as other technologies.

To address the remaining fossil fuels in transport, a replacement with electro- or biofuels could be considered similar to Samsø with either local biogas production or additional hydrogen. However, if electricity-based fuels are considered, so must the amount of excess electricity be taken into account, which is still making up a large share as can be seen in Figure 7. Alternatively, additional RE capacity might be required to allow these further electrification measures. The options for the long-term scenario targeting 100% RE requires further discussion in the following.

As is further illustrated in Figure 7, the industrial demands have not been addressed with these improvements of heating and transport sector. Due to insufficient data and the unusually complex conditions in the industrial sector, an optimization of it requires an in-depth study. Another recommendation is therefore the investigation of this sector, besides the transport sector, which might still rely on fossil fuels. The final Sankey diagram presents Orkney in the second RE-integration phase, after which balancing and interconnected are needed to further approach the 100% RE target.

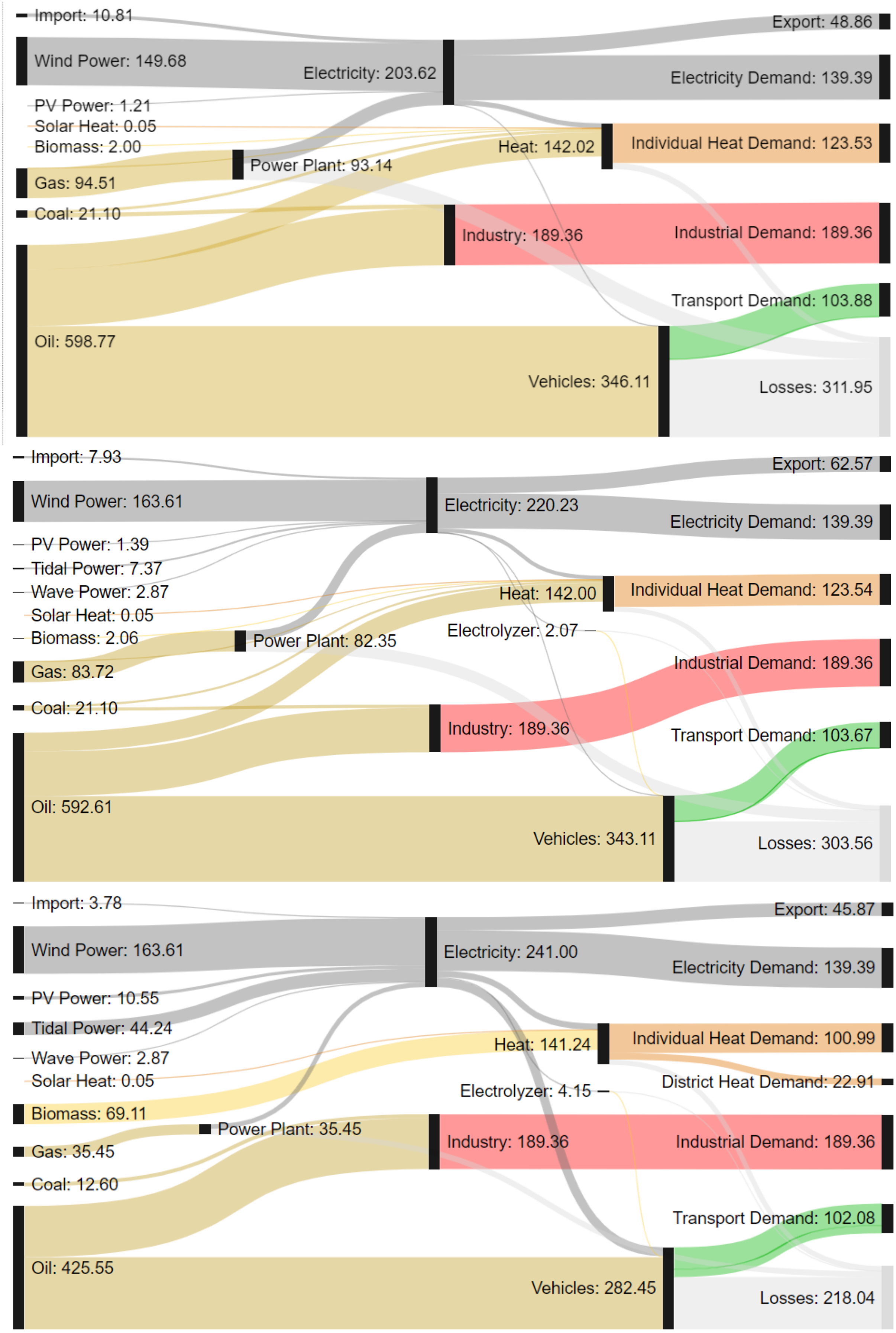


Figure 7: Sankey diagrams of Orkney 2014, 2022 and 2030

While the total heat demand in the scenarios is rather limited, as was discussed in D8.1, the potentially larger demands could require further improvements. Even though the majority of heat demand could be supplied by individual HPs or biomass boilers, alternatively, an additional DH system in Stromness, next to the maximal possible extension of the presented Kirkwall DH could be targeted. After evaluation of possible current waste heat sources, such as from industry, the DH could furthermore be expanded and/or improved.

Figure 8 illustrates the presented steps in terms of fuel and electricity demands, as well as resulting CO_2 emissions and annual costs. As presented above, the increase of tidal power capacity has the best impacts on import and fuel reduction, while it is the most costly. This cost, however, can barely be noted. The result is an almost constant cost of the total system over the years, while the cheapest solution of wind and PV capacity combination would result in 52.6 M€ instead of 59.9 M€ as is the case for same PV and tidal capacity.

Further sensitivity study shows the potential share of 41% RE share with additional 20 MW PV and 5 MW wind capacity, which would, however, result in a minimum of 2.5 GWh critical electricity production – potentially more if placed unfavourable regarding internal bottlenecks.

Above, the DH operation is presented as being supplied electrically with a HP during excess electricity production and otherwise relying on a back-up unit using biomass. If this DH demand was to be fully supplied by HP, the total electricity demand would increase by 13 GWh annually, of which 4 GWh would have to be imported and 3 GWh could come from otherwise exported electricity. The remaining demand could be provided from the local power plant, hence, not very sustainable. However, this scenario would not require more biomass than the amount used in the reference model and might be cheaper. It therefore presents an alternative 2030 scenario[1] to consider, while the scenario presented in the following models a combined DH supply from HP and biomass.

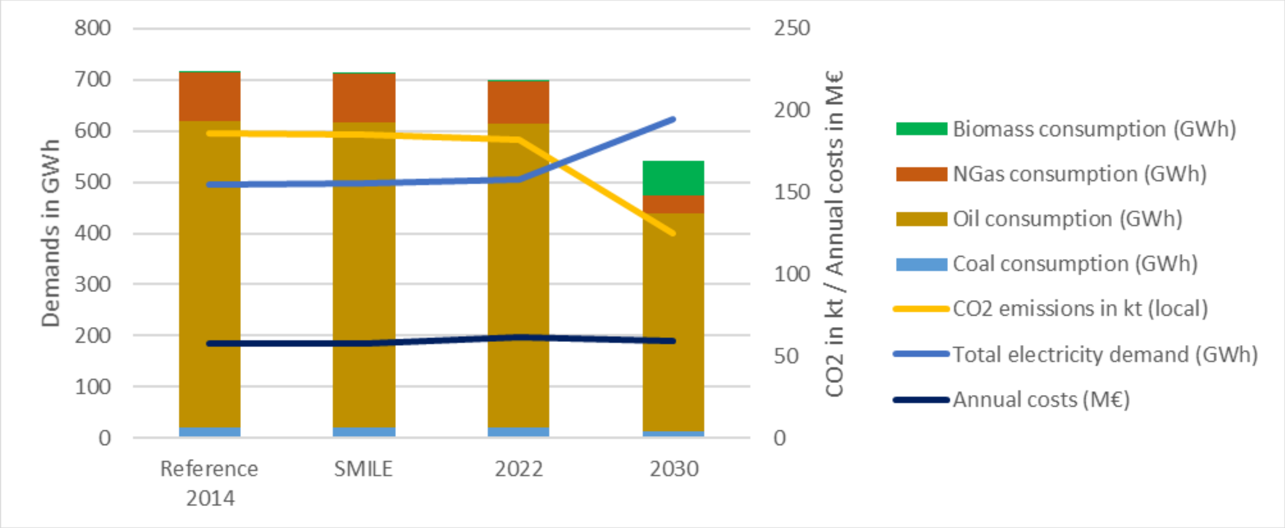


Figure 8: Scenario comparison of demands and resulting CO_2 emission and costs for Orkney

---

[1] With less biomass consumption, but more electricity consumption and resulting fossil fuel demand for the power plant, as well as higher CO_2 emissions

3.4 Madeira

The high RE scenarios for Madeira take their starting point in the reference model presented in D8.1, which uses 2014 as the reference year. Without a transmission line to neither Europe nor Africa, Madeira is the only SMILE island with an autonomous electricity grid – 900 km from the European continent. Therefore, the dependency on imports and need for better utilization of local resources is even greater than for most other islands.

The Madeira energy system as of 2014 is supplied with various hydro power plants, as well as onshore wind turbines and PV power from a number of small installations. This sums up to 115 MW RE capacity, which is far from sufficient for the comparably large electricity demands on Madeira, resulting in the necessary operation of oil and gas-based power plants to supply the majority of power. The heating sector – and with it the cooling sector – is further heavily electrified, which makes it hard to evaluate the actual heating demand. Otherwise, the heat supplied by furnaces and similar are mainly supplied with gas and biomass – on top of which comes some solar heat in 2014. With high amounts of fossil fuels in the electricity and heating sector, as well as the transport sector, the RE-share reaches only 11% if waste incineration is to be considered renewable – 7% if not.

Comparing to the other SMILE islands, Madeira is the only autonomous island with resulting large power plant capacity and local waste incineration, as well as limits in terms of capability to install more RE capacity due to grid limits and stabilization problems that potentially come with fluctuating electricity. If heating or transport were to increase the electricity consumption, it has to be done in compliance with various stakeholders, such as the local electricity company.

This results in the definition of the SMILE demonstration projects (“pilots”) for Madeira. These address the existing PV installations with BESS, which are partly restricted from injecting surplus electricity into the grid, as well as the optimization of the transport sector through EVs. In relation to the first BESS pilot, a final demonstration pilot utilizes BESS to optimize conditions and options in the grid further. The overall target under SMILE on Madeira lies in the optimization of local resources and the reduction of fossil fuels in the power production and transport sector.

3.4.1 Short-term scenario 2022 for Madeira

The short-term evaluation for Madeira includes the SMILE demonstration pilots 1-5, as well as the local strategies and plans regarding the energy system, provided by EEM. With pilot 1-4, the electricity demand of Madeira is addressed as it is influencing – firstly – the demand at households and businesses, which have PV installation, of which currently some of this electricity is lost due to non-existing storage possibilities and – secondly – the electricity needed for the uptake and improvement in the transport sector.

Figure 9 from D8.1 reminds us of the currently highest electricity demands being in the service sector (hotels, public business, etc.) and the household sector, while the transport sector represented the smallest share in 2014 of less than 0.01% (0.1 out of 839 GWh). Further presented is the current electricity sector’s hourly demand and supply over the whole year for 2014, showing the currently insufficient RE production to supply the electricity consumption.

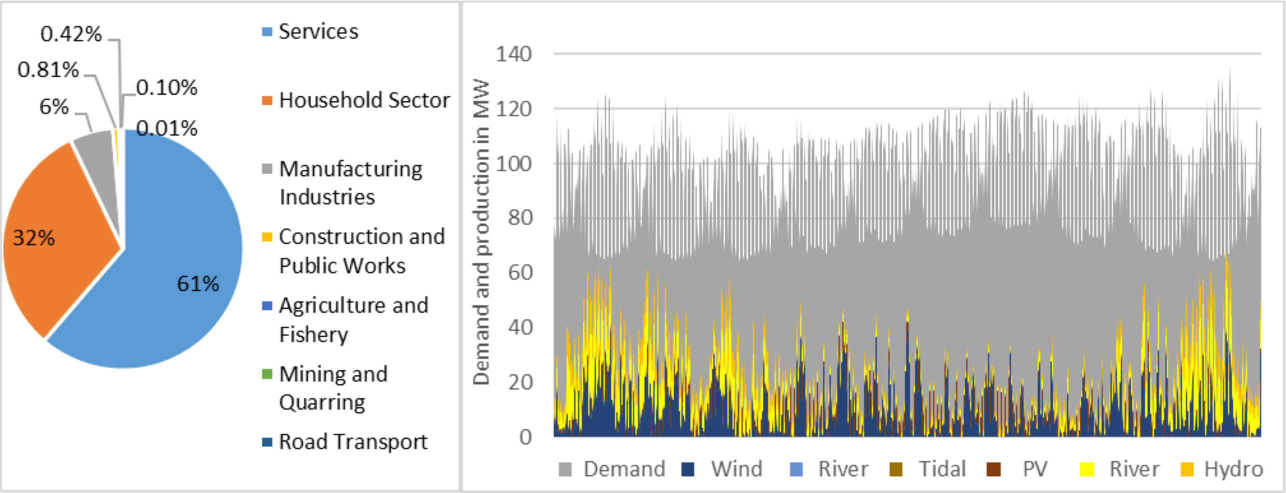


Figure 9: Electricity demand on Madeira by sectors, 2014 [15]

First, the currently limited utilization of the installed PV panels, which are not connected to the grid (so-called UPACs) is addressed with pilots 1 and 2, which address domestic and commercial UPAC owners respectively. As presented in WP4, UPAC PV installations are restricted in their ability to provide any excess electricity into the Madeira grid, which results in a comparably low total number of these RE installations even though the climate conditions are very appropriate for such in this region. With a successful pilot 1 and 2, this number might be increased and can be an important part of the future energy system of Madeira.

Out of the existing 36 private and 13 commercial UPAC installations, about half of them are studied to select the ones suitable for the pilots [D4.5]. Out of those, several have limited PV power or have a demand high enough that a BESS would not make any significant improvements. Table 5 shows the resulting selection to demonstrate how BESS can improve the energy system with already existing PV installations.

Table 5: Summary of the BESS to deploy in Madeira Island, and the respective installation sites [D4.5]

UPAC	Type	Contracted Power (kVA)	Installed PV Power (kWp)	Tariff	BESS Size
U06	Domestic	10.35	2.7	Single-rate	3 kW / 8.6 kWh Single-phase
U09		6.9	4.5	Single-rate	
U12		6.9	3	Dual-rate	
U2/U5/U10		10.35	1.5	Single-rate	
U8	Commercial	20.7	3.92	Single-rate	3 kW / 8.6 kWh Three-phase

For D8.2, these households and one business are modelled hourly over a year with the typical PV production data on Madeira and the BESS specifications from LiBAL. The electricity demand from these houses is represented as a relative share of the total hourly electricity consumption from the reference year [see D8.1]. Similar to the related SMILE publication on PV and battery combination, this model operates without regard to the overall system and is therefore developed externally before implementing the results into EnergyPLAN [2]. As presented in D8.1, EnergyPLAN simulates the different production and consumption sides aggregated, which requires external modelling of these pilots.

Figure 10 presents how this model looks before and after installation of the BESS. Before, according to the simulation, a majority of the PV production is lost and only 44% can be directly used without adjusting the hours of consumption. Any possible adjustments of consumption[1] due to PV availability are disregarded in this simulation. After the BESS addition to these selected houses, the usable share increases by another 34%-points, hence, 78% of the PV can now be utilized directly or within a few hours afterwards. While some of the remaining PV production might be lost due to conversion losses and dis-/charging efficiencies, the overall losses are reduced by 60%.

In total, pilots 1 and 2 can reduce the demand from the grid by 11.34 MWh annually in this model, especially in hours after sunset and in the summer. Figure 10 further shows the utilization of the various BESS combined to the total capacity of about 60 kWh of which 80% is made available for the simulation. This reduction, as well as the resulting new total demand distribution is used in the new EnergyPLAN scenario. What Figure 10 suggests is potentially a larger exploration of these pilots with similar BESS specifications, as the constellation and its results look promising.

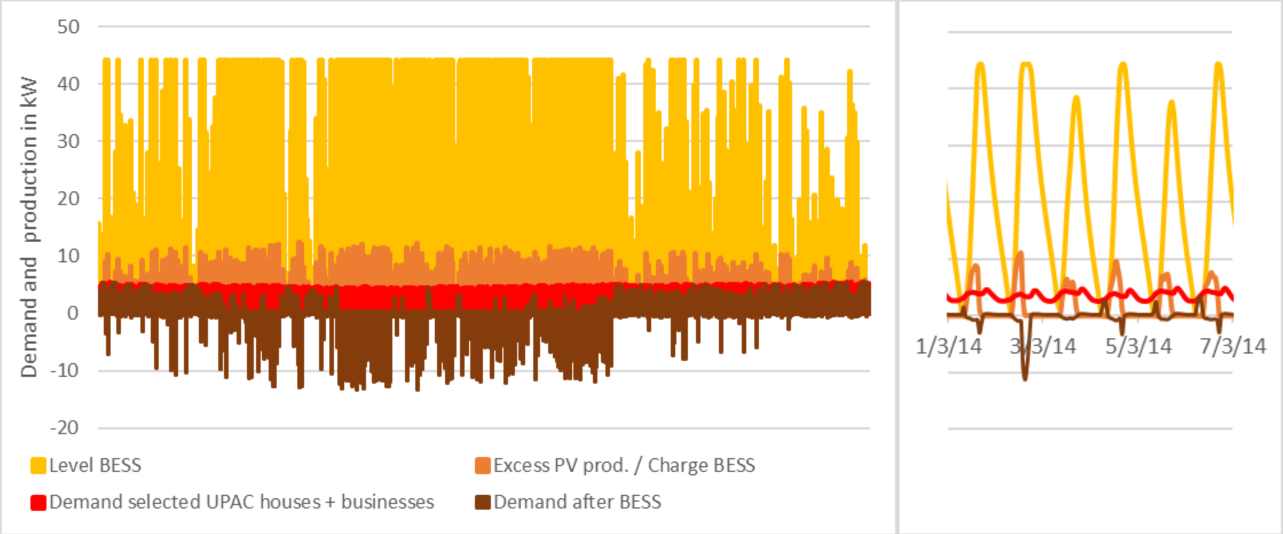


Figure 10: Electricity demand and production at selected households with BESS and PV (UPAC) for a whole year and a week in March

Secondly, pilot 3 and 4 address the electricity demand through EVs and the approach of 1) two local companies with various EVs and a sightseeing vehicle fleet[2], as well as 2) the EEM garage consisting of several charging points and EVs. For the SMILE scenario, the demand for electric transportation is expected to increase, of which 20% if assumed to be charging the EVs smartly. This results from the number of selected vehicles for the pilots in comparison to total number of EVs. The EV charging is simulated with a semi-flexible charging demand profile, as well as fixed capacities and shares of vehicles being able to charge at the same time.

The number of EVs is even considered to be reaching 1,000 in the short-term until 2022, hence, the demand would increase to 1.6 GWh annually for charging, while at the same time, the number of combustion vehicles is reduced. Out of this, 25% is assumed to be able to charge smartly by then, based on the SMILE demonstrations. At this moment, the effects on the energy system of Madeira do not show a clear advantage in the switch from combustion vehicles to EVs, because the replaced Diesel/Petrol will now be required as power plant fuel to produce the additionally needed electricity for the EVs. While the efficiency of EVs is better than combustion cars, the previous conversion from fuel oil to electricity in the power plants to a large extent counterbalances this advantage. This step would only be truly beneficial to the system when additional RE capacity is supplying more electricity for the EVs.

---

[1] E.g. moving large demands from night time to hours with sunshine/PV production

[2] 20 Renault Twizy + 6 Piaggio (Tukxi)

Finally, Madeira is presenting a final pilot 5 within the SMILE project, which also includes BESS and addresses the limits within PV electricity production. In a residential area of several PV installations, this BESS is supposed to stabilize the electricity grid, as sudden overcast can cause instability in the grid. Therefore, this pilot aims at improving the integration of UPP-PV installations, which are fully injecting into the island grid. An extra (6th) pilot is working similar to pilot 5 with the aim of improving the stability for the time of sunset and evening peaks, where a duck curve challenge can be observed [D4.5]. However, both pilot 5 and the extra pilot are addressing intra-hour problems or problems limited to a specific local area. Therefore, they play no role in the short- or medium-term scenarios that are looking at the hourly level and above[1].

Despite some of the limits and difficulties, the SMILE approaches in the currently planned scope (without upscaling and replicating the different demonstrations) would already cause reductions in the overall oil consumption (transport fuel), as well as reductions in the annual CO_2 emissions. These are reduced by about 122 t per year, due to the reduced electricity demands at UPAC houses and the replacement of transport fuel with electricity, which is produced at the PP, but partly with the more efficient natural gas as fuel.

Next in line to finalize the energy system scenario of Madeira for 2022, the plans and changes regarding RE capacity are implemented. Expected invested to be made in Madeira in the next few years are as follows[2]:

- 2018: Decommission of old hydro plant with 3.5 MW
- 2018: New PV capacity since 2014 of 50 kW
- 2019: New dammed hydro plant of 30 MW with 16.5 MW pump (1 million m^3 storage; 16 GWh)
- 2019: New wind capacity of 18 MW
- 2020: New PV capacity of 50 MW
- 2020: New battery of 15 MW and 10 MWh
- 2021: New dammed hydro plant of 4.4 MW with 1 MW pump

Despite the effort of moving towards RE electricity, the power plants are still highly utilized to supply the demands. As Figure 11 below points out, the largest share of the electricity demand must be met by something else than the now installed 63.1 MW wind, 69.1 MW PV, 23.2 MW run-of-river hydro and 58.4 MW dammed hydro power. In 2022, the electricity is supplied by 52% from power plants, while the RE combined present 48%. This may also be one of the reasons the 15 MW battery is not utilized as much as it could be, since the model would only store excess renewable energy and the fossil-fuelled and hydro productions already offer some flexibility.

---

[1] EnergyPLAN simulates hour-to-hour which leads to difficulties of spotting bottlenecks within the system

[2] Source: EEM

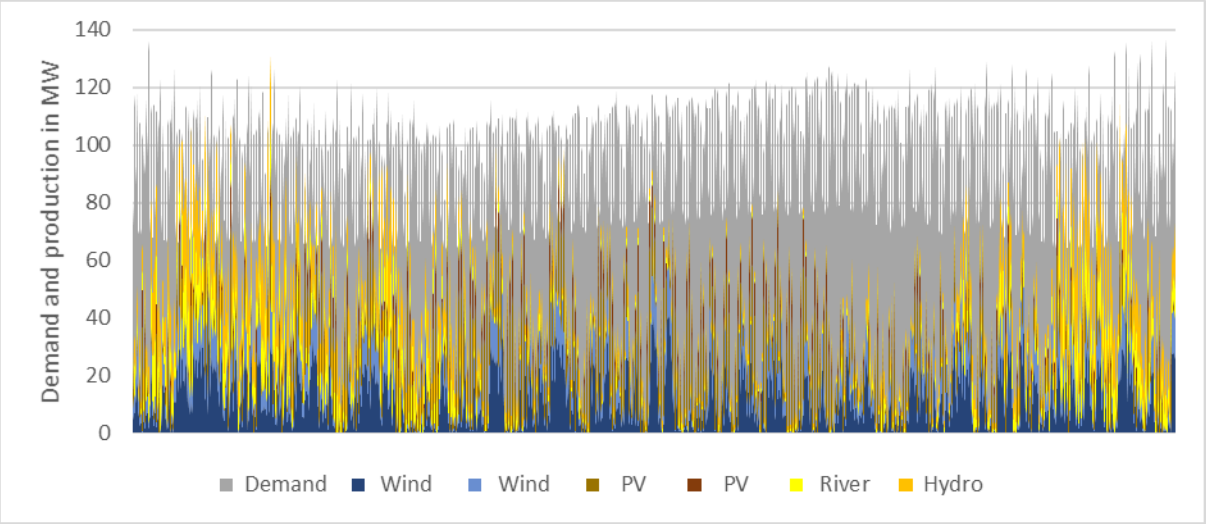


Figure 11: RE electricity production and total demand in 2022 on Madeira

While the electricity production now reaches 48% from RES, the total PES is supplied only with a share of 16%. This is due to the mainly fossil-fuelled heating and transport sectors as well as industrial fuels. The total amount of fossil fuels on Madeira would by 2022 be reduced by 11% compared to the reference model, but still amount to 3 TWh annually. Further details of the short-term scenario for Madeira can be found in Table 6.

3.4.2 Medium-term scenario 2030 for Madeira

The medium-term scenario for Madeira firstly incorporates the additionally planned RE capacities as follows:

- 2023: Decommission of Vitória power plant (167 MW out of 203 MW (EEM))
    - Not removed in the model, due to insufficient supply
- 2024: New wind capacity of 30 MW
- 2024: New hydro capacity of 30 MW with 27.5 MW pumps
- 2024: New PV capacity of 12.6 MW
- 2025: Decommission of Caniçal power plant (remaining 36 MW (Private))
- 2025: New geothermal capacity of 30 MW

Even though the power plants are planned to be decommissioned partly in 2023 (EEM's thermal power plant) and 2025 (Private power plant), this is not possible even with the extended RE capacities and the total RE production (585 GWh) in combination with the reference energy demand (840 GWh). Especially with the upcoming presentation of an EV uptake as well as the recommendation to install HPs instead of gas boilers, complementary to biomass heater or solar thermal production. Regarding the decommissioning of the power plants, they will remain in the energy system model, but a possible partly decommission can be discussed with the final scenario.

All additional RE capacity is modelled with efficiencies and production similar to the respective data in the reference model or with slightly improved capacity factors, representing probable production for the specific location of Madeira. For some of the new technologies, such as the new geothermal power plant, research influenced the modelling, such as expected efficiencies for this type of power plant being modelled at 12% [16].

Next to the new RE capacities, the transport sector can be addressed closer. After the introduction of EV for both commercial, touristic and private purposes with the addition of smart chargers, a further exploration can be assumed. Similar to Orkney, an exponential increase of EV by the year 2030 is modelled in the medium-term scenario. With a final electricity demand for EVs instead of combustion vehicles equalling 100,000 vehicles, about 50% of the transport can be covered. Further fuel options for this sector can be discussed for the time after 2030. Instead, the number of EVs can be modelled to include the option of V2G, reducing the production at the power plant by enabling EVs to be used as temporary electrical storages.

Eventually also the heating sector must be addressed. With the uncertainty of heating demand within the electricity consumption, improvements can only be modelled to a limited extent. A first logic step is the replacement of oil and natural gas for heating with HP. In the same step, more solar thermal could be explored to support this heat production and keep the electricity requirement to hours with insufficient natural heat resources. In total, the solar heat production is doubled from the reference to the medium-term scenario.

After the electricity demand is increased as a consequence of increased demands from EVs and HPs, new RE capacity is required. While the EV demand added 158 GWh to the total demand and HPs another 46 GWh, the power plant produced an additional 160 GWh. Therefore, a sensitivity study of additional RE capacity is made, resulting in the suggestion of 40 MW additional capacity for both wind and PV. Further capacity would result in critical excess electricity production at only minor system improvements.

The results of the additional capacities, as well as of the other assumed improvements – partly based on SMILE demonstrations – can be seen in Table 6. The RE-share reaches just above 30.6% while the share for the electricity production is at 73.5%. Adding RE capacity would increase both even further, but would at the same time result in critical excess electricity production, so the benefits would decrease. Therefore, a more balanced approach towards the 100% RE share is required in the longer term.

3.4.3 Overview and discussion for Madeira

Table 6 presents the results of both the reference model of Madeira, as well as the short- and medium-term scenarios. These are further illustrated with the corresponding Sankey diagrams in Figure 12 and Figure 13 depicting the final demands and results in one graph including all scenarios. Appendix 7.3 presents the final overview of inputs and outputs from the EnergyPLAN models.

Table 6: The annual energy supply and demands on Madeira – reference, short- and medium-term

		2014 Reference	2022 SMILE (BESS, EV), PV, hydro wind	2030 RES, EV, HP
	Supply (GWh)			
▨	Wind onshore	85.9	**141.9**	**311.5**
▨	PV	25.0	**98.8**	**214.0**
▨	Hydro	95.3	**132.9**	**151.4**
▨	Geothermal	0	0	**31.6**
▨	Waste incineration	32.9	32.9	32.9
🟧	Solar collectors, indv.	22.3	22.3	**38.8**
🟨	Biomass	32.4	32.4	32.4
🟫	Oils	2910.4	**2582.7**	**1791.7**
🟫	Gas (natural), LPG	503.3	**438.9**	**232.0**
	Total PES	3848.1	**3623.3**	**2953.3**
	Demand (GWh)			
▨	Electricity for heating	N/A[1]	N/A	N/A **+46.3**
▨	Electricity for transport	0.1	**1.6**	**160.0**

---

[1] Data not available, but large heating and cooling demands expected within the electricity sector

⬜	Electricity for electrolyser	0	0	0
🟧	Biomass for indv. boilers	32.4	32.4	**8.79**
🟧	Oil for indv. boilers	0.1	0.1	**0**
🟧	Gas for indv. heating	154.3	154.3	**0**
🟨	Oil for power plant	1219.1	**896.6**	**633.7**
🟨	Gas for power plant	243.8	**179.3**	**126.7**
🟥	Oil for industry	180.4	180.4	180.4
🟥	Gas for industry	104.7	104.7	104.7
🟩	Diesel for cars	877.9	**876.8**	**716.8**
🟩	Petrol for cars	372.1	**368.0**	**0**
🟩	LPG for cars	0.5	0.5	0.5
🟩	Hydrogen for cars	0	0	0
🟩	Jet fuel for airplanes	260.8	260.8	260.8
	Results/System indicators			
	RES share of PES (incl. waste)	10.5%	**15.7%**[1]	**30.6%**
	RES share of electricity prod.	28.5%	**48.4%**	**73.6%**
	CO_2 emissions on island	894.5 kt	**794.1 kt**	**541.1 kt**
	Electric heating share	N/A	N/A	N/A+ **60.5%**
	Bio heating share	12.3%	12.3%	12.3%
	Solar heating share	11.6%	11.6%	**23.2%**
	Electric transport share (no H2)	0.1%	**0.4%**	**42.6%**
	Bio transport share	0%	0%	**0%**
	Total system costs	315.7 M€	**296.7 M€**	**251.2 M€**

The data from Table 6 is depicted in Figure 12 through Sankey diagrams, showing the energy flows of the three scenarios. The major change that can be noted is the reduction in fossil fuels, mainly oils from 2014 to 2030. Instead, electricity is produced more from RES, but further optimization should be found for the remaining oil and gas consumption.

As it could be tested for Samsø and expanded on Orkney, Hydrogen production through electrolyzer could become relevant for the replacement of fossil fuels in the transport sector. Alternatively, biogas production could be strived for. With respect to the second technology, the local biomass potential – both dry and wet biomass – should be evaluated, before it can be included in the model.

Besides the above suggested additional RE capacity of wind and PV, the potential for further hydro power plants or even offshore energy could be exploited. For this, another evaluation of potential areas is required before it can be further discussed for a long-term scenario.

---

[1] Not including the small UPAC production, since their demand is also not part of model; would increase the share only slightly

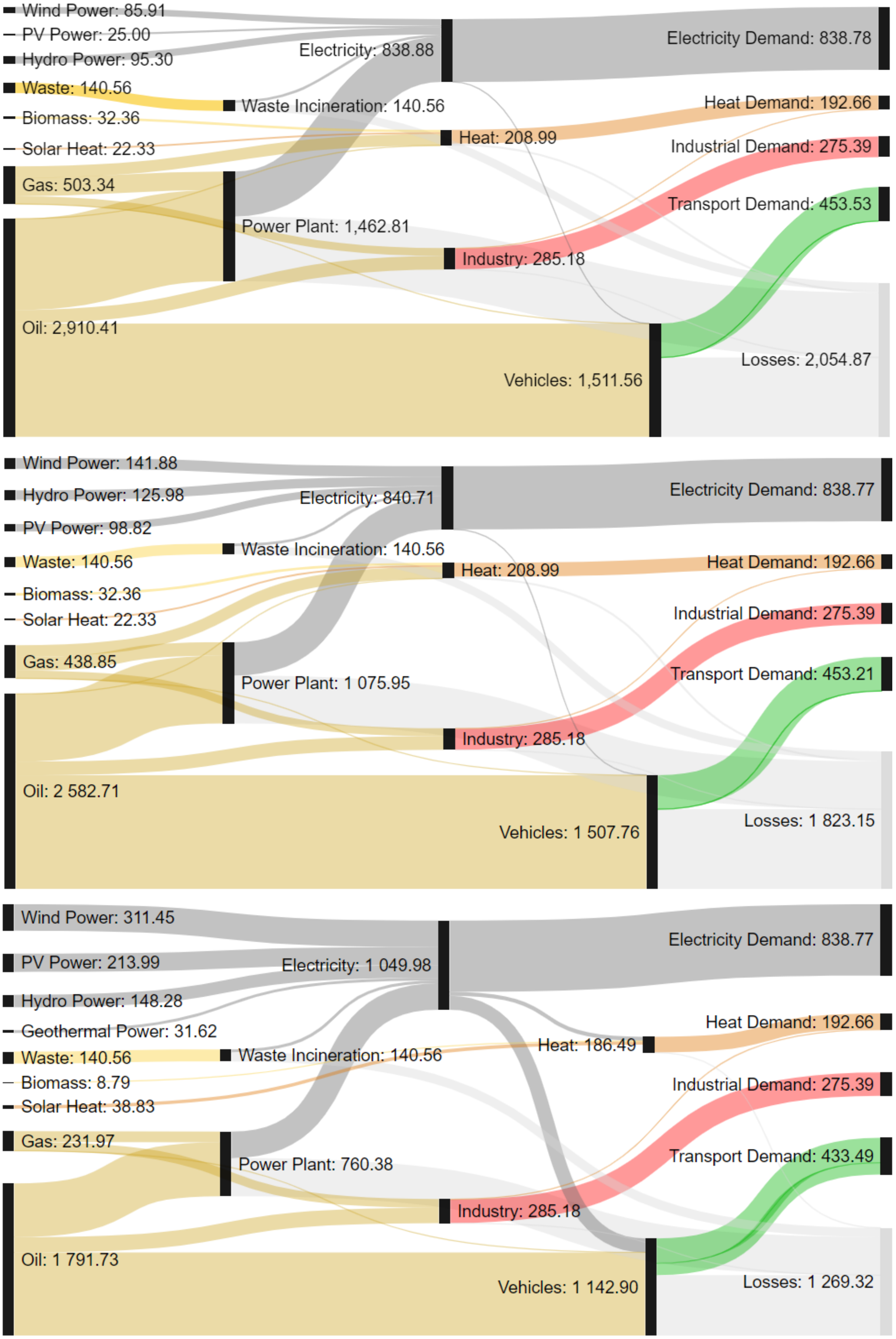


Figure 12: Sankey diagrams of Madeira 2014, 2022 and 2030

The final point of discussion relates to the heating sector optimization, since – also here – improvements are required for the overall development of the Madeira energy system towards 100% RE. The actual heating demands within the electricity sector can provide relevant information for possible improvements. If inefficient boilers and heaters are used, a replacement with efficient HPs or even the establishment of DH could improve the energy system. Besides the uncertainties in the heating sector, the demands for cooling could be evaluated and improved. With the possibility of district cooling, the service sector of Madeira could achieve benefits through better suitable technologies and supply of the demands.

The final illustration in Figure 13 for Madeira shows the different scenarios in the short and medium term. Especially the changes presented until 2030 decrease the fuel consumption and CO_2 emissions with a minor increase in total electricity demand, similar to the Samsø and Orkney scenarios.

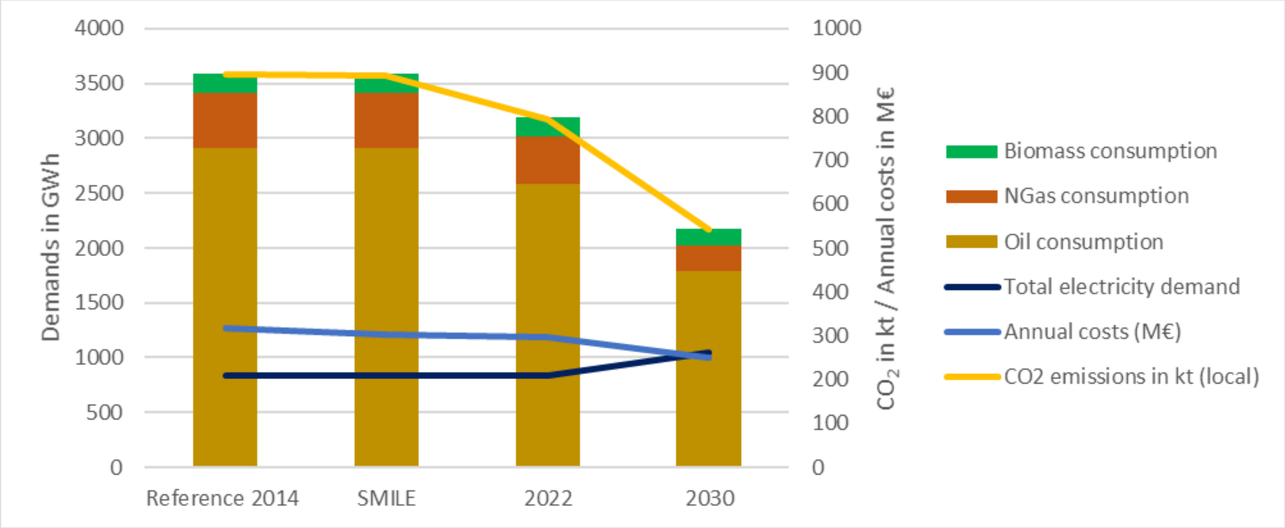


Figure 13: Scenario comparison of demands and resulting CO_2 emission and costs for Madeira

4 Demonstrator Comparison and Discussion

This section presents an overview of the different scenarios and resulting island energy systems' characteristics. It can be used to review the different changes between the reference year, 2022 and 2030 and their results. The overview can help see the short- and medium-term changes with its impacts and can give information also to the other demonstrator islands. Even though the three islands are of different size and population, some similarities in regards to their energy systems can be made out. For example, the RE electricity production capacity are rather similar despite the large differences in demands. By presenting the different RE capacities and their impacts, possible gaps or potentials in the plans and models of the other islands can be found and help shape the future creation of the energy systems.

Table 7 present the energy demands by sectors for Samsø, Orkney and Madeira with the reference, short- and medium-term scenario. Here, only the electricity demand seems to change, which is mostly due to more electricity in the heating or the transport sector. The other sectors, however, but also the electricity one, are improved within, while the total demands stay the same. As explained in Chapter 3, some general possible changes in the demand due to demography or efficiency measures are excluded, even though they could interfere with these. The changes that are made within the main sectors of electricity and heat production are presented in the tables afterwards, along with the overall fuel consumption.

Table 7: Comparison of energy demands

Annual reference data	**Samsø**			**Orkney**			**Madeira**		
	2015	**2022**	**2030**	**2014**	**2022**	**2030**	**2014**	**2022**	**2030**
Electricity Demand (GWh)	25.5	28.6	41.8	154.7	157.7	195.0	838.8	840.4	1050
Heat Demand (GWh)	51.9	51.9	51.9	123.5	123.5	123.5	192.7	192.7	192.7
Cooling Demand (GWh)	-	-	-	-	-	-	N/A	N/A	N/A
Transport Demand (GWh)	30.0	29.9	28.9	103.9	103.7	99.7	453.5	453.2	433.8
Industry Demand (GWh)	0.4	0.4	0.4	189.4	189.4	189.4	275.4	275.4	275.4

In D8.1 in the corresponding table to Table 7, also the cooling demand is listed, as it presents an important part of the energy system, especially for Madeira. Similarly to the heating demand, this is currently obscured within the electricity consumption data while no detailed data is available and hence an optimization neglected for now. This could be a relevant contribution in future energy scenarios and might even find potential on the industrial sites on Samsø and Orkney.

Table 8 shows the different approaches for the demonstrator islands in regard of added RE capacity and resulting RE production. Despite the plans of decommissioning the power plants on Madeira, as well as lifting the dependence on the power plant on Orkney, the energy system analysis shows the still required power to be supplied from there under the modelled circumstances.

Table 8: Comparison of electricity production

Annual reference data	**Samsø**			**Orkney**			**Madeira**		
	2015	**2022**	**2030**	**2014**	**2022**	**2030**	**2014**	**2022**	**2030**
Power plant capacity (MW)	-	-	-	10.5	10.5	*10.5*	203.0	203.0	*203.0*
Power plant power supply	-	-	-	41.9	37.1	16.0	599.7	441.1	311.8
Wind power capacity (MW)	34.4	34.4	34.4	48.3	52.8	52.8	45.1	63.1	133.1
Wind power supply (GWh)	108.4	108.5	108.5	149.7	163.6	163.6	85.9	141.9	311.5
PV capacity (MW)	1.3	1.5	11.5	1.2	1.5	11.5	19.1	69.1	121.7
PV power supply (GWh)	3.1	3.4	26.9	1.2	1.4	10.6	25.0	98.8	214.0
Tidal, Wave capacity (MW)	-	-	-	-	9.0	19.0	-	-	-
Tidal, Wave supply (GWh)	-	-	-	-	10.2	47.1	-	-	-
Geothermal capacity (MW)	-	-	-	-	-	-	-	-	30.0

Geothermal supply (GWh)	-	-	-	-	-	-	-	-	31.6
Hydro power capacity (MW)	-	-	-	-	-	-	50.7	81.7	111.6
Hydro power supply (GWh)	-	-	-	-	-	-	95.3	132.9	151.4
Waste incineration (GWh)	-	-	-	-	-	-	32.9	32.9	32.9
Transmission capacity (MW)	40	40	40	40	40	40	-	-	-

Table 9 shows the shifts of fuel within the heating sector and

Table 10 present the resulting fuel demands, partly resulting from the changes in the heating sector, but also from the transport upgrades and power plant reliance. Since the fossil fuel reduction was paid special attention to in order to increase the RE share in the energy systems, they are included in the last rows of

Table 10. It shows that the fossil fuel consumption on Samsø is reduced by 68% between 2015 and 2030 with the presented scenarios. Similarly, on Orkney, this number is reduced by 34% and on Madeira by 40%.

Table 9: Comparison of heat production

Annual reference data	**Samsø**			**Orkney**			**Madeira**		
	2015	**2022**	**2030**	**2014**	**2022**	**2030**	**2014**	**2022**	**2030**
Heat production DH	35%	35%	35%	0%	0%	19%	0%	0%	0%
Heat from oil (GWh)	10.0	9.5	-	60.2	60.2	-	0.1	0.1	-
Heat from biomass (GWh)	50.3	42.1	28.9	1.4	1.6	57.5	22.7	22.7	6.2
Heat from gas (GWh)	-	-	-	1.2	1.2	-	138.9	138.9	-
Heat from electricity (GWh)	5.9	14.9	32.6	54.1	54.6	71.7	-	-	138.9
Heat from coal (GWh)	-	-	-	6.0	6.0	-	-	-	-
Heat from solar (GWh)	1.4	1.4	1.4	0.1	0.1	0.1	22.3	22.3	38.8
Total heat production (GWh)	51.9	51.9	51.9	123.5	123.5	123.5	192.7	192.7	192.7

Table 10: Comparison of fuel consumption

Annual reference data	**Samsø**			**Orkney**			**Madeira**		
	2015	**2022**	**2030**	**2014**	**2022**	**2030**	**2014**	**2022**	**2030**
Oil consumption (GWh)	89.0	83.5	36.0	598.8	592.6	425.6	2910	2583	-
Biomass consumption (GWh)	52.2	73.3	74.2	2.0	2.0	69.1	172.9	172.9	149.4
Gas consumption (GWh)	23.4	0.4	0.4	94.5	83.8	35.5	503.3	438.9	232.0
Coal consumption (GWh)	-	-	-	21.1	21.1	12.6	-	-	-
Total fossil fuels (GWh)	112.4	83.9	36.4	714.4	698.0	473.7	3414	3022	2023
Total consumption (GWh)	164.6	157.2	110.6	716.4	700.0	542.8	3586	3195	2173

Finally, Table 11 presents the overall energy system indicators for the demonstrator islands, including RES shares, electricity exchange and resulting emissions as well as costs. These are shortly discussed below.

Table 11: Comparison of energy system indicators

Annual reference data	**Samsø**			**Orkney**			**Madeira**		
	2015	**2022**	**2030**	**2014**	**2022**	**2030**	**2014**	**2022**	**2030**
RES share of PES	60%	69%	85%	18%	20%	38%	11%	16%	31%
RES share of electricity prod.	437%	391%	324%	98%	123%	123%	29%	47%	71%
Imported electricity (GWh)	1.5	1.5	1.8	10.8	7.9	3.8	-	-	-
Exported electricity (GWh)	87.5	84.8	93.4	48.9	62.6	46.0	-	-	-
CO_2 emissions on island (kt)	28.5	22.3	9.7	186.0	182.2	124.9	894.5	794.2	541.1
Total system costs (M€)	16.5	17.0	15.6	57.7	61.7	59.6	315.7	296.7	251.2

In Table 11, the comparison of the RES share shows generally great improvements with increases of 20% points and more. However, for Orkney and Madeira is still a long way to the large-scale and high RE target of

100%, despite the ambitious scenarios to improve the energy systems presented in this report. This can partly be explained by the more balanced approached taken in the scenario creation, rather than a simple increase in RE capacities, which would increase the RES share, but also the export and potential curtailment/critical excess production. Instead, more moderate capacity additions are introduced together with balancing options, such as smart charging and storage options.

Further targets for island energy systems are the limitation of both import and export to increase the share of local energy consumption and self-sufficiency. While Samsø's share of renewable electricity is very large and the suggested additional capacity increases this slightly, the share of the local electricity that is exported is still lower (see Table 2). The same it can be said about Orkney, while the island furthermore reduces their import share from 7% to 2% of the electricity demand. Finally, on Madeira, it is possible to keep the critical excess production at 0.02%.

Similarly, the CO_2 emissions are reduced with the increase of RE and decrease of fuel combustion. On Samsø, the reduction is 66%, 33% on Orkney and 40% on Madeira, being in line with the phase they are currently modelled in, as presented in Table 1 with the definition of RE integration phases. The final CO_2 emissions are equal to about 2.6 t, 5.7 t and 2.2 t per capita for Samsø, Orkney and Madeira respectively. The high amount for Orkney might relate to the big industrial sector and limited biomass potential.

And finally, the last row of Table 11 shows the tendencies for annual total system costs with current data on technologies, fuels, operation and CO_2 costs. For each of the islands Samsø, Orkney and Madeira, the annual costs are similar or even decreased in the medium term – compared to the references – by -5%, +3% and -20%.

5 Conclusions

For the SMILE project, this report present D8.2 resulting from the corresponding Task 8.2 of establishing and simulating short- and medium-term high-RE scenarios for the three pilot islands. Build upon D8.1, where the reference energy systems of 2014/2015 were created through cooperation with the SMILE partners, D8.2 is incorporating the SMILE demonstration projects for each island, as well as changes in the energy system to present possible future energy system scenarios. Therefore, the current state and reports of the demonstrators' work influenced the results, as well as local plans and strategies for the upcoming years.
The result is the presentation of the SMILE impacts on the three island energy systems, as well as short-term scenario of the year 2022 and a medium-term scenario of 2030. For this, the general approach of targeting an energy system of high RE-share is presented as a three-step approach, of which Samsø is at the farthest step while Orkney and Madeira are in the second step towards high RE systems.

Therefore, Samsø's energy system is moving from the reference system with already 60% RE share towards a system with 100%, resulting in the incorporation of technologies focusing at balancing the energy system instead of increasing RE capacity. Within the medium-term timeframe, the RE share is presented to reach 85% with possibilities of further improvements. As part of both scenarios, the SMILE approach directs the energy system of Samsø in the right direction with the addition of PV, HP and BESS, but represents only a minor step of what is required to reach high RE shares. While the application for the SMILE demonstration is somewhat limited due to the specific application at marinas, the combination of PV and BESS, as well as electrifying heat during hours of RE production can generally be replicated and thereby improve the energy system from various consumption sides.

Orkney's energy system of 2014 consists of 18% RE in the PES, hence, the increase of this share was in focus instead of balancing the energy production and demands. Incorporating the marine energy production facilities and additional RE capacity, next to improvements in the heating and transport sector raised this share to 38%. More RE capacity could benefit the energy system further, which should be further discussed in the development of the future Orkney energy system. Additionally focusing more on the heating sector, as well as improving the transport sector, as is suggested with the local SMILE demonstration, can aid this future development in Orkney. In combination with the consideration of managing the industrial load(s) in a smart way, various demands, which are currently still fossil-fuelled, can make the switch to a renewable alternative. As D8.2 showed, more potential RE capacity would be required as well as the potential further exploration of BESS to support this fragile energy system.

Also Madeira is in the process of introducing more RE to their energy system and aiming at an increase of its share, while targeting the 100% RE goal also in the long term. With an initial RE share in 2014 of 11%, Madeira's medium-term development focuses at the expansion of various RE capacity. Taking into further consideration the SMILE project, as well as potentials in the transport and heating sector, the RE share by 2030 can reach 31% with the suggested technologies under these specific circumstances. The importance of the SMILE project was shown in the various demonstrations implemented in the energy system scenarios. Approaching not only the electricity consumers, but also the private PV owners and taking smart transportation options into account addresses many critical points in the energy system of Madeira. The combination with BESS in various alternatives plays another major part in an autonomous energy system, such as Madeira.

D8.2 presented scenarios of Samsø, Orkney and Madeira as evaluated with the current data on the islands and general technologies available, as well as influenced by SMILE demonstrations projects. The SMILE scenarios of 2022 and 2030 have shown that more of these smart technologies could be required to help the islands reach higher RE shares and secure their energy systems. Hence, the scenarios can always be improved with further re-evaluation of the presented scenarios and taking other options into account. Further cooperation between the SMILE partners and discussions based on this report could therefore benefit the development of the demonstrator islands and secure long-term sustainable growth.

6 Bibliography

[1] H. Lund, *Renewable Energy Systems A Smart Energy Systems Approach to Second Edition*. 2014.

[2] H. M. Marczinkowski and P. A. Østergaard, “Residential versus communal combination of photovoltaic and battery in smart energy systems,” *Energy*, vol. 152, pp. 466–475, Jun. 2018.

[3] Samso Energy Academy, “Samsø Energy Academy,” *Vedvarende Energi-Ø*. [Online]. Available: https://energiakademiet.dk/vedvarende-energi-o/. [Accessed: 20-Oct-2017].

[4] Planenergi, “Samsø 3.0,” 2017.

[5] OREF, “Orkney Electric Vehicle Strategy 2018-2023,” pp. 1–57, 2018.

[6] Department for Business Energy & Industrial Strategy, “UK statistics on renewable electricity,” 2018. [Online]. Available: https://www.gov.uk/government/statistics/regional-renewable-statistics. [Accessed: 23-Nov-2017].

[7] Community Energy Scotland, “Deliverable D2.1 Schematic and technical description of Orkney DSM system architecture,” 2017.

[8] Community Energy Scotland, “Surf ‘n’ Turf web page,” 2018. [Online]. Available: http://www.surfnturf.org.uk/page/introduction.

[9] G. Zhao, E. R. Nielsen, E. Troncoso, K. Hyde, J. S. Romeo, and M. Diderich, “Life cycle cost analysis: A case study of hydrogen energy application on the Orkney Islands,” *International Journal of Hydrogen Energy*. 2018.

[10] Community Energy Scotland, “Orkney - Wide Energy Audit 2014,” 2015.

[11] FuelCellsWorks, “BIG HIT (Building Innovative Green Hydrogen systems in an Isolated Territory),” 2018. [Online]. Available: https://fuelcellsworks.com/news/big-hit-building-innovative-green-hydrogen-systems-in-an-isolated-territory-celebrates-official-ha.

[12] H. Lund and W. Kempton, “Integration of renewable energy into the transport and electricity sectors through V2G,” *Energy Policy*, vol. 36, no. 9, pp. 3578–3587, 2008.

[13] The Scottish Government, “Scotland Heat Map,” 2017. [Online]. Available: http://heatmap.scotland.gov.uk/. [Accessed: 29-Nov-2017].

[14] Brian Vad Mathiesen et al, “Heat Roadmap Europe: A low-carbon heating and cooling strategy for Europe,” *Resources and Results*, 2018. [Online]. Available: http://heatroadmap.eu/.

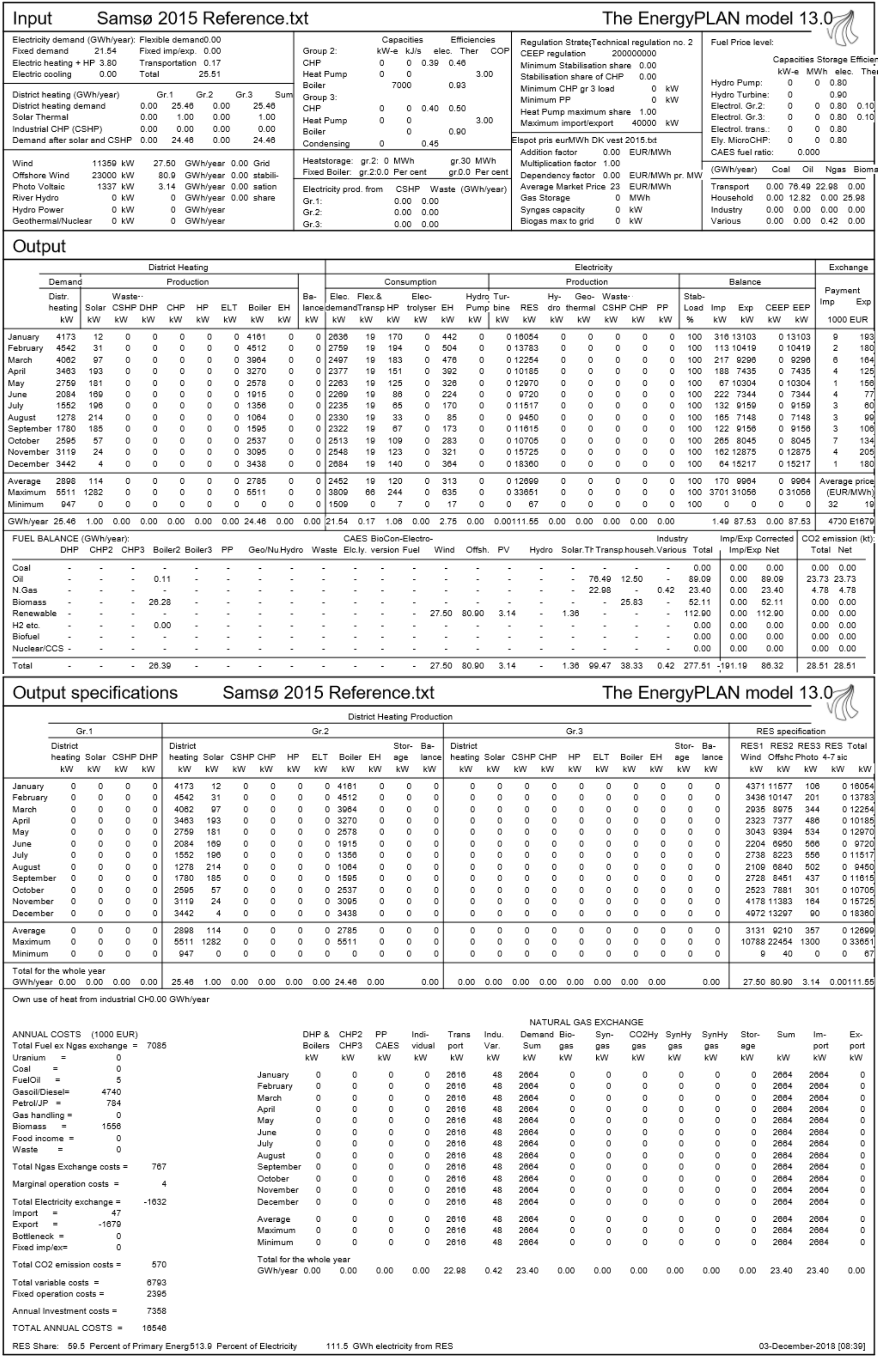
[15] Miguel Martins, “Energy balance of RAM (Autonomous Region of Madeira).” Governo Regional da Madeira, 2017.

[16] S. J. Zarrouk and H. Moon, “Efficiency of geothermal power plants: A worldwide review,” *Geothermics*, vol. 51, pp. 142–153, 2014.

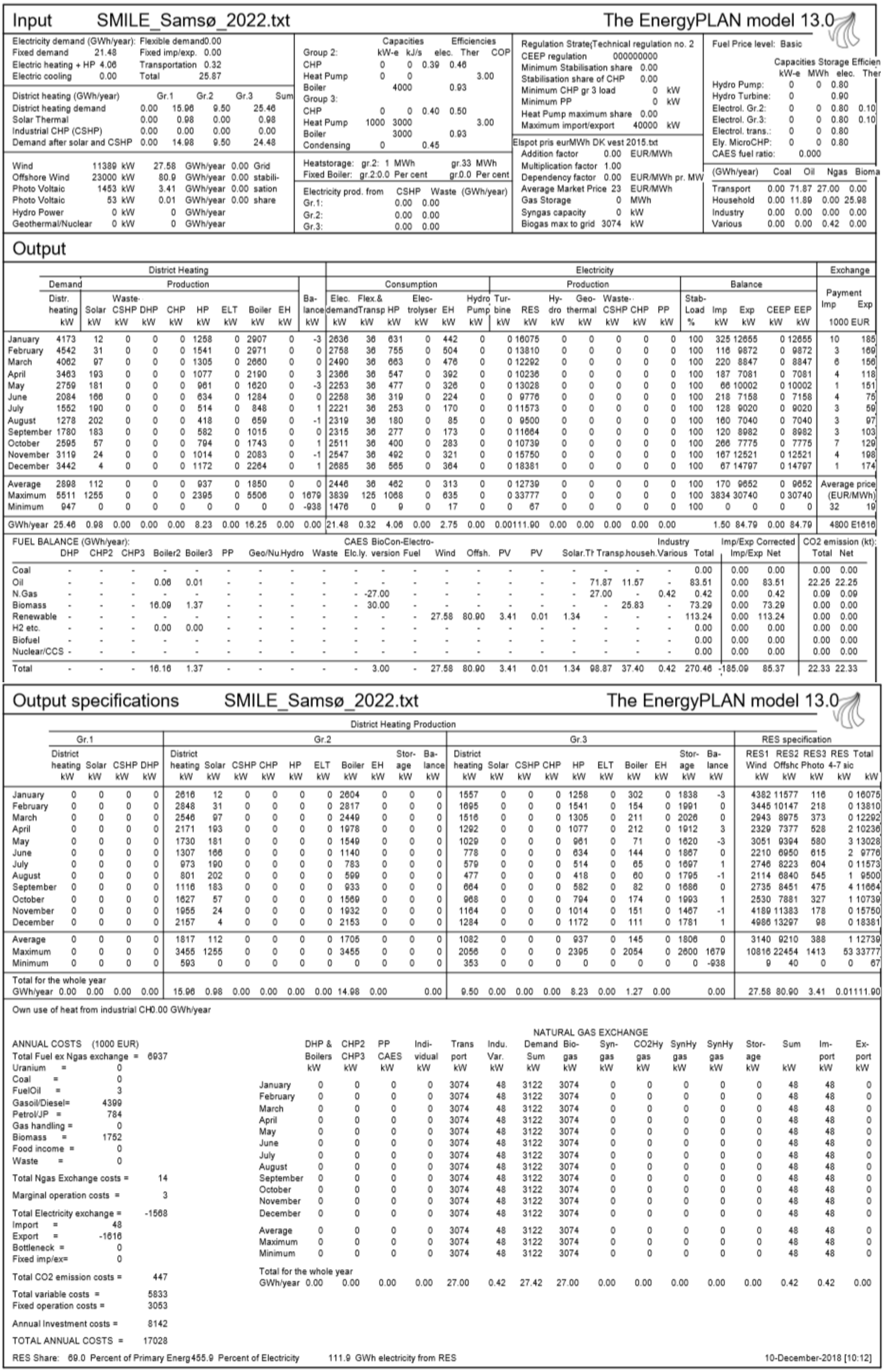
7 Appendix

Here, the data sheets of the EnergyPLAN simulations can be found, as created through the tool. While the reference models of Samsø (2015), Orkney and Madeira (2014) are also included in D8.1, the following presents them with updated cost data and included minor modifications. Being followed by the data sheets for the short- and medium-term scenarios of 2022 and 2030 for each of the demonstrator islands, a comparison can made between all three major scenarios. On the sheets, all inputs and outputs specifications of the EnergyPLAN model are presented, including demands, productions, fuel use and costs.

7.1 Samsø EnergyPLAN data sheets for the 2015, 2022 and 2030 scenarios



```
Input        Samsø 2015 Reference.txt                                   The EnergyPLAN model 13.0

Electricity demand (GWh/year): Flexible demand0.00
Fixed demand           21.54   Fixed imp/exp.   0.00
Electric heating + HP  3.80    Transportation   0.17
Electric cooling       0.00    Total           25.51

District heating (GWh/year)         Gr.1     Gr.2     Gr.3      Sum
District heating demand             0.00    25.46     0.00    25.46
Solar Thermal                       0.00     1.00     0.00     1.00
Industrial CHP (CSHP)               0.00     0.00     0.00     0.00
Demand after solar and CSHP         0.00    24.46     0.00    24.46

Wind                 11359  kW     27.50  GWh/year  0.00  Grid
Offshore Wind        23000  kW     80.9   GWh/year  0.00  stabili-
Photo Voltaic         1337  kW      3.14  GWh/year  0.00  sation
River Hydro              0  kW      0     GWh/year  0.00  share
Hydro Power              0  kW      0     GWh/year
Geothermal/Nuclear       0  kW      0     GWh/year

                   Capacities      Efficiencies
Group 2:           kW-e   kJ/s    elec.  Ther   COP
CHP                  0      0     0.39   0.46
Heat Pump            0      0                   3.00
Boiler                   7000            0.93
Group 3:
CHP                  0      0     0.40   0.50
Heat Pump            0      0                   3.00
Boiler                      0            0.90
Condensing           0            0.45

Heatstorage:   gr.2:  0  MWh          gr.30  MWh
Fixed Boiler:  gr.2:0.0  Per cent     gr.0.0  Per cent

Electricity prod. from     CSHP    Waste  (GWh/year)
Gr.1:                      0.00    0.00
Gr.2:                      0.00    0.00
Gr.3:                      0.00    0.00

Regulation Strate(Technical regulation no. 2
CEEP regulation            200000000
Minimum Stabilisation share    0.00
Stabilisation share of CHP     0.00
Minimum CHP gr 3 load             0    kW
Minimum PP                        0    kW
Heat Pump maximum share        1.00
Maximum import/export         40000    kW

Elspot pris eurMWh DK vest 2015.txt
Addition factor          0.00   EUR/MWh
Multiplication factor    1.00
Dependency factor        0.00   EUR/MWh pr. MW
Average Market Price     23     EUR/MWh
Gas Storage                0    MWh
Syngas capacity            0    kW
Biogas max to grid         0    kW

Fuel Price level:

                     Capacities Storage Efficier
                     kW-e    MWh    elec.  Ther
Hydro Pump:            0      0     0.80
Hydro Turbine:         0            0.90
Electrol. Gr.2:        0      0     0.80   0.10
Electrol. Gr.3:        0      0     0.80   0.10
Electrol. trans.:      0      0     0.80
Ely. MicroCHP:         0      0     0.80
CAES fuel ratio:          0.000

(GWh/year)      Coal     Oil    Ngas   Bioma
Transport       0.00   76.49   22.98    0.00
Household       0.00   12.82    0.00   25.98
Industry        0.00    0.00    0.00    0.00
Various         0.00    0.00    0.42    0.00

Output

                              District Heating
           Demand                     Production
           Distr.        Waste-·                                           Ba-
           heating Solar CSHP DHP  CHP   HP   ELT  Boiler  EH              lance
           kW      kW    kW   kW   kW    kW   kW   kW      kW              kW

January     4173    12    0    0    0     0    0   4161     0               0
February    4542    31    0    0    0     0    0   4512     0               0
March       4062    97    0    0    0     0    0   3964     0               0
April       3463   193    0    0    0     0    0   3270     0               0
May         2759   181    0    0    0     0    0   2578     0               0
June        2084   169    0    0    0     0    0   1915     0               0
July        1552   196    0    0    0     0    0   1356     0               0
August      1278   214    0    0    0     0    0   1064     0               0
September   1780   185    0    0    0     0    0   1595     0               0
October     2595    57    0    0    0     0    0   2537     0               0
November    3119    24    0    0    0     0    0   3095     0               0
December    3442     4    0    0    0     0    0   3438     0               0

Average     2898   114    0    0    0     0    0   2785     0               0
Maximum     5511  1282    0    0    0     0    0   5511     0               0
Minimum      947     0    0    0    0     0    0      0     0               0

GWh/year   25.46  1.00 0.00 0.00 0.00  0.00 0.00  24.46  0.00            0.00

                                              Electricity
           Consumption                              Production
           Elec.  Flex.&        Elec-         Hydro Tur-         Hy-  Geo-    Waste-·
           demand Transp HP     trolyser EH   Pump  bine  RES    dro  thermal CSHP CHP  PP
           kW     kW     kW     kW       kW   kW    kW    kW     kW   kW      kW   kW   kW

January    2636   19     170    0        442  0     0  16054     0    0       0    0    0
February   2759   19     194    0        504  0     0  13783     0    0       0    0    0
March      2497   19     183    0        476  0     0  12254     0    0       0    0    0
April      2377   19     151    0        392  0     0  10185     0    0       0    0    0
May        2263   19     125    0        326  0     0  12970     0    0       0    0    0
June       2269   19      86    0        224  0     0   9720     0    0       0    0    0
July       2235   19      65    0        170  0     0  11517     0    0       0    0    0
August     2330   19      33    0         85  0     0   9450     0    0       0    0    0
September  2322   19      67    0        173  0     0  11615     0    0       0    0    0
October    2513   19     109    0        283  0     0  10705     0    0       0    0    0
November   2548   19     123    0        321  0     0  15725     0    0       0    0    0
December   2684   19     140    0        364  0     0  18360     0    0       0    0    0

Average    2452   19     120    0        313  0     0  12699     0    0       0    0    0
Maximum    3809   66     244    0        635  0     0  33651     0    0       0    0    0
Minimum    1509    0       7    0         17  0     0     67     0    0       0    0    0

GWh/year  21.54  0.17   1.06  0.00      2.75 0.00  0.00111.55  0.00 0.00    0.00 0.00 0.00

                    Balance                              Exchange
           Stab-                                         Payment
           Load   Imp     Exp     CEEP    EEP            Imp      Exp
           %      kW      kW      kW      kW             1000 EUR

January    100     316   13103     0    13103             9      193
February   100     113   10419     0    10419             2      180
March      100     217    9296     0     9296             6      164
April      100     188    7435     0     7435             4      125
May        100      67   10304     0    10304             1      156
June       100     222    7344     0     7344             4       77
July       100     132    9159     0     9159             3       60
August     100     165    7148     0     7148             3       99
September  100     122    9156     0     9156             3      106
October    100     265    8045     0     8045             7      134
November   100     162   12875     0    12875             4      205
December   100      64   15217     0    15217             1      180

Average    100     170    9964     0     9964         Average price
Maximum    100    3701   31056     0    31056          (EUR/MWh)
Minimum    100       0       0     0        0            32       19

GWh/year          1.49   87.53  0.00    87.53             4700 E1679

FUEL BALANCE (GWh/year):                                                  CAES BioCon-Electro-
              DHP   CHP2  CHP3  Boiler2 Boiler3  PP   Geo/Nu.Hydro  Waste Elc.ly. version Fuel

Coal           -     -     -      -       -      -      -      -      -      -      -      -
Oil            -     -     -     0.11     -      -      -      -      -      -      -      -
N.Gas          -     -     -      -       -      -      -      -      -      -      -      -
Biomass        -     -     -    26.28     -      -      -      -      -      -      -      -
Renewable      -     -     -      -       -      -      -      -      -      -      -      -
H2 etc.        -     -     -     0.00     -      -      -      -      -      -      -      -
Biofuel        -     -     -      -       -      -      -      -      -      -      -      -
Nuclear/CCS    -     -     -      -       -      -      -      -      -      -      -      -

Total          -     -     -    26.39     -      -      -      -      -      -      -      -

                                                                Industry             Imp/Exp Corrected   CO2 emission (kt):
              Wind   Offsh.  PV    Hydro  Solar.Th Transp.househ.Various  Total    Imp/Exp   Net         Total   Net

Coal           -      -      -      -      -        -       -       -       0.00     0.00     0.00        0.00    0.00
Oil            -      -      -      -      -      76.49   12.50     -      89.09     0.00    89.09       23.73   23.73
N.Gas          -      -      -      -      -      22.98     -      0.42    23.40     0.00    23.40        4.78    4.78
Biomass        -      -      -      -      -        -     25.83     -      52.11     0.00    52.11        0.00    0.00
Renewable    27.50  80.90   3.14    -     1.36      -       -       -     112.90     0.00   112.90        0.00    0.00
H2 etc.        -      -      -      -      -        -       -       -       0.00     0.00     0.00        0.00    0.00
Biofuel        -      -      -      -      -        -       -       -       0.00     0.00     0.00        0.00    0.00
Nuclear/CCS    -      -      -      -      -        -       -       -       0.00     0.00     0.00        0.00    0.00

Total        27.50  80.90   3.14    -     1.36    99.47   38.33    0.42   277.51  -191.19    86.32       28.51   28.51

Output specifications        Samsø 2015 Reference.txt                   The EnergyPLAN model 13.0

                                   District Heating Production
           Gr.1                          Gr.2
           District                      District                                                Stor-  Ba-
           heating Solar CSHP DHP        heating Solar CSHP CHP  HP   ELT  Boiler EH             age    lance
           kW      kW    kW   kW         kW      kW    kW   kW   kW   kW   kW     kW             kW     kW

January      0      0     0    0         4173     12    0    0    0    0   4161    0              0      0
February     0      0     0    0         4542     31    0    0    0    0   4512    0              0      0
March        0      0     0    0         4062     97    0    0    0    0   3964    0              0      0
April        0      0     0    0         3463    193    0    0    0    0   3270    0              0      0
May          0      0     0    0         2759    181    0    0    0    0   2578    0              0      0
June         0      0     0    0         2084    169    0    0    0    0   1915    0              0      0
July         0      0     0    0         1552    196    0    0    0    0   1356    0              0      0
August       0      0     0    0         1278    214    0    0    0    0   1064    0              0      0
September    0      0     0    0         1780    185    0    0    0    0   1595    0              0      0
October      0      0     0    0         2595     57    0    0    0    0   2537    0              0      0
November     0      0     0    0         3119     24    0    0    0    0   3095    0              0      0
December     0      0     0    0         3442      4    0    0    0    0   3438    0              0      0

Average      0      0     0    0         2898    114    0    0    0    0   2785    0              0      0
Maximum      0      0     0    0         5511   1282    0    0    0    0   5511    0              0      0
Minimum      0      0     0    0          947      0    0    0    0    0      0    0              0      0

Total for the whole year
GWh/year   0.00   0.00  0.00 0.00        25.46   1.00 0.00 0.00 0.00 0.00  24.46 0.00                  0.00

           Gr.3                                                               RES specification
           District                                             Stor-  Ba-    RES1   RES2   RES3  RES  Total
           heating Solar CSHP CHP  HP   ELT  Boiler EH          age    lance  Wind   Offshc Photo 4-7 sic
           kW      kW    kW   kW   kW   kW   kW     kW          kW     kW     kW     kW     kW    kW   kW

January      0      0     0    0    0    0    0     0            0      0     4371  11577   106    0 16054
February     0      0     0    0    0    0    0     0            0      0     3436  10147   201    0 13783
March        0      0     0    0    0    0    0     0            0      0     2935   8975   344    0 12254
April        0      0     0    0    0    0    0     0            0      0     2323   7377   486    0 10185
May          0      0     0    0    0    0    0     0            0      0     3043   9394   534    0 12970
June         0      0     0    0    0    0    0     0            0      0     2204   6950   566    0  9720
July         0      0     0    0    0    0    0     0            0      0     2738   8223   556    0 11517
August       0      0     0    0    0    0    0     0            0      0     2109   6840   502    0  9450
September    0      0     0    0    0    0    0     0            0      0     2728   8451   437    0 11615
October      0      0     0    0    0    0    0     0            0      0     2523   7881   301    0 10705
November     0      0     0    0    0    0    0     0            0      0     4178  11383   164    0 15725
December     0      0     0    0    0    0    0     0            0      0     4972  13297    90    0 18360

Average      0      0     0    0    0    0    0     0            0      0     3131   9210   357    0 12699
Maximum      0      0     0    0    0    0    0     0            0      0    10788  22454  1300    0 33651
Minimum      0      0     0    0    0    0    0     0            0      0        9     40     0    0    67

Total for the whole year
GWh/year   0.00   0.00  0.00 0.00 0.00 0.00 0.00  0.00                 0.00    27.50  80.90  3.14  0.00111.55

Own use of heat from industrial CH0.00 GWh/year

ANNUAL COSTS    (1000 EUR)
Total Fuel ex Ngas exchange =   7085
Uranium      =             0
Coal         =             0
FuelOil      =             5
Gasoil/Diesel=          4740
Petrol/JP    =           784
Gas handling =             0
Biomass      =          1556
Food income  =             0
Waste        =             0

Total Ngas Exchange costs =      767

Marginal operation costs  =        4

Total Electricity exchange =   -1632
Import       =            47
Export       =         -1679
Bottleneck   =             0
Fixed imp/ex=              0

Total CO2 emission costs =       570

Total variable costs  =         6793
Fixed operation costs =         2395

Annual Investment costs =       7358

TOTAL ANNUAL COSTS  =          16546

                                                    NATURAL GAS EXCHANGE
           DHP &   CHP2  PP    Indi-   Trans  Indu.  Demand Bio-  Syn-  CO2Hy SynHy SynHy Stor-  Sum    Im-    Ex-
           Boilers CHP3  CAES  vidual  port   Var.   Sum    gas   gas   gas   gas   gas   age           port   port
           kW      kW    kW    kW      kW     kW     kW     kW    kW    kW    kW    kW    kW     kW     kW     kW

January      0      0     0     0      2616    48    2664    0     0     0     0     0     0     2664   2664    0
February     0      0     0     0      2616    48    2664    0     0     0     0     0     0     2664   2664    0
March        0      0     0     0      2616    48    2664    0     0     0     0     0     0     2664   2664    0
April        0      0     0     0      2616    48    2664    0     0     0     0     0     0     2664   2664    0
May          0      0     0     0      2616    48    2664    0     0     0     0     0     0     2664   2664    0
June         0      0     0     0      2616    48    2664    0     0     0     0     0     0     2664   2664    0
July         0      0     0     0      2616    48    2664    0     0     0     0     0     0     2664   2664    0
August       0      0     0     0      2616    48    2664    0     0     0     0     0     0     2664   2664    0
September    0      0     0     0      2616    48    2664    0     0     0     0     0     0     2664   2664    0
October      0      0     0     0      2616    48    2664    0     0     0     0     0     0     2664   2664    0
November     0      0     0     0      2616    48    2664    0     0     0     0     0     0     2664   2664    0
December     0      0     0     0      2616    48    2664    0     0     0     0     0     0     2664   2664    0

Average      0      0     0     0      2616    48    2664    0     0     0     0     0     0     2664   2664    0
Maximum      0      0     0     0      2616    48    2664    0     0     0     0     0     0     2664   2664    0
Minimum      0      0     0     0      2616    48    2664    0     0     0     0     0     0     2664   2664    0

Total for the whole year
GWh/year   0.00   0.00  0.00  0.00    22.98  0.42   23.40  0.00  0.00  0.00  0.00  0.00  0.00  23.40  23.40  0.00

RES Share:   59.5  Percent of Primary Energ513.9  Percent of Electricity      111.5  GWh electricity from RES          03-December-2018 [08:39]
```



Input SMILE_Samsø_2022.txt

The EnergyPLAN model 13.0

Electricity demand (GWh/year):		Flexible demand	0.00
Fixed demand	21.48	Fixed imp/exp.	0.00
Electric heating + HP	4.06	Transportation	0.32
Electric cooling	0.00	Total	25.87

District heating (GWh/year)	Gr.1	Gr.2	Gr.3	Sum
District heating demand	0.00	15.96	9.50	25.46
Solar Thermal	0.00	0.98	0.00	0.98
Industrial CHP (CSHP)	0.00	0.00	0.00	0.00
Demand after solar and CSHP	0.00	14.98	9.50	24.48

Wind	11389 kW	27.58	GWh/year	0.00	Grid
Offshore Wind	23000 kW	80.9	GWh/year	0.00	stabili-
Photo Voltaic	1453 kW	3.41	GWh/year	0.00	sation
Photo Voltaic	53 kW	0.01	GWh/year	0.00	share
Hydro Power	0 kW	0	GWh/year		
Geothermal/Nuclear	0 kW	0	GWh/year		

	Capacities		Efficiencies		
Group 2:	kW-e	kJ/s	elec.	Ther	COP
CHP	0	0	0.39	0.46	
Heat Pump	0	0			3.00
Boiler		4000		0.93	
Group 3:					
CHP	0	0	0.40	0.50	
Heat Pump	1000	3000			3.00
Boiler		3000		0.93	
Condensing	0		0.45		

Heatstorage: gr.2: 1 MWh gr.33 MWh
Fixed Boiler: gr.2:0.0 Per cent gr.0.0 Per cent

Electricity prod. from	CSHP	Waste (GWh/year)
Gr.1:	0.00	0.00
Gr.2:	0.00	0.00
Gr.3:	0.00	0.00

Regulation Strate(Technical regulation no. 2
CEEP regulation 000000000
Minimum Stabilisation share 0.00
Stabilisation share of CHP 0.00
Minimum CHP gr 3 load 0 kW
Minimum PP 0 kW
Heat Pump maximum share 0.00
Maximum import/export 40000 kW

Elspot pris eurMWh DK vest 2015.txt
Addition factor 0.00 EUR/MWh
Multiplication factor 1.00
Dependency factor 0.00 EUR/MWh pr. MW
Average Market Price 23 EUR/MWh
Gas Storage 0 MWh
Syngas capacity 0 kW
Biogas max to grid 3074 kW

Fuel Price level: Basic

	Capacities	Storage	Efficien	
	kW-e	MWh	elec.	Ther
Hydro Pump:	0	0	0.80	
Hydro Turbine:	0		0.90	
Electrol. Gr.2:	0	0	0.80	0.10
Electrol. Gr.3:	0	0	0.80	0.10
Electrol. trans.:	0	0	0.80	
Ely. MicroCHP:	0	0	0.80	
CAES fuel ratio:		0.000		

(GWh/year)	Coal	Oil	Ngas	Bioma
Transport	0.00	71.87	27.00	0.00
Household	0.00	11.89	0.00	25.98
Industry	0.00	0.00	0.00	0.00
Various	0.00	0.00	0.42	0.00

Output

	District Heating										Electricity																			Exchange	
	Demand	Production									Consumption						Production							Balance						Payment	
	Distr. heating kW	Solar kW	Waste-CSHP kW	DHP kW	CHP kW	HP kW	ELT kW	Boiler kW	EH kW	Ba-lance kW	Elec. demand kW	Flex.& Transp kW	HP kW	Elec-trolyser kW	EH kW	Hydro Pump kW	Tur-bine kW	RES kW	Hy-dro kW	Geo-thermal kW	Waste-CSHP kW	CHP kW	PP kW	Stab-Load %	Imp kW	Exp kW	CEEP kW	EEP kW	Imp 1000 EUR	Exp
January	4173	12	0	0	0	1258	0	2907	0	-3	2636	36	631	0	442	0	0	16075	0	0	0	0	0	100	325	12655	0	12655	10	185
February	4542	31	0	0	0	1541	0	2971	0	0	2758	36	755	0	504	0	0	13810	0	0	0	0	0	100	116	9872	0	9872	3	169
March	4062	97	0	0	0	1305	0	2660	0	0	2490	36	663	0	476	0	0	12292	0	0	0	0	0	100	220	8847	0	8847	6	156
April	3463	193	0	0	0	1077	0	2190	0	3	2366	36	547	0	392	0	0	10236	0	0	0	0	0	100	187	7081	0	7081	4	118
May	2759	181	0	0	0	961	0	1620	0	-3	2253	36	477	0	326	0	0	13028	0	0	0	0	0	100	66	10002	0	10002	1	151
June	2084	166	0	0	0	634	0	1284	0	0	2258	36	319	0	224	0	0	9776	0	0	0	0	0	100	218	7158	0	7158	4	75
July	1552	190	0	0	0	514	0	848	0	1	2221	36	253	0	170	0	0	11573	0	0	0	0	0	100	128	9020	0	9020	3	59
August	1278	202	0	0	0	418	0	659	0	-1	2319	36	180	0	85	0	0	9500	0	0	0	0	0	100	160	7040	0	7040	3	97
September	1780	183	0	0	0	582	0	1015	0	0	2315	36	277	0	173	0	0	11664	0	0	0	0	0	100	120	8982	0	8982	3	103
October	2595	57	0	0	0	794	0	1743	0	1	2511	36	400	0	283	0	0	10739	0	0	0	0	0	100	266	7775	0	7775	7	129
November	3119	24	0	0	0	1014	0	2083	0	-1	2547	36	492	0	321	0	0	15750	0	0	0	0	0	100	167	12521	0	12521	4	198
December	3442	4	0	0	0	1172	0	2264	0	1	2685	36	565	0	364	0	0	18381	0	0	0	0	0	100	67	14797	0	14797	1	174
Average	2898	112	0	0	0	937	0	1850	0	0	2446	36	462	0	313	0	0	12739	0	0	0	0	0	100	170	9652	0	9652	Average price	
Maximum	5511	1255	0	0	0	2395	0	5506	0	1679	3839	125	1068	0	635	0	0	33777	0	0	0	0	0	100	3834	30740	0	30740	(EUR/MWh)	
Minimum	947	0	0	0	0	0	0	0	0	-938	1476	0	9	0	17	0	0	67	0	0	0	0	0	100	0	0	0	0	32	19
GWh/year	25.46	0.98	0.00	0.00	0.00	8.23	0.00	16.25	0.00	0.00	21.48	0.32	4.06	0.00	2.75	0.00	0.00	111.90	0.00	0.00	0.00	0.00	0.00		1.50	84.79	0.00	84.79	4800	E1616

FUEL BALANCE (GWh/year):

	DHP	CHP2	CHP3	Boiler2	Boiler3	PP	Geo/Nu.	Hydro	Waste	CAES Elc.ly.	BioCon-version	Electro-Fuel	Wind	Offsh.	PV	PV	Solar.Th	Transp.	househ.	Industry Various	Total	Imp/Exp Corrected Imp/Exp	Net	CO2 emission (kt): Total	Net
Coal	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.00	0.00	0.00	0.00	0.00
Oil	-	-	-	0.06	0.01	-	-	-	-	-	-	-	-	-	-	-	-	71.87	11.57	-	83.51	0.00	83.51	22.25	22.25
N.Gas	-	-	-	-	-	-	-	-	-	-	-27.00	-	-	-	-	-	-	27.00	-	0.42	0.42	0.00	0.42	0.09	0.09
Biomass	-	-	-	16.09	1.37	-	-	-	-	-	30.00	-	-	-	-	-	-	-	25.83	-	73.29	0.00	73.29	0.00	0.00
Renewable	-	-	-	-	-	-	-	-	-	-	-	-	27.58	80.90	3.41	0.01	1.34	-	-	-	113.24	0.00	113.24	0.00	0.00
H2 etc.	-	-	-	0.00	0.00	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.00	0.00	0.00	0.00	0.00
Biofuel	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.00	0.00	0.00	0.00	0.00
Nuclear/CCS	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.00	0.00	0.00	0.00	0.00
Total	-	-	-	16.16	1.37	-	-	-	-	-	3.00	-	27.58	80.90	3.41	0.01	1.34	98.87	37.40	0.42	270.46	-185.09	85.37	22.33	22.33

Output specifications SMILE_Samsø_2022.txt

The EnergyPLAN model 13.0

District Heating Production

	Gr.1				Gr.2										Gr.3										RES specification				
	District heating kW	Solar kW	CSHP kW	DHP kW	District heating kW	Solar kW	CSHP kW	CHP kW	HP kW	ELT kW	Boiler kW	EH kW	Stor-age kW	Ba-lance kW	District heating kW	Solar kW	CSHP kW	CHP kW	HP kW	ELT kW	Boiler kW	EH kW	Stor-age kW	Ba-lance kW	RES1 Wind kW	RES2 Offshc kW	RES3 Photo kW	RES 4-7 kW	Total aic kW
January	0	0	0	0	2616	12	0	0	0	0	2604	0	0	0	1557	0	0	0	1258	0	302	0	1838	-3	4382	11577	116	0	16075
February	0	0	0	0	2848	31	0	0	0	0	2817	0	0	0	1695	0	0	0	1541	0	154	0	1991	0	3445	10147	218	0	13810
March	0	0	0	0	2546	97	0	0	0	0	2449	0	0	0	1516	0	0	0	1305	0	211	0	2026	0	2943	8975	373	0	12292
April	0	0	0	0	2171	193	0	0	0	0	1978	0	0	0	1292	0	0	0	1077	0	212	0	1912	3	2329	7377	528	2	10236
May	0	0	0	0	1730	181	0	0	0	0	1549	0	0	0	1029	0	0	0	961	0	71	0	1620	-3	3051	9394	580	3	13028
June	0	0	0	0	1307	166	0	0	0	0	1140	0	0	0	778	0	0	0	634	0	144	0	1867	0	2210	6950	615	2	9776
July	0	0	0	0	973	190	0	0	0	0	783	0	0	0	579	0	0	0	514	0	65	0	1697	1	2746	8223	604	0	11573
August	0	0	0	0	801	202	0	0	0	0	599	0	0	0	477	0	0	0	418	0	60	0	1795	-1	2114	6840	545	1	9500
September	0	0	0	0	1116	183	0	0	0	0	933	0	0	0	664	0	0	0	582	0	82	0	1686	0	2735	8451	475	4	11664
October	0	0	0	0	1627	57	0	0	0	0	1569	0	0	0	968	0	0	0	794	0	174	0	1993	1	2530	7881	327	1	10739
November	0	0	0	0	1955	24	0	0	0	0	1932	0	0	0	1164	0	0	0	1014	0	151	0	1467	-1	4189	11383	178	0	15750
December	0	0	0	0	2157	4	0	0	0	0	2153	0	0	0	1284	0	0	0	1172	0	111	0	1781	1	4986	13297	98	0	18381
Average	0	0	0	0	1817	112	0	0	0	0	1705	0	0	0	1082	0	0	0	937	0	145	0	1806	0	3140	9210	388	1	12739
Maximum	0	0	0	0	3455	1255	0	0	0	0	3455	0	0	0	2056	0	0	0	2395	0	2054	0	2600	1679	10816	22454	1413	53	33777
Minimum	0	0	0	0	593	0	0	0	0	0	0	0	0	0	353	0	0	0	0	0	0	0	0	-938	9	40	0	0	67
Total for the whole year GWh/year	0.00	0.00	0.00	0.00	15.96	0.98	0.00	0.00	0.00	0.00	14.98	0.00		0.00	9.50	0.00	0.00	0.00	8.23	0.00	1.27	0.00		0.00	27.58	80.90	3.41	0.01	111.90

Own use of heat from industrial CH0.00 GWh/year

ANNUAL COSTS (1000 EUR)

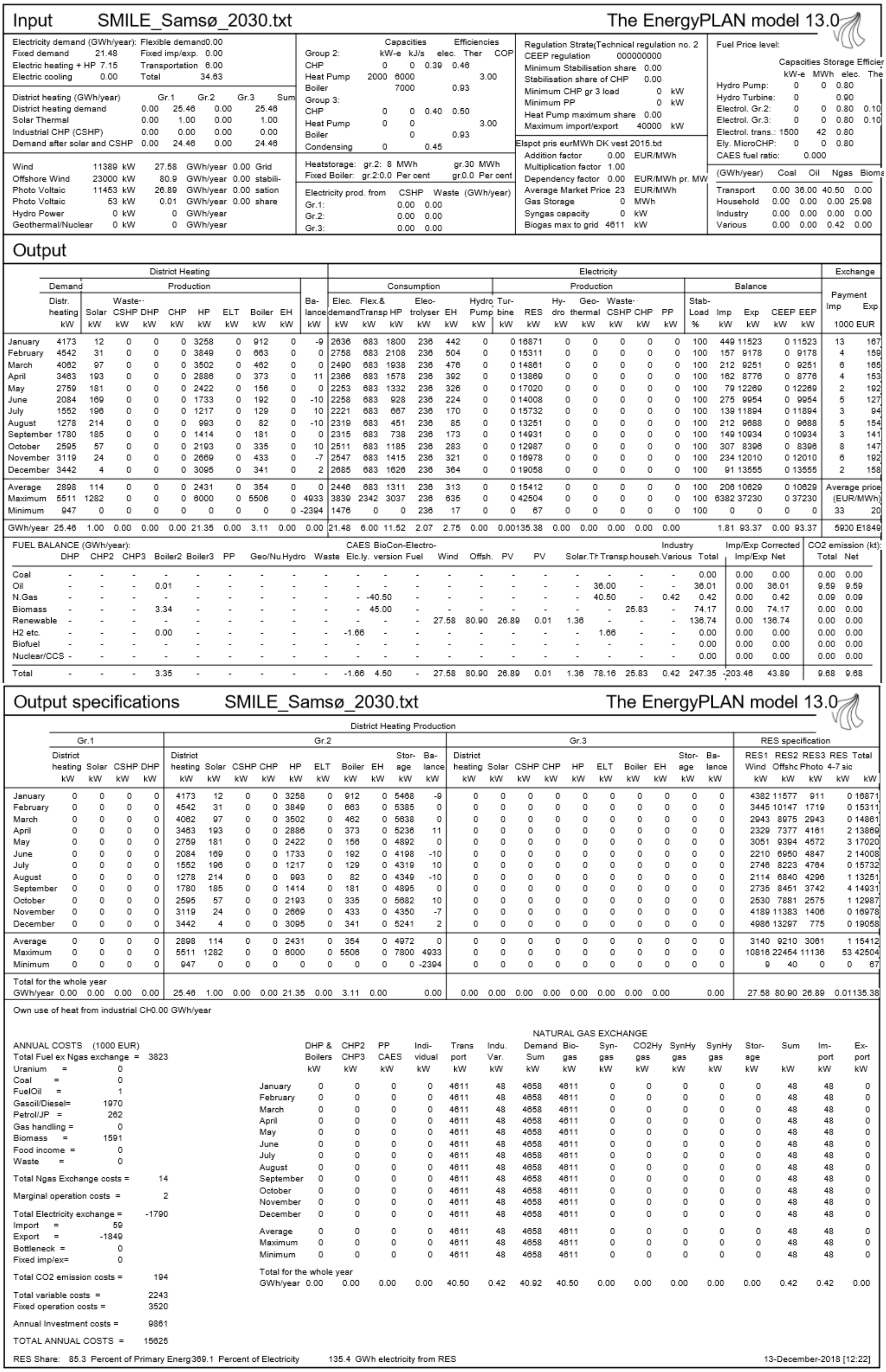
Total Fuel ex Ngas exchange =	6937
Uranium =	0
Coal =	0
FuelOil =	3
Gasoil/Diesel=	4399
Petrol/JP =	784
Gas handling =	0
Biomass =	1752
Food income =	0
Waste =	0
Total Ngas Exchange costs =	14
Marginal operation costs =	3
Total Electricity exchange =	-1568
Import =	48
Export =	-1616
Bottleneck =	0
Fixed imp/ex=	0
Total CO2 emission costs =	447
Total variable costs =	5833
Fixed operation costs =	3053
Annual Investment costs =	8142
TOTAL ANNUAL COSTS =	17028

NATURAL GAS EXCHANGE

	DHP & Boilers kW	CHP2 CHP3 kW	PP CAES kW	Indi-vidual kW	Trans port kW	Indu. Var. kW	Demand Sum kW	Bio-gas kW	Syn-gas kW	CO2Hy gas kW	SynHy gas kW	SynHy gas kW	Stor-age kW	Sum kW	Im-port kW	Ex-port kW
January	0	0	0	0	3074	48	3122	3074	0	0	0	0	0	48	48	0
February	0	0	0	0	3074	48	3122	3074	0	0	0	0	0	48	48	0
March	0	0	0	0	3074	48	3122	3074	0	0	0	0	0	48	48	0
April	0	0	0	0	3074	48	3122	3074	0	0	0	0	0	48	48	0
May	0	0	0	0	3074	48	3122	3074	0	0	0	0	0	48	48	0
June	0	0	0	0	3074	48	3122	3074	0	0	0	0	0	48	48	0
July	0	0	0	0	3074	48	3122	3074	0	0	0	0	0	48	48	0
August	0	0	0	0	3074	48	3122	3074	0	0	0	0	0	48	48	0
September	0	0	0	0	3074	48	3122	3074	0	0	0	0	0	48	48	0
October	0	0	0	0	3074	48	3122	3074	0	0	0	0	0	48	48	0
November	0	0	0	0	3074	48	3122	3074	0	0	0	0	0	48	48	0
December	0	0	0	0	3074	48	3122	3074	0	0	0	0	0	48	48	0
Average	0	0	0	0	3074	48	3122	3074	0	0	0	0	0	48	48	0
Maximum	0	0	0	0	3074	48	3122	3074	0	0	0	0	0	48	48	0
Minimum	0	0	0	0	3074	48	3122	3074	0	0	0	0	0	48	48	0
Total for the whole year GWh/year	0.00	0.00	0.00	0.00	27.00	0.42	27.42	27.00	0.00	0.00	0.00	0.00	0.00	0.42	0.42	0.00

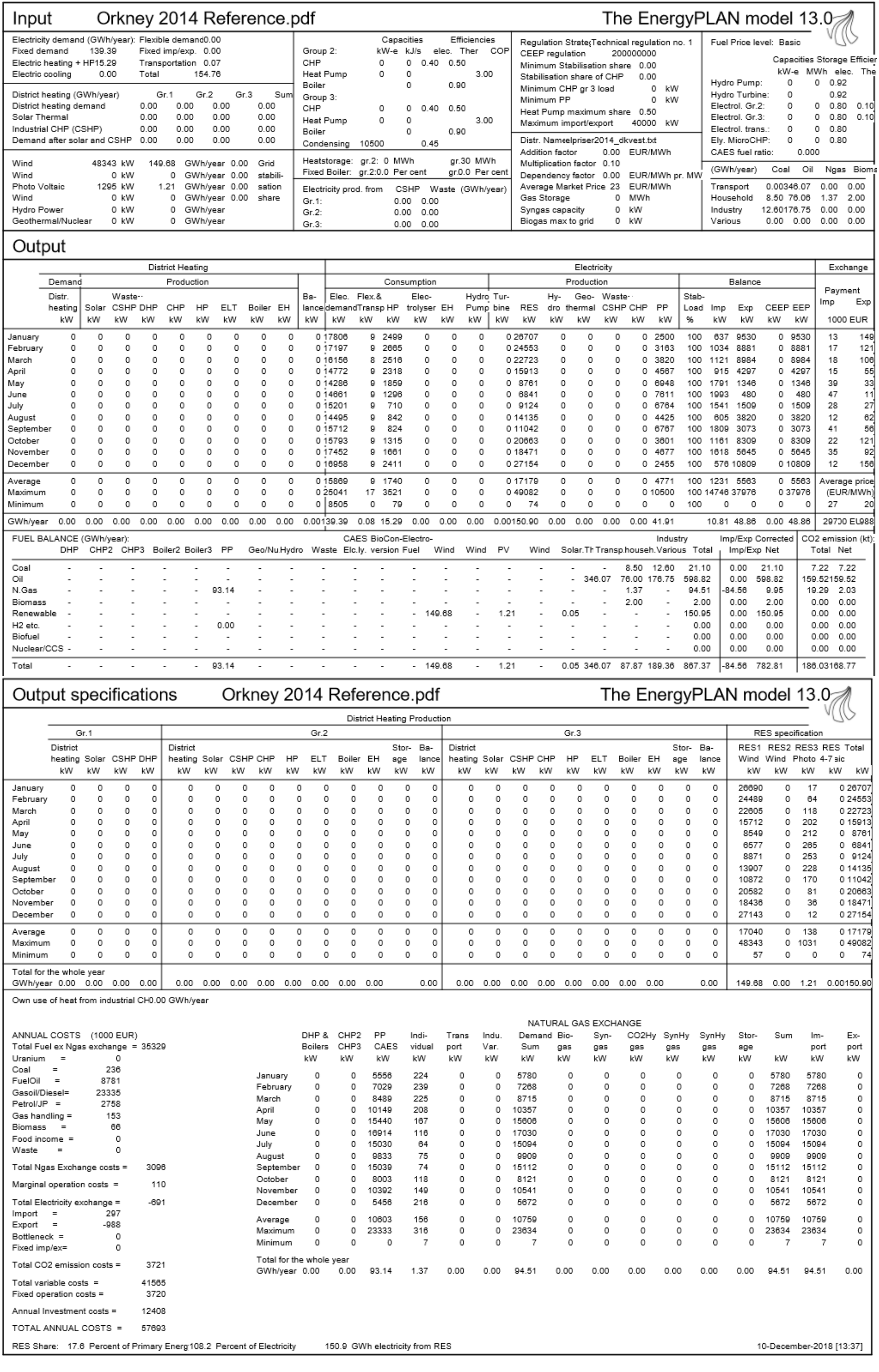
RES Share: 69.0 Percent of Primary Energ455.9 Percent of Electricity 111.9 GWh electricity from RES

10-December-2018 [10:12]



```
Input        SMILE_Samsø_2030.txt                                              The EnergyPLAN model 13.0

Electricity demand (GWh/year): Flexible demand0.00 |                 Capacities     Efficiencies | Regulation Strate(Technical regulation no. 2 | Fuel Price level:
Fixed demand          21.48   Fixed imp/exp.  0.00 | Group 2:        kW-e  kJ/s   elec. Ther  COP | CEEP regulation          000000000       |
Electric heating + HP  7.15   Transportation  6.00 | CHP                0     0   0.39  0.46      | Minimum Stabilisation share  0.00        |          Capacities Storage Efficier
Electric cooling       0.00   Total          34.63 | Heat Pump       2000  6000               3.00 | Stabilisation share of CHP   0.00        |             kW-e   MWh  elec.  The
                                                   | Boiler                7000         0.93      | Minimum CHP gr 3 load          0  kW     | Hydro Pump:      0     0  0.80
District heating (GWh/year)    Gr.1   Gr.2   Gr.3   Sum | Group 3:                              | Minimum PP                     0  kW     | Hydro Turbine:   0        0.90
District heating demand        0.00  25.46   0.00  25.46 | CHP             0     0   0.40  0.50  | Heat Pump maximum share  0.00            | Electrol. Gr.2:  0     0  0.80  0.10
Solar Thermal                  0.00   1.00   0.00   1.00 | Heat Pump       0     0             3.00 | Maximum import/export    40000  kW       | Electrol. Gr.3:  0     0  0.80  0.10
Industrial CHP (CSHP)          0.00   0.00   0.00   0.00 | Boiler                0      0.93     |                                          | Electrol. trans.: 1500 42  0.80
Demand after solar and CSHP    0.00  24.46   0.00  24.46 | Condensing      0          0.45      | Elspot pris eurMWh DK vest 2015.txt      | Ely. MicroCHP:   0     0  0.80
                                                         |                                      | Addition factor        0.00  EUR/MWh     | CAES fuel ratio:      0.000
Wind               11389 kW   27.58  GWh/year 0.00 Grid  | Heatstorage:  gr.2: 8 MWh   gr.30 MWh | Multiplication factor  1.00              |
Offshore Wind      23000 kW    80.9  GWh/year 0.00 stabili- | Fixed Boiler: gr.2:0.0 Per cent gr.0.0 Per cent | Dependency factor 0.00 EUR/MWh pr. MW | (GWh/year)   Coal   Oil  Ngas  Bioma
Photo Voltaic      11453 kW   26.89  GWh/year 0.00 sation  | Electricity prod. from  CSHP  Waste (GWh/year) | Average Market Price 23  EUR/MWh  | Transport   0.00 36.00 40.50  0.00
Photo Voltaic         53 kW    0.01  GWh/year 0.00 share   | Gr.1:               0.00  0.00     | Gas Storage              0  MWh          | Household   0.00  0.00  0.00 25.98
Hydro Power            0 kW       0  GWh/year              | Gr.2:               0.00  0.00     | Syngas capacity          0  kW           | Industry    0.00  0.00  0.00  0.00
Geothermal/Nuclear     0 kW       0  GWh/year              | Gr.3:               0.00  0.00     | Biogas max to grid    4611  kW           | Various     0.00  0.00  0.42  0.00

Output

                              District Heating                            |                                      Electricity                                              | Exchange
          Demand |                  Production                      |     |              Consumption              |                Production                 |          Balance            | Payment
          Distr. |       Waste--                                    | Ba- | Elec.  Flex.&        Elec-          Hydro | Tur-         Hy-   Geo-   Waste--             | Stab-                        | Imp    Exp
          heating| Solar CSHP DHP  CHP   HP   ELT  Boiler  EH       |lance|demand Transp HP    trolyser EH   Pump  | bine  RES    dro  thermal CSHP  CHP   PP  | Load  Imp   Exp   CEEP  EEP  |
            kW   |  kW   kW   kW   kW    kW   kW    kW    kW       | kW  |  kW     kW    kW      kW     kW    kW   |  kW   kW     kW    kW     kW    kW    kW  |  %    kW    kW    kW    kW   | 1000 EUR
January    4173     12    0    0    0  3258    0   912    0           -9  2636   683  1800     236   442     0      0 16871    0     0      0     0     0    100   449 11523     0 11523    13    167
February   4542     31    0    0    0  3849    0   663    0            0  2758   683  2108     236   504     0      0 15311    0     0      0     0     0    100   157  9178     0  9178     4    159
March      4062     97    0    0    0  3502    0   462    0            0  2490   683  1938     236   476     0      0 14861    0     0      0     0     0    100   212  9251     0  9251     6    165
April      3463    193    0    0    0  2886    0   373    0           11  2366   683  1578     236   392     0      0 13869    0     0      0     0     0    100   162  8776     0  8776     4    153
May        2759    181    0    0    0  2422    0   156    0            0  2253   683  1332     236   326     0      0 17020    0     0      0     0     0    100    79 12269     0 12269     2    192
June       2084    169    0    0    0  1733    0   192    0          -10  2258   683   928     236   224     0      0 14008    0     0      0     0     0    100   275  9954     0  9954     5    127
July       1552    196    0    0    0  1217    0   129    0           10  2221   683   667     236   170     0      0 15732    0     0      0     0     0    100   139 11894     0 11894     3     94
August     1278    214    0    0    0   993    0    82    0          -10  2319   683   451     236    85     0      0 13251    0     0      0     0     0    100   212  9688     0  9688     5    154
September  1780    185    0    0    0  1414    0   181    0            0  2315   683   738     236   173     0      0 14931    0     0      0     0     0    100   149 10934     0 10934     3    141
October    2595     57    0    0    0  2193    0   335    0           10  2511   683  1185     236   283     0      0 12987    0     0      0     0     0    100   307  8396     0  8396     8    147
November   3119     24    0    0    0  2669    0   433    0           -7  2547   683  1415     236   321     0      0 16978    0     0      0     0     0    100   234 12010     0 12010     6    192
December   3442      4    0    0    0  3095    0   341    0            2  2685   683  1626     236   364     0      0 19058    0     0      0     0     0    100    91 13555     0 13555     2    158

Average    2898    114    0    0    0  2431    0   354    0            0  2446   683  1311     236   313     0      0 15412    0     0      0     0     0    100   206 10629     0 10629  Average price
Maximum    5511   1282    0    0    0  6000    0  5506    0         4933  3839  2342  3037     236   635     0      0 42504    0     0      0     0     0    100  6382 37230     0 37230   (EUR/MWh)
Minimum     947      0    0    0    0     0    0     0    0        -2394  1476     0     0     236    17     0      0    67    0     0      0     0     0    100     0     0     0     0    33     20

GWh/year  25.46   1.00 0.00 0.00 0.00 21.35 0.00  3.11 0.00         0.00 21.48  6.00 11.52    2.07  2.75  0.00  0.00135.38 0.00  0.00   0.00  0.00  0.00         1.81 93.37  0.00 93.37   5900 E1849

FUEL BALANCE (GWh/year):                                                       CAES BioCon-Electro-                                                    Industry        Imp/Exp Corrected | CO2 emission (kt):
             DHP  CHP2  CHP3  Boiler2 Boiler3  PP   Geo/Nu.Hydro  Waste  Elc.ly. version Fuel  Wind   Offsh.  PV     PV    Solar.Th Transp.househ.Various  Total | Imp/Exp  Net      | Total   Net

Coal          -     -     -     -       -      -      -      -      -      -      -       -     -      -       -      -      -       -      -      -       0.00 |  0.00    0.00     |  0.00   0.00
Oil           -     -     -    0.01     -      -      -      -      -      -      -       -     -      -       -      -      -     36.00     -      -      36.01 |  0.00   36.01     |  9.59   9.59
N.Gas         -     -     -     -       -      -      -      -      -      -   -40.50     -     -      -       -      -      -     40.50     -    0.42     0.42 |  0.00    0.42     |  0.09   0.09
Biomass       -     -     -    3.34     -      -      -      -      -      -    45.00     -     -      -       -      -      -       -    25.83     -      74.17 |  0.00   74.17     |  0.00   0.00
Renewable     -     -     -     -       -      -      -      -      -      -      -       -   27.58  80.90   26.89   0.01   1.36      -      -      -     136.74 |  0.00  136.74     |  0.00   0.00
H2 etc.       -     -     -    0.00     -      -      -      -      -    -1.66    -       -     -      -       -      -      -      1.66     -      -       0.00 |  0.00    0.00     |  0.00   0.00
Biofuel       -     -     -     -       -      -      -      -      -      -      -       -     -      -       -      -      -       -      -      -       0.00 |  0.00    0.00     |  0.00   0.00
Nuclear/CCS   -     -     -     -       -      -      -      -      -      -      -       -     -      -       -      -      -       -      -      -       0.00 |  0.00    0.00     |  0.00   0.00

Total         -     -     -    3.35     -      -      -      -      -    -1.66   4.50     -   27.58  80.90   26.89   0.01   1.36   78.16  25.83   0.42   247.35 |-203.46  43.89     |  9.68   9.68

Output specifications        SMILE_Samsø_2030.txt                                                    The EnergyPLAN model 13.0

                                                     District Heating Production
            Gr.1            |                          Gr.2                                 |                        Gr.3                                  | RES specification
          District          | District                                    Stor-  Ba-        | District                                     Stor-  Ba-      | RES1  RES2  RES3  RES  Total
          heating Solar CSHP DHP | heating Solar CSHP CHP  HP   ELT Boiler EH  age  lance  | heating Solar CSHP CHP  HP  ELT  Boiler EH   age   lance   | Wind  Offshc Photo 4-7 aic
            kW    kW   kW   kW   |   kW     kW   kW   kW   kW   kW   kW   kW   kW    kW    |   kW    kW   kW   kW   kW   kW   kW    kW   kW    kW     |  kW    kW    kW    kW   kW

January      0     0    0    0      4173    12    0    0  3258   0   912   0  5468    -9       0     0    0    0    0    0    0     0    0     0       4382 11577   911    0 16871
February     0     0    0    0      4542    31    0    0  3849   0   663   0  5385     0       0     0    0    0    0    0    0     0    0     0       3445 10147  1719    0 15311
March        0     0    0    0      4062    97    0    0  3502   0   462   0  5638     0       0     0    0    0    0    0    0     0    0     0       2943  8975  2943    0 14861
April        0     0    0    0      3463   193    0    0  2886   0   373   0  5236    11       0     0    0    0    0    0    0     0    0     0       2329  7377  4161    2 13869
May          0     0    0    0      2759   181    0    0  2422   0   156   0  4892     0       0     0    0    0    0    0    0     0    0     0       3051  9394  4572    3 17020
June         0     0    0    0      2084   169    0    0  1733   0   192   0  4198   -10       0     0    0    0    0    0    0     0    0     0       2210  6950  4847    2 14008
July         0     0    0    0      1552   196    0    0  1217   0   129   0  4319    10       0     0    0    0    0    0    0     0    0     0       2746  8223  4764    0 15732
August       0     0    0    0      1278   214    0    0   993   0    82   0  4349   -10       0     0    0    0    0    0    0     0    0     0       2114  6840  4296    1 13251
September    0     0    0    0      1780   185    0    0  1414   0   181   0  4895     0       0     0    0    0    0    0    0     0    0     0       2735  8451  3742    4 14931
October      0     0    0    0      2595    57    0    0  2193   0   335   0  5682    10       0     0    0    0    0    0    0     0    0     0       2530  7881  2575    1 12987
November     0     0    0    0      3119    24    0    0  2669   0   433   0  4350    -7       0     0    0    0    0    0    0     0    0     0       4189 11383  1406    0 16978
December     0     0    0    0      3442     4    0    0  3095   0   341   0  5241     2       0     0    0    0    0    0    0     0    0     0       4986 13297   775    0 19058

Average      0     0    0    0      2898   114    0    0  2431   0   354   0  4972     0       0     0    0    0    0    0    0     0    0     0       3140  9210  3061    1 15412
Maximum      0     0    0    0      5511  1282    0    0  6000   0  5506   0  7800  4933       0     0    0    0    0    0    0     0    0     0      10816 22454 11136   53 42504
Minimum      0     0    0    0       947     0    0    0     0   0     0   0     0 -2394       0     0    0    0    0    0    0     0    0     0          9    40     0    0    67

Total for the whole year
GWh/year  0.00  0.00 0.00 0.00     25.46  1.00 0.00 0.00 21.35 0.00 3.11 0.00        0.00    0.00  0.00 0.00 0.00 0.00 0.00 0.00  0.00        0.00     27.58 80.90 26.89  0.01135.38

Own use of heat from industrial CH0.00 GWh/year

                                                                                       NATURAL GAS EXCHANGE
ANNUAL COSTS    (1000 EUR)                    DHP &   CHP2  PP    Indi-  Trans Indu. Demand Bio-  Syn-  CO2Hy SynHy SynHy Stor-  Sum   Im-   Ex-
Total Fuel ex Ngas exchange =  3823           Boilers CHP3  CAES  vidual port  Var.  Sum    gas   gas   gas   gas   gas   age          port  port
Uranium     =          0                        kW     kW    kW    kW    kW    kW    kW     kW    kW    kW    kW    kW    kW     kW    kW    kW
Coal        =          0
FuelOil     =          1            January     0      0     0     0    4611   48   4658   4611   0     0     0     0     0     48    48     0
Gasoil/Diesel=      1970            February    0      0     0     0    4611   48   4658   4611   0     0     0     0     0     48    48     0
Petrol/JP   =        262            March       0      0     0     0    4611   48   4658   4611   0     0     0     0     0     48    48     0
Gas handling =         0            April       0      0     0     0    4611   48   4658   4611   0     0     0     0     0     48    48     0
Biomass     =       1591            May         0      0     0     0    4611   48   4658   4611   0     0     0     0     0     48    48     0
Food income  =         0            June        0      0     0     0    4611   48   4658   4611   0     0     0     0     0     48    48     0
Waste       =          0            July        0      0     0     0    4611   48   4658   4611   0     0     0     0     0     48    48     0
                                    August      0      0     0     0    4611   48   4658   4611   0     0     0     0     0     48    48     0
Total Ngas Exchange costs =    14   September   0      0     0     0    4611   48   4658   4611   0     0     0     0     0     48    48     0
                                    October     0      0     0     0    4611   48   4658   4611   0     0     0     0     0     48    48     0
Marginal operation costs  =     2   November    0      0     0     0    4611   48   4658   4611   0     0     0     0     0     48    48     0
                                    December    0      0     0     0    4611   48   4658   4611   0     0     0     0     0     48    48     0
Total Electricity exchange =  -1790
Import      =         59            Average     0      0     0     0    4611   48   4658   4611   0     0     0     0     0     48    48     0
Export      =      -1849            Maximum     0      0     0     0    4611   48   4658   4611   0     0     0     0     0     48    48     0
Bottleneck  =          0            Minimum     0      0     0     0    4611   48   4658   4611   0     0     0     0     0     48    48     0
Fixed imp/ex=          0
                                    Total for the whole year
Total CO2 emission costs =    194   GWh/year  0.00   0.00  0.00  0.00  40.50  0.42 40.92  40.50 0.00  0.00  0.00  0.00  0.00  0.42  0.42  0.00

Total variable costs  =      2243
Fixed operation costs =      3520

Annual Investment costs =    9861

TOTAL ANNUAL COSTS  =       15625

RES Share:  85.3  Percent of Primary Energ369.1  Percent of Electricity      135.4  GWh electricity from RES                   13-December-2018 [12:22]
```

7.2 Orkney EnergyPLAN data sheets for the 2014, 2022 and 2030 scenarios



Input Orkney 2014 Reference.pdf The EnergyPLAN model 13.0

Electricity demand (GWh/year): Flexible demand0.00
Fixed demand 139.39 Fixed imp/exp. 0.00
Electric heating + HP15.29 Transportation 0.07
Electric cooling 0.00 Total 154.76

District heating (GWh/year)	Gr.1	Gr.2	Gr.3	Sum
District heating demand	0.00	0.00	0.00	0.00
Solar Thermal	0.00	0.00	0.00	0.00
Industrial CHP (CSHP)	0.00	0.00	0.00	0.00
Demand after solar and CSHP	0.00	0.00	0.00	0.00

Wind	48343	kW	149.68	GWh/year	0.00	Grid
Wind	0	kW	0	GWh/year	0.00	stabili-
Photo Voltaic	1295	kW	1.21	GWh/year	0.00	sation
Wind	0	kW	0	GWh/year	0.00	share
Hydro Power	0	kW	0	GWh/year		
Geothermal/Nuclear	0	kW	0	GWh/year		

	Capacities kW-e	Capacities kJ/s	Efficiencies elec.	Efficiencies Ther	COP
Group 2:					
CHP	0	0	0.40	0.50	
Heat Pump	0	0			3.00
Boiler		0		0.90	
Group 3:					
CHP	0	0	0.40	0.50	
Heat Pump	0	0			3.00
Boiler		0		0.90	
Condensing	10500		0.45		

Heatstorage: gr.2: 0 MWh gr.30 MWh
Fixed Boiler: gr.2:0.0 Per cent gr.0.0 Per cent

Electricity prod. from	CSHP	Waste (GWh/year)
Gr.1:	0.00	0.00
Gr.2:	0.00	0.00
Gr.3:	0.00	0.00

Regulation Strate(Technical regulation no. 1
CEEP regulation 200000000
Minimum Stabilisation share 0.00
Stabilisation share of CHP 0.00
Minimum CHP gr 3 load 0 kW
Minimum PP 0 kW
Heat Pump maximum share 0.50
Maximum import/export 40000 kW

Distr. Nameelpriser2014_dkvest.txt
Addition factor 0.00 EUR/MWh
Multiplication factor 0.10
Dependency factor 0.00 EUR/MWh pr. MW
Average Market Price 23 EUR/MWh
Gas Storage 0 MWh
Syngas capacity 0 kW
Biogas max to grid 0 kW

Fuel Price level: Basic

	Capacities kW-e	Storage MWh	Efficier elec.	The
Hydro Pump:	0	0	0.92	
Hydro Turbine:	0		0.92	
Electrol. Gr.2:	0	0	0.80	0.10
Electrol. Gr.3:	0	0	0.80	0.10
Electrol. trans.:	0	0	0.80	
Ely. MicroCHP:	0	0	0.80	

CAES fuel ratio: 0.000

(GWh/year)	Coal	Oil	Ngas	Bioma
Transport	0.00	346.07	0.00	0.00
Household	8.50	76.06	1.37	2.00
Industry	12.60	176.75	0.00	0.00
Various	0.00	0.00	0.00	0.00

Output

	District Heating: Demand Distr. heating kW	Production Solar kW	Waste-CSHP kW	DHP kW	CHP kW	HP kW	ELT kW	Boiler kW	EH kW	Ba-lance kW	Electricity: Consumption Elec. demand kW	Flex.& Transp kW	HP kW	Elec-trolyser kW	EH kW	Hydro Pump kW	Production Tur-bine kW	RES kW	Hy-dro kW	Geo-thermal kW	Waste-CSHP kW	CHP kW	PP kW	Balance Stab-Load %	Imp kW	Exp kW	CEEP kW	EEP kW	Exchange Payment Imp 1000 EUR	Exp
January	0	0	0	0	0	0	0	0	0	0	17806	9	2499	0	0	0	0	26707	0	0	0	0	2500	100	637	9530	0	9530	13	149
February	0	0	0	0	0	0	0	0	0	0	17197	9	2665	0	0	0	0	24553	0	0	0	0	3163	100	1034	8881	0	8881	17	121
March	0	0	0	0	0	0	0	0	0	0	16156	8	2516	0	0	0	0	22723	0	0	0	0	3820	100	1121	8984	0	8984	18	106
April	0	0	0	0	0	0	0	0	0	0	14772	9	2318	0	0	0	0	15913	0	0	0	0	4567	100	915	4297	0	4297	15	55
May	0	0	0	0	0	0	0	0	0	0	14286	9	1859	0	0	0	0	8761	0	0	0	0	6948	100	1791	1346	0	1346	39	33
June	0	0	0	0	0	0	0	0	0	0	14661	9	1296	0	0	0	0	6841	0	0	0	0	7611	100	1993	480	0	480	47	11
July	0	0	0	0	0	0	0	0	0	0	15201	9	710	0	0	0	0	9124	0	0	0	0	6764	100	1541	1509	0	1509	28	27
August	0	0	0	0	0	0	0	0	0	0	14495	9	842	0	0	0	0	14135	0	0	0	0	4425	100	605	3820	0	3820	12	62
September	0	0	0	0	0	0	0	0	0	0	15712	9	824	0	0	0	0	11042	0	0	0	0	6767	100	1809	3073	0	3073	41	56
October	0	0	0	0	0	0	0	0	0	0	15793	9	1315	0	0	0	0	20663	0	0	0	0	3601	100	1161	8309	0	8309	22	121
November	0	0	0	0	0	0	0	0	0	0	17452	9	1661	0	0	0	0	18471	0	0	0	0	4677	100	1618	5645	0	5645	35	92
December	0	0	0	0	0	0	0	0	0	0	16958	9	2411	0	0	0	0	27154	0	0	0	0	2455	100	576	10809	0	10809	12	156
Average	0	0	0	0	0	0	0	0	0	0	15869	9	1740	0	0	0	0	17179	0	0	0	0	4771	100	1231	5563	0	5563	Average price	
Maximum	0	0	0	0	0	0	0	0	0	0	25041	17	3521	0	0	0	0	49082	0	0	0	0	10500	100	14746	37976	0	37976	(EUR/MWh)	
Minimum	0	0	0	0	0	0	0	0	0	0	8505	0	79	0	0	0	0	74	0	0	0	0	0	100	0	0	0	0	27	20
GWh/year	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	139.39	0.08	15.29	0.00	0.00	0.00	0.00	150.90	0.00	0.00	0.00	0.00	41.91		10.81	48.86	0.00	48.86	29730 EL988	

FUEL BALANCE (GWh/year):	DHP	CHP2	CHP3	Boiler2	Boiler3	PP	Geo/Nu.	Hydro	Waste	CAES Elc.ly.	BioCon-version	Electro-Fuel	Wind	Wind	PV	Wind	Solar.Th	Transp.	househ.	Industry Various	Total	Imp/Exp Corrected Imp/Exp	Net	CO2 emission (kt): Total	Net
Coal	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	8.50	12.60	21.10	0.00	21.10	7.22	7.22
Oil	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	346.07	76.00	176.75	598.82	0.00	598.82	159.52	159.52
N.Gas	-	-	-	-	-	93.14	-	-	-	-	-	-	-	-	-	-	-	-	1.37	-	94.51	-84.56	9.95	19.29	2.03
Biomass	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2.00	-	2.00	0.00	2.00	0.00	0.00
Renewable	-	-	-	-	-	-	-	-	-	-	-	-	149.68	-	1.21	-	0.05	-	-	-	150.95	0.00	150.95	0.00	0.00
H2 etc.	-	-	-	-	-	0.00	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.00	0.00	0.00	0.00	0.00
Biofuel	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.00	0.00	0.00	0.00	0.00
Nuclear/CCS	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.00	0.00	0.00	0.00	0.00
Total	-	-	-	-	-	93.14	-	-	-	-	-	-	149.68	-	1.21	-	0.05	346.07	87.87	189.36	867.37	-84.56	782.81	186.03	168.77

Output specifications Orkney 2014 Reference.pdf The EnergyPLAN model 13.0

District Heating Production

	Gr.1 District heating kW	Solar kW	CSHP kW	DHP kW	Gr.2 District heating kW	Solar kW	CSHP kW	CHP kW	HP kW	ELT kW	Boiler kW	EH kW	Stor-age kW	Ba-lance kW	Gr.3 District heating kW	Solar kW	CSHP kW	CHP kW	HP kW	ELT kW	Boiler kW	EH kW	Stor-age kW	Ba-lance kW	RES specification RES1 Wind kW	RES2 Wind kW	RES3 Photo kW	RES 4-7 kW	Total kW
January	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	26690	0	17	0	26707
February	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	24489	0	64	0	24553
March	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	22605	0	118	0	22723
April	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	15712	0	202	0	15913
May	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8549	0	212	0	8761
June	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6577	0	265	0	6841
July	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8871	0	253	0	9124
August	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	13907	0	228	0	14135
September	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10872	0	170	0	11042
October	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	20582	0	81	0	20663
November	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	18436	0	36	0	18471
December	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	27143	0	12	0	27154
Average	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	17040	0	138	0	17179
Maximum	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	48343	0	1031	0	49082
Minimum	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	57	0	0	0	74
Total for the whole year GWh/year	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		0.00	149.68	0.00	1.21	0.00	150.90

Own use of heat from industrial CH0.00 GWh/year

ANNUAL COSTS (1000 EUR)
Total Fuel ex Ngas exchange = 35329
Uranium = 0
Coal = 236
FuelOil = 8781
Gasoil/Diesel= 23335
Petrol/JP = 2758
Gas handling = 153
Biomass = 66
Food income = 0
Waste = 0

Total Ngas Exchange costs = 3096

Marginal operation costs = 110

Total Electricity exchange = -691
Import = 297
Export = -988
Bottleneck = 0
Fixed imp/ex= 0

Total CO2 emission costs = 3721

Total variable costs = 41565
Fixed operation costs = 3720

Annual Investment costs = 12408

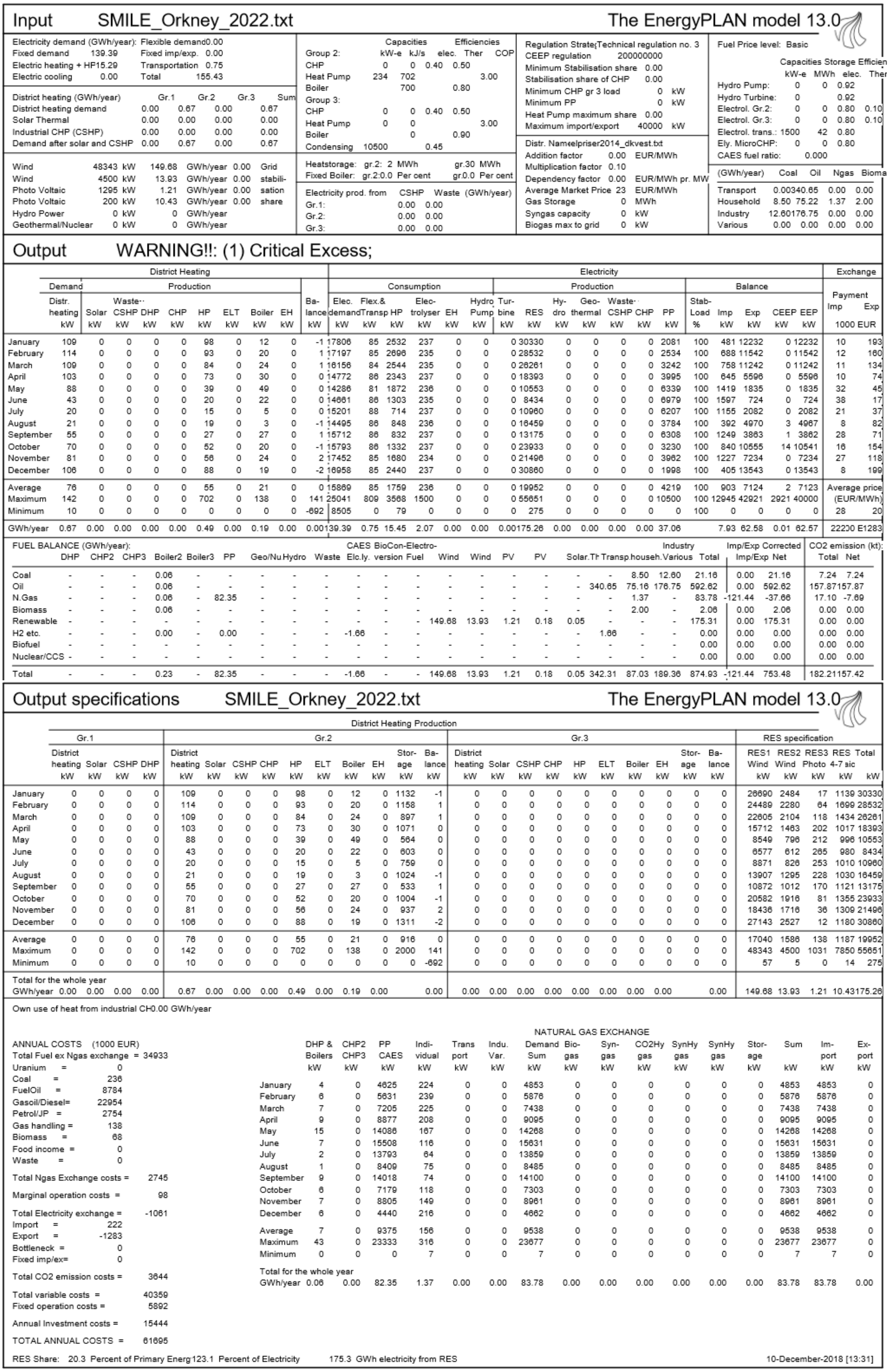
TOTAL ANNUAL COSTS = 57693

NATURAL GAS EXCHANGE

	DHP & Boilers kW	CHP2 CHP3 kW	PP CAES kW	Indi-vidual kW	Trans port kW	Indu. Var. kW	Demand Sum kW	Bio-gas kW	Syn-gas kW	CO2Hy gas kW	SynHy gas kW	SynHy gas kW	Stor-age kW	Sum kW	Im-port kW	Ex-port kW
January	0	0	5556	224	0	0	5780	0	0	0	0	0	0	5780	5780	0
February	0	0	7029	239	0	0	7268	0	0	0	0	0	0	7268	7268	0
March	0	0	8489	225	0	0	8715	0	0	0	0	0	0	8715	8715	0
April	0	0	10149	208	0	0	10357	0	0	0	0	0	0	10357	10357	0
May	0	0	15440	167	0	0	15606	0	0	0	0	0	0	15606	15606	0
June	0	0	16914	116	0	0	17030	0	0	0	0	0	0	17030	17030	0
July	0	0	15030	64	0	0	15094	0	0	0	0	0	0	15094	15094	0
August	0	0	9833	75	0	0	9909	0	0	0	0	0	0	9909	9909	0
September	0	0	15039	74	0	0	15112	0	0	0	0	0	0	15112	15112	0
October	0	0	8003	118	0	0	8121	0	0	0	0	0	0	8121	8121	0
November	0	0	10392	149	0	0	10541	0	0	0	0	0	0	10541	10541	0
December	0	0	5456	216	0	0	5672	0	0	0	0	0	0	5672	5672	0
Average	0	0	10603	156	0	0	10759	0	0	0	0	0	0	10759	10759	0
Maximum	0	0	23333	316	0	0	23634	0	0	0	0	0	0	23634	23634	0
Minimum	0	0	0	7	0	0	7	0	0	0	0	0	0	7	7	0
Total for the whole year GWh/year	0.00	0.00	93.14	1.37	0.00	0.00	94.51	0.00	0.00	0.00	0.00	0.00	0.00	94.51	94.51	0.00

RES Share: 17.6 Percent of Primary Energ 108.2 Percent of Electricity 150.9 GWh electricity from RES

10-December-2018 [13:37]



Input SMILE_Orkney_2022.txt — The EnergyPLAN model 13.0

Electricity demand (GWh/year):		Flexible demand	0.00
Fixed demand	139.39	Fixed imp/exp.	0.00
Electric heating + HP	15.29	Transportation	0.75
Electric cooling	0.00	Total	155.43

District heating (GWh/year)	Gr.1	Gr.2	Gr.3	Sum
District heating demand	0.00	0.67	0.00	0.67
Solar Thermal	0.00	0.00	0.00	0.00
Industrial CHP (CSHP)	0.00	0.00	0.00	0.00
Demand after solar and CSHP	0.00	0.67	0.00	0.67

Wind	48343	kW	149.68	GWh/year	0.00	Grid
Wind	4500	kW	13.93	GWh/year	0.00	stabili-
Photo Voltaic	1295	kW	1.21	GWh/year	0.00	sation
Photo Voltaic	200	kW	10.43	GWh/year	0.00	share
Hydro Power	0	kW	0	GWh/year		
Geothermal/Nuclear	0	kW	0	GWh/year		

	Capacities		Efficiencies		
Group 2:	kW-e	kJ/s	elec.	Ther	COP
CHP	0	0	0.40	0.50	
Heat Pump	234	702			3.00
Boiler		700		0.80	
Group 3:					
CHP	0	0	0.40	0.50	
Heat Pump	0	0			3.00
Boiler		0		0.90	
Condensing	10500		0.45		

Heatstorage: gr.2: 2 MWh gr.30 MWh
Fixed Boiler: gr.2:0.0 Per cent gr.0.0 Per cent

Electricity prod. from	CSHP	Waste (GWh/year)
Gr.1:	0.00	0.00
Gr.2:	0.00	0.00
Gr.3:	0.00	0.00

Regulation Strate(	Technical regulation no. 3	
CEEP regulation	200000000	
Minimum Stabilisation share	0.00	
Stabilisation share of CHP	0.00	
Minimum CHP gr 3 load	0	kW
Minimum PP	0	kW
Heat Pump maximum share	0.00	
Maximum import/export	40000	kW

Distr. Name	eelpriser2014_dkvest.txt	
Addition factor	0.00	EUR/MWh
Multiplication factor	0.10	
Dependency factor	0.00	EUR/MWh pr. MW
Average Market Price	23	EUR/MWh
Gas Storage	0	MWh
Syngas capacity	0	kW
Biogas max to grid	0	kW

Fuel Price level: Basic

	Capacities	Storage	Efficien	
	kW-e	MWh	elec.	Ther
Hydro Pump:	0	0	0.92	
Hydro Turbine:	0		0.92	
Electrol. Gr.2:	0	0	0.80	0.10
Electrol. Gr.3:	0	0	0.80	0.10
Electrol. trans.:	1500	42	0.80	
Ely. MicroCHP:	0	0	0.80	
CAES fuel ratio:	0.000			

(GWh/year)	Coal	Oil	Ngas	Bioma
Transport	0.00	340.65	0.00	0.00
Household	8.50	75.22	1.37	2.00
Industry	12.60	176.75	0.00	0.00
Various	0.00	0.00	0.00	0.00

Output WARNING!!: (1) Critical Excess;

	District Heating										Electricity																		Exchange	
	Demand	Production									Consumption						Production							Balance					Payment	
	Distr. heating	Solar	Waste CSHP	DHP	CHP	HP	ELT	Boiler	EH	Balance	Elec. demand	Flex.& Transp	HP	Electrolyser	EH	Hydro Pump	Turbine	RES	Hydro	Geothermal	Waste CSHP	CHP	PP	Stab-Load	Imp	Exp	CEEP	EEP	Imp	Exp
	kW	kW	kW	kW	kW	kW	kW	kW	kW	kW	kW	kW	kW	kW	kW	kW	kW	kW	kW	kW	kW	kW	kW	%	kW	kW	kW	kW	1000 EUR	
January	109	0	0	0	0	98	0	12	0	-1	17806	85	2532	237	0	0	0	30330	0	0	0	0	2081	100	481	12232	0	12232	10	193
February	114	0	0	0	0	93	0	20	0	1	17197	85	2696	235	0	0	0	28532	0	0	0	0	2534	100	688	11542	0	11542	12	160
March	109	0	0	0	0	84	0	24	0	1	16156	84	2544	235	0	0	0	26261	0	0	0	0	3242	100	758	11242	0	11242	11	134
April	103	0	0	0	0	73	0	30	0	0	14772	86	2343	237	0	0	0	18393	0	0	0	0	3995	100	645	5596	0	5596	10	74
May	88	0	0	0	0	39	0	49	0	0	14286	81	1872	236	0	0	0	10553	0	0	0	0	6339	100	1419	1835	0	1835	32	45
June	43	0	0	0	0	20	0	22	0	0	14661	86	1303	235	0	0	0	8434	0	0	0	0	6979	100	1597	724	0	724	38	17
July	20	0	0	0	0	15	0	5	0	0	15201	88	714	237	0	0	0	10960	0	0	0	0	6207	100	1155	2082	0	2082	21	37
August	21	0	0	0	0	19	0	3	0	-1	14495	86	848	236	0	0	0	16459	0	0	0	0	3784	100	392	4970	3	4967	8	82
September	55	0	0	0	0	27	0	27	0	1	15712	86	832	237	0	0	0	13175	0	0	0	0	6308	100	1249	3863	1	3862	28	71
October	70	0	0	0	0	52	0	20	0	-1	15793	86	1332	237	0	0	0	23933	0	0	0	0	3230	100	840	10555	14	10541	16	154
November	81	0	0	0	0	56	0	24	0	2	17452	85	1680	234	0	0	0	21496	0	0	0	0	3962	100	1227	7234	0	7234	27	118
December	106	0	0	0	0	88	0	19	0	-2	16958	85	2440	237	0	0	0	30860	0	0	0	0	1998	100	405	13543	0	13543	8	199
Average	76	0	0	0	0	55	0	21	0	0	15869	85	1759	236	0	0	0	19952	0	0	0	0	4219	100	903	7124	2	7123	Average price	
Maximum	142	0	0	0	0	702	0	138	0	141	25041	809	3568	1500	0	0	0	55651	0	0	0	0	10500	100	12945	42921	2921	40000	(EUR/MWh)	
Minimum	10	0	0	0	0	0	0	0	0	-692	8505	0	79	0	0	0	0	275	0	0	0	0	0	100	0	0	0	0	28	20
GWh/year	0.67	0.00	0.00	0.00	0.00	0.49	0.00	0.19	0.00	0.00	139.39	0.75	15.45	2.07	0.00	0.00	0.00	175.26	0.00	0.00	0.00	0.00	37.06		7.93	62.58	0.01	62.57	22200	E1283

FUEL BALANCE (GWh/year):

	DHP	CHP2	CHP3	Boiler2	Boiler3	PP	Geo/Nu.	Hydro	Waste	CAES Elc.ly.	BioCon-version	Electro-Fuel	Wind	Wind	PV	PV	Solar.Th	Transp.	househ.	Industry Various	Total	Imp/Exp Corrected Imp/Exp	Net	CO2 emission (kt): Total	Net
Coal	-	-	-	0.06	-	-	-	-	-	-	-	-	-	-	-	-	-	-	8.50	12.60	21.16	0.00	21.16	7.24	7.24
Oil	-	-	-	0.06	-	-	-	-	-	-	-	-	-	-	-	-	-	340.65	75.16	176.75	592.62	0.00	592.62	157.87	157.87
N.Gas	-	-	-	0.06	-	82.35	-	-	-	-	-	-	-	-	-	-	-	-	1.37	-	83.78	-121.44	-37.66	17.10	-7.69
Biomass	-	-	-	0.06	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2.00	-	2.06	0.00	2.06	0.00	0.00
Renewable	-	-	-	-	-	-	-	-	-	-	-	-	149.68	13.93	1.21	0.18	0.05	-	-	-	175.31	0.00	175.31	0.00	0.00
H2 etc.	-	-	-	0.00	-	0.00	-	-	-	-1.66	-	-	-	-	-	-	-	1.66	-	-	0.00	0.00	0.00	0.00	0.00
Biofuel	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.00	0.00	0.00	0.00	0.00
Nuclear/CCS	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.00	0.00	0.00	0.00	0.00
Total	-	-	-	0.23	-	82.35	-	-	-	-1.66	-	-	149.68	13.93	1.21	0.18	0.05	342.31	87.03	189.36	874.93	-121.44	753.48	182.21	157.42

Output specifications SMILE_Orkney_2022.txt — The EnergyPLAN model 13.0

District Heating Production

	Gr.1				Gr.2										Gr.3										RES specification				
	District heating	Solar	CSHP	DHP	District heating	Solar	CSHP	CHP	HP	ELT	Boiler	EH	Storage	Balance	District heating	Solar	CSHP	CHP	HP	ELT	Boiler	EH	Storage	Balance	RES1 Wind	RES2 Wind	RES3 Photo	RES 4-7	Total aic
	kW	kW	kW	kW	kW	kW	kW	kW	kW	kW	kW	kW	kW	kW	kW	kW	kW	kW	kW	kW	kW	kW	kW	kW	kW	kW	kW	kW	kW
January	0	0	0	0	109	0	0	0	98	0	12	0	1132	-1	0	0	0	0	0	0	0	0	0	0	26690	2484	17	1139	30330
February	0	0	0	0	114	0	0	0	93	0	20	0	1158	1	0	0	0	0	0	0	0	0	0	0	24489	2280	64	1699	28532
March	0	0	0	0	109	0	0	0	84	0	24	0	897	1	0	0	0	0	0	0	0	0	0	0	22605	2104	118	1434	26261
April	0	0	0	0	103	0	0	0	73	0	30	0	1071	0	0	0	0	0	0	0	0	0	0	0	15712	1463	202	1017	18393
May	0	0	0	0	88	0	0	0	39	0	49	0	564	0	0	0	0	0	0	0	0	0	0	0	8549	796	212	996	10553
June	0	0	0	0	43	0	0	0	20	0	22	0	603	0	0	0	0	0	0	0	0	0	0	0	6577	612	265	980	8434
July	0	0	0	0	20	0	0	0	15	0	5	0	759	0	0	0	0	0	0	0	0	0	0	0	8871	826	253	1010	10960
August	0	0	0	0	21	0	0	0	19	0	3	0	1024	-1	0	0	0	0	0	0	0	0	0	0	13907	1295	228	1030	16459
September	0	0	0	0	55	0	0	0	27	0	27	0	533	1	0	0	0	0	0	0	0	0	0	0	10872	1012	170	1121	13175
October	0	0	0	0	70	0	0	0	52	0	20	0	1004	-1	0	0	0	0	0	0	0	0	0	0	20582	1916	81	1355	23933
November	0	0	0	0	81	0	0	0	56	0	24	0	937	2	0	0	0	0	0	0	0	0	0	0	18436	1716	36	1309	21496
December	0	0	0	0	106	0	0	0	88	0	19	0	1311	-2	0	0	0	0	0	0	0	0	0	0	27143	2527	12	1180	30860
Average	0	0	0	0	76	0	0	0	55	0	21	0	916	0	0	0	0	0	0	0	0	0	0	0	17040	1586	138	1187	19952
Maximum	0	0	0	0	142	0	0	0	702	0	138	0	2000	141	0	0	0	0	0	0	0	0	0	0	48343	4500	1031	7850	55651
Minimum	0	0	0	0	10	0	0	0	0	0	0	0	0	-692	0	0	0	0	0	0	0	0	0	0	57	5	0	14	275
Total for the whole year GWh/year	0.00	0.00	0.00	0.00	0.67	0.00	0.00	0.00	0.49	0.00	0.19	0.00		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		0.00	149.68	13.93	1.21	10.43	175.26

Own use of heat from industrial CH0.00 GWh/year

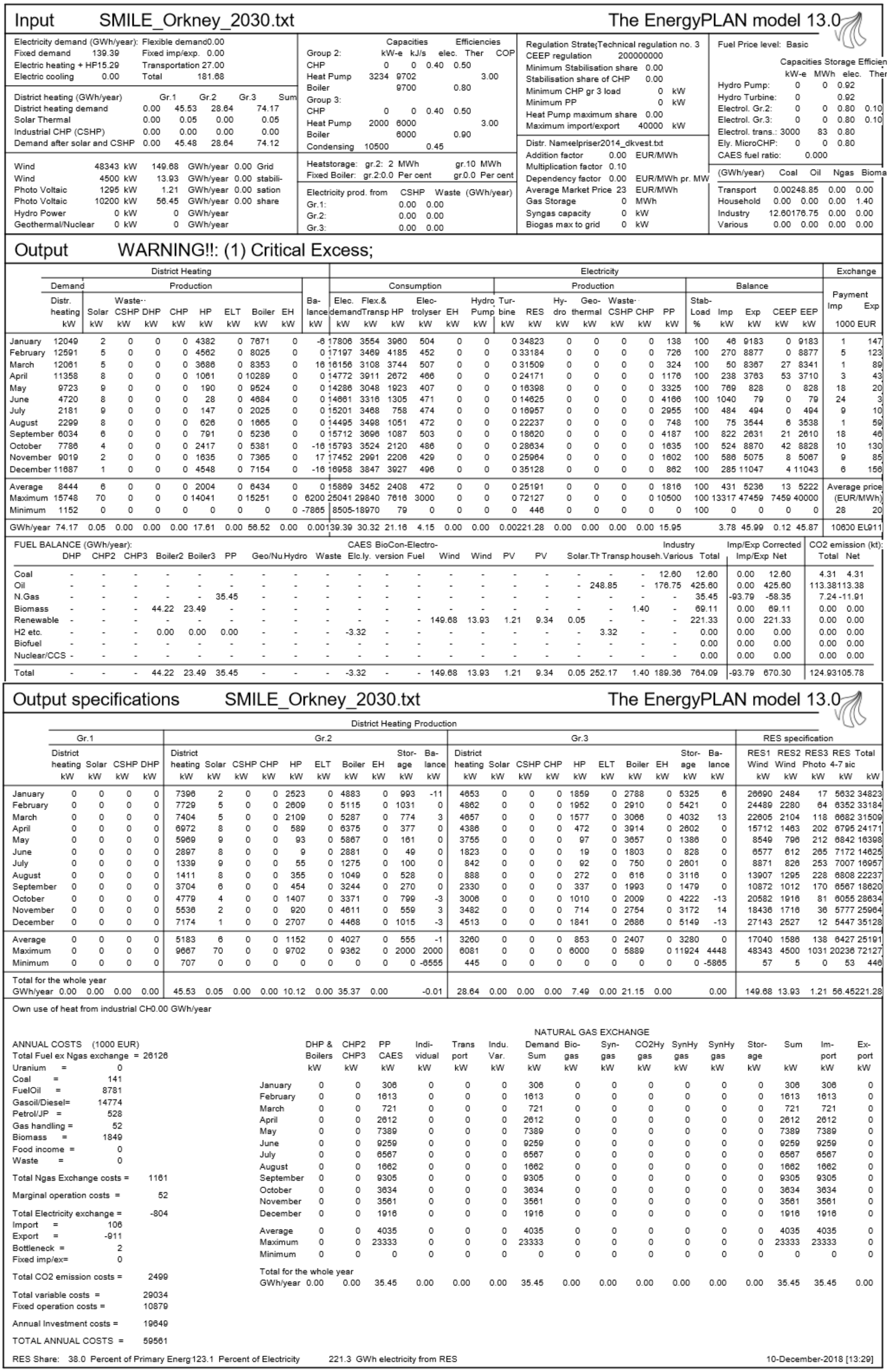
ANNUAL COSTS	(1000 EUR)
Total Fuel ex Ngas exchange =	34933
Uranium =	0
Coal =	236
FuelOil =	8784
Gasoil/Diesel=	22954
Petrol/JP =	2754
Gas handling =	138
Biomass =	68
Food income =	0
Waste =	0
Total Ngas Exchange costs =	2745
Marginal operation costs =	98
Total Electricity exchange =	-1061
Import =	222
Export =	-1283
Bottleneck =	0
Fixed imp/ex=	0
Total CO2 emission costs =	3644
Total variable costs =	40359
Fixed operation costs =	5892
Annual Investment costs =	15444
TOTAL ANNUAL COSTS =	61695

NATURAL GAS EXCHANGE

	DHP & Boilers	CHP2 CHP3	PP CAES	Individual	Trans port	Indu. Var.	Demand Sum	Bio-gas	Syn-gas	CO2Hy gas	SynHy gas	SynHy gas	Storage	Sum	Import	Export
	kW	kW	kW	kW	kW	kW	kW	kW	kW	kW	kW	kW	kW	kW	kW	kW
January	4	0	4625	224	0	0	4853	0	0	0	0	0	0	4853	4853	0
February	6	0	5631	239	0	0	5876	0	0	0	0	0	0	5876	5876	0
March	7	0	7205	225	0	0	7438	0	0	0	0	0	0	7438	7438	0
April	9	0	8877	208	0	0	9095	0	0	0	0	0	0	9095	9095	0
May	15	0	14086	167	0	0	14268	0	0	0	0	0	0	14268	14268	0
June	7	0	15508	116	0	0	15631	0	0	0	0	0	0	15631	15631	0
July	2	0	13793	64	0	0	13859	0	0	0	0	0	0	13859	13859	0
August	1	0	8409	75	0	0	8485	0	0	0	0	0	0	8485	8485	0
September	9	0	14018	74	0	0	14100	0	0	0	0	0	0	14100	14100	0
October	6	0	7179	118	0	0	7303	0	0	0	0	0	0	7303	7303	0
November	7	0	8805	149	0	0	8961	0	0	0	0	0	0	8961	8961	0
December	6	0	4440	216	0	0	4662	0	0	0	0	0	0	4662	4662	0
Average	7	0	9375	156	0	0	9538	0	0	0	0	0	0	9538	9538	0
Maximum	43	0	23333	316	0	0	23677	0	0	0	0	0	0	23677	23677	0
Minimum	0	0	0	7	0	0	7	0	0	0	0	0	0	7	7	0
Total for the whole year GWh/year	0.06	0.00	82.35	1.37	0.00	0.00	83.78	0.00	0.00	0.00	0.00	0.00	0.00	83.78	83.78	0.00

RES Share: 20.3 Percent of Primary Energ 123.1 Percent of Electricity 175.3 GWh electricity from RES

10-December-2018 [13:31]

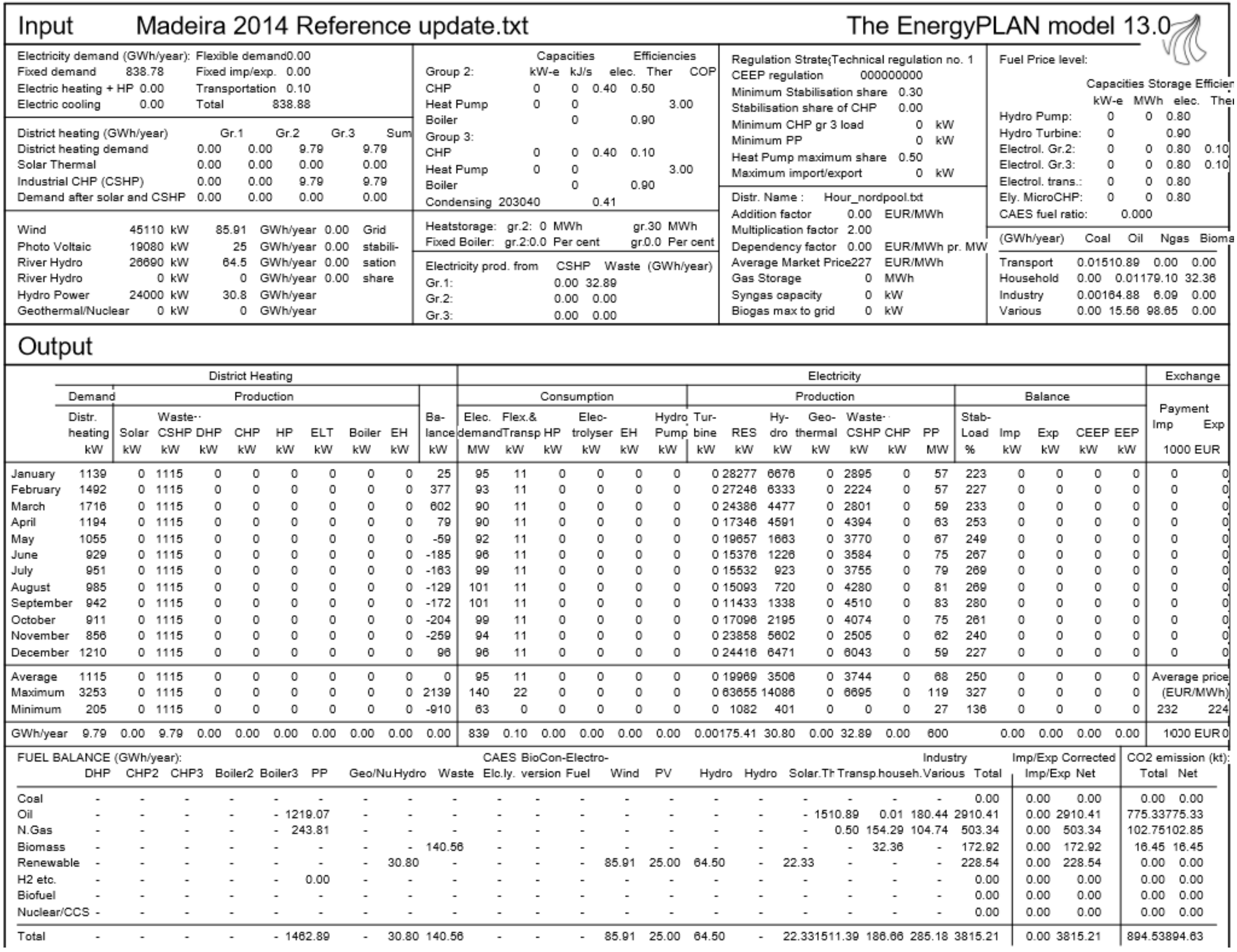


```
Input        SMILE_Orkney_2030.txt                                                              The EnergyPLAN model 13.0

Electricity demand (GWh/year): Flexible demand0.00    |                  Capacities     Efficiencies  | Regulation Strate(Technical regulation no. 3     | Fuel Price level:  Basic
Fixed demand        139.39   Fixed imp/exp.   0.00    | Group 2:         kW-e  kJ/s   elec.  Ther COP | CEEP regulation          200000000              |
Electric heating + HP15.29   Transportation 27.00     | CHP                 0     0   0.40  0.50      | Minimum Stabilisation share   0.00              |        Capacities Storage Efficien
Electric cooling      0.00   Total          181.68    | Heat Pump        3234  9702               3.00| Stabilisation share of CHP    0.00              |          kW-e   MWh   elec.  Ther
                                                      | Boiler                 9700         0.80      | Minimum CHP gr 3 load           0   kW          | Hydro Pump:      0     0   0.92
District heating (GWh/year)    Gr.1   Gr.2   Gr.3  Sum| Group 3:                                      | Minimum PP                      0   kW          | Hydro Turbine:   0         0.92
District heating demand        0.00  45.53  28.64  74.17| CHP               0     0   0.40  0.50      | Heat Pump maximum share       0.00              | Electrol. Gr.2:  0     0   0.80   0.10
Solar Thermal                  0.00   0.05   0.00   0.05| Heat Pump        2000  6000               3.00| Maximum import/export     40000   kW            | Electrol. Gr.3:  0     0   0.80   0.10
Industrial CHP (CSHP)          0.00   0.00   0.00   0.00| Boiler                 6000         0.90      |                                                 | Electrol. trans.: 3000  83  0.80
Demand after solar and CSHP    0.00  45.48  28.64  74.12| Condensing  10500           0.45              | Distr. Nameelpriser2014_dkvest.txt              | Ely. MicroCHP:   0     0   0.80
                                                      |                                               | Addition factor        0.00  EUR/MWh            | CAES fuel ratio:     0.000
Wind               48343 kW   149.68 GWh/year 0.00 Grid    | Heatstorage:  gr.2:  2  MWh      gr.10  MWh | Multiplication factor  0.10                     |
Wind                4500 kW    13.93 GWh/year 0.00 stabili-| Fixed Boiler: gr.2:0.0 Per cent  gr.0.0 Per cent| Dependency factor  0.00  EUR/MWh pr. MW       | (GWh/year)   Coal     Oil    Ngas  Bioma
Photo Voltaic       1295 kW     1.21 GWh/year 0.00 sation  |                                            | Average Market Price  23  EUR/MWh               | Transport    0.00248.85    0.00   0.00
Photo Voltaic      10200 kW    56.45 GWh/year 0.00 share   | Electricity prod. from   CSHP  Waste (GWh/year)| Gas Storage          0   MWh                   | Household    0.00   0.00   0.00   1.40
Hydro Power            0 kW        0 GWh/year              | Gr.1:                    0.00   0.00       | Syngas capacity      0   kW                    | Industry    12.60176.75    0.00   0.00
Geothermal/Nuclear     0 kW        0 GWh/year              | Gr.2:                    0.00   0.00       | Biogas max to grid   0   kW                    | Various      0.00   0.00   0.00   0.00
                                                           | Gr.3:                    0.00   0.00       |
```

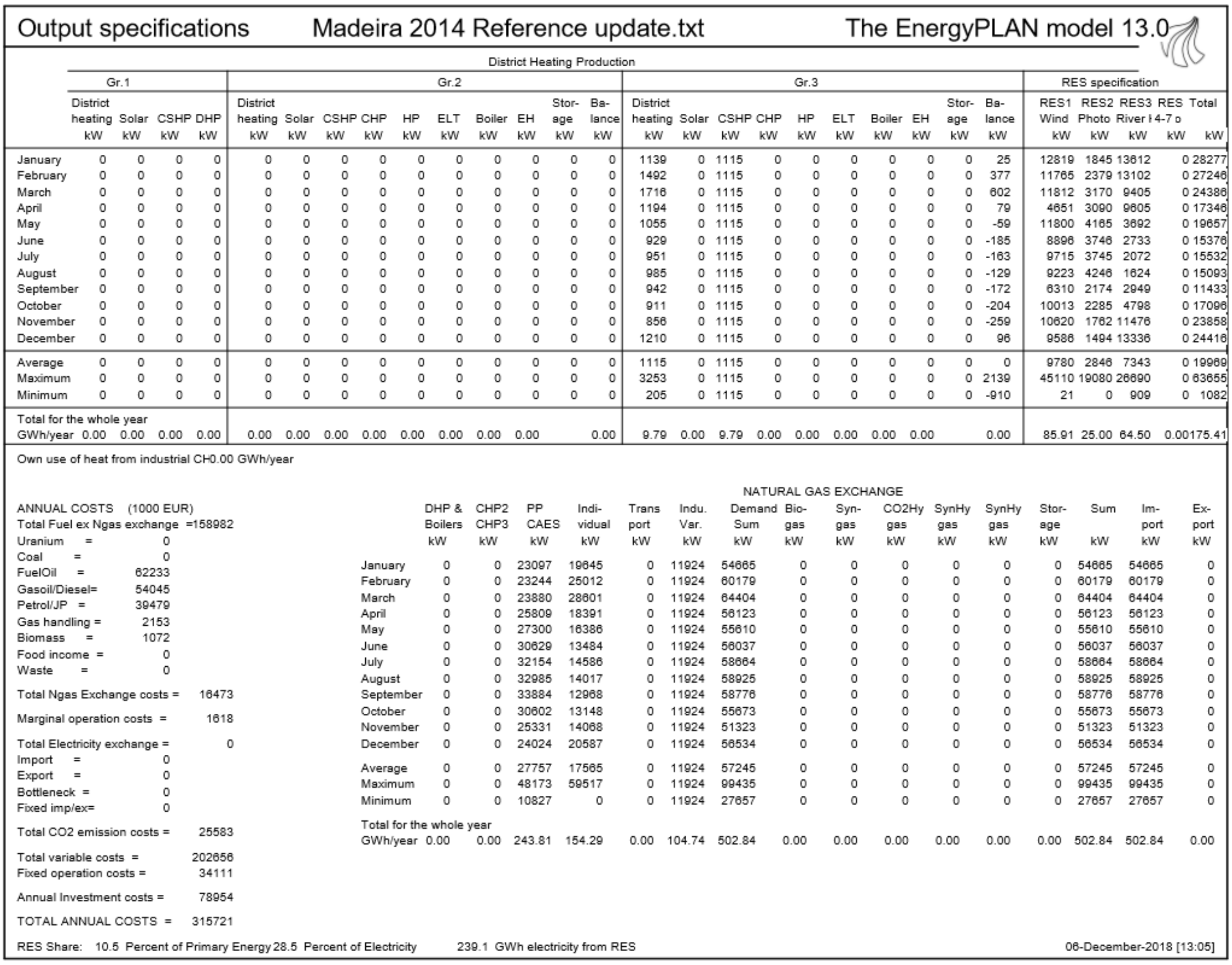
```
Output       WARNING!!: (1) Critical Excess;

                         District Heating                          |                          Electricity                                                                   | Exchange
          Demand |            Production                    |      |             Consumption                |                 Production                |           Balance                  | Payment
          Distr. |       Waste-                             | Ba-  | Elec.  Flex.&        Elec-        Hydro| Tur-         Hy-   Geo-   Waste-               | Stab-                              | Imp     Exp
          heating| Solar CSHP  DHP   CHP    HP    ELT Boiler EH | lance|demand Transp  HP  trolyser EH  Pump | bine   RES   dro  thermal CSHP  CHP    PP   | Load   Imp    Exp   CEEP   EEP     |
            kW   |  kW    kW    kW    kW    kW    kW    kW   kW |  kW  |  kW     kW    kW     kW    kW   kW  |  kW     kW    kW    kW    kW    kW    kW   |  %     kW     kW     kW     kW     | 1000 EUR

January    12049    2     0     0     0   4382    0   7671   0    -6  17806  3554  3960   504     0    0     0 34823    0     0     0     0    138    100     46   9183      0   9183      1   147
February   12591    5     0     0     0   4562    0   8025   0     0  17197  3469  4185   452     0    0     0 33184    0     0     0     0    726    100    270   8877      0   8877      5   123
March      12061    5     0     0     0   3686    0   8353   0    16  16156  3108  3744   507     0    0     0 31509    0     0     0     0    324    100     50   8367     27   8341      1    89
April      11358    8     0     0     0   1061    0  10289   0     0  14772  3911  2672   466     0    0     0 24171    0     0     0     0   1176    100    238   3763     53   3710      3    43
May         9723    9     0     0     0    190    0   9524   0     0  14286  3048  1923   407     0    0     0 16398    0     0     0     0   3325    100    769    828      0    828     18    20
June        4720    8     0     0     0     28    0   4684   0     0  14661  3316  1305   471     0    0     0 14625    0     0     0     0   4166    100   1040     79      0     79     24     3
July        2181    9     0     0     0    147    0   2025   0     0  15201  3468   758   474     0    0     0 16957    0     0     0     0   2955    100    484    494      0    494      9    10
August      2299    8     0     0     0    626    0   1665   0     0  14495  3498  1051   472     0    0     0 22237    0     0     0     0    748    100     75   3544      6   3538      1    59
September   6034    6     0     0     0    791    0   5236   0     0  15712  3696  1087   503     0    0     0 18620    0     0     0     0   4187    100    822   2631     21   2610     18    46
October     7786    4     0     0     0   2417    0   5381   0   -16  15793  3524  2120   486     0    0     0 28634    0     0     0     0   1635    100    524   8870     42   8828     10   130
November    9019    2     0     0     0   1635    0   7365   0    17  17452  2991  2206   429     0    0     0 25964    0     0     0     0   1602    100    586   5075      8   5067      9    85
December   11687    1     0     0     0   4548    0   7154   0   -16  16958  3847  3927   496     0    0     0 35128    0     0     0     0    862    100    285  11047      4  11043      6   156

Average     8444    6     0     0     0   2004    0   6434   0     0  15869  3452  2408   472     0    0     0 25191    0     0     0     0   1816    100    431   5236     13   5222   Average price
Maximum    15748   70     0     0     0  14041    0  15251   0  6200  25041 29840  7616  3000     0    0     0 72127    0     0     0     0  10500    100  13317  47459   7459  40000    (EUR/MWh)
Minimum     1152    0     0     0     0      0    0      0   0 -7865   8505-18970    79     0     0    0     0   446    0     0     0     0      0    100      0      0      0      0     28    20

GWh/year   74.17  0.05  0.00  0.00  0.00  17.61 0.00  56.52 0.00 0.00139.39 30.32 21.16  4.15  0.00  0.00 0.00221.28 0.00  0.00  0.00  0.00  15.95          3.78  45.99   0.12  45.87   10600 EL911

FUEL BALANCE (GWh/year):                                                   CAES BioCon-Electro-                                            Industry          Imp/Exp Corrected  CO2 emission (kt):
             DHP   CHP2  CHP3  Boiler2 Boiler3  PP    Geo/Nu.Hydro  Waste  Elc.ly. version Fuel   Wind    Wind   PV    PV   Solar.Th Transp.househ.Various  Total |  Imp/Exp  Net     |  Total   Net

Coal          -     -     -      -       -      -       -      -      -      -      -      -      -       -      -     -      -       -       -     12.60   12.60 |  0.00    12.60   |   4.31   4.31
Oil           -     -     -      -       -      -       -      -      -      -      -      -      -       -      -     -      -     248.85    -    176.75  425.60 |  0.00   425.60   | 113.38113.38
N.Gas         -     -     -      -       -    35.45     -      -      -      -      -      -      -       -      -     -      -       -       -       -     35.45 | -93.79  -58.35   |   7.24 -11.91
Biomass       -     -     -    44.22   23.49    -       -      -      -      -      -      -      -       -      -     -      -       -     1.40      -     69.11 |  0.00    69.11   |   0.00   0.00
Renewable     -     -     -      -       -      -       -      -      -      -      -      -   149.68   13.93  1.21  9.34   0.05      -       -       -    221.33 |  0.00   221.33   |   0.00   0.00
H2 etc.       -     -     -     0.00    0.00   0.00     -      -      -    -3.32    -      -      -       -      -     -      -      3.32     -       -      0.00 |  0.00     0.00   |   0.00   0.00
Biofuel       -     -     -      -       -      -       -      -      -      -      -      -      -       -      -     -      -       -       -       -      0.00 |  0.00     0.00   |   0.00   0.00
Nuclear/CCS   -     -     -      -       -      -       -      -      -      -      -      -      -       -      -     -      -       -       -       -      0.00 |  0.00     0.00   |   0.00   0.00

Total         -     -     -    44.22   23.49  35.45     -      -      -    -3.32    -      -   149.68   13.93  1.21  9.34   0.05  252.17   1.40  189.36  764.09 | -93.79  670.30   | 124.93105.78
```

```
Output specifications        SMILE_Orkney_2030.txt                                                  The EnergyPLAN model 13.0

                                                           District Heating Production
              Gr.1           |                       Gr.2                                   |                          Gr.3                                 |      RES specification
          District           | District                                       Stor-   Ba-   | District                                       Stor-   Ba-    | RES1   RES2  RES3  RES   Total
          heating Solar CSHP DHP| heating Solar CSHP CHP   HP   ELT  Boiler  EH   age   lance | heating Solar CSHP CHP   HP   ELT  Boiler  EH   age    lance | Wind   Wind  Photo 4-7 aic
            kW    kW   kW   kW |   kW    kW    kW   kW   kW    kW    kW    kW    kW    kW   |   kW    kW    kW   kW   kW    kW    kW    kW    kW     kW   |  kW     kW    kW    kW    kW

January      0     0    0    0    7396    2     0    0  2523    0   4883    0    993   -11     4653    0     0    0  1859    0   2788    0   5325      6    26690  2484    17  5632 34823
February     0     0    0    0    7729    5     0    0  2609    0   5115    0   1031     0     4862    0     0    0  1952    0   2910    0   5421      0    24489  2280    64  6352 33184
March        0     0    0    0    7404    5     0    0  2109    0   5287    0    774     3     4657    0     0    0  1577    0   3066    0   4032     13    22605  2104   118  6682 31509
April        0     0    0    0    6972    8     0    0   589    0   6375    0    377     0     4386    0     0    0   472    0   3914    0   2602      0    15712  1463   202  6795 24171
May          0     0    0    0    5969    9     0    0    93    0   5867    0    161     0     3755    0     0    0    97    0   3657    0   1386      0     8549   796   212  6842 16398
June         0     0    0    0    2897    8     0    0     9    0   2881    0     49     0     1823    0     0    0    19    0   1803    0    828      0     6577   612   265  7172 14625
July         0     0    0    0    1339    9     0    0    55    0   1275    0    100     0      842    0     0    0    92    0    750    0   2601      0     8871   826   253  7007 16957
August       0     0    0    0    1411    8     0    0   355    0   1049    0    528     0      888    0     0    0   272    0    616    0   3116      0    13907  1295   228  6808 22237
September    0     0    0    0    3704    6     0    0   454    0   3244    0    270     0     2330    0     0    0   337    0   1993    0   1479      0    10872  1012   170  6567 18620
October      0     0    0    0    4779    4     0    0  1407    0   3371    0    799    -3     3006    0     0    0  1010    0   2009    0   4222    -13    20582  1916    81  6055 28634
November     0     0    0    0    5536    2     0    0   920    0   4611    0    559     3     3482    0     0    0   714    0   2754    0   3172     14    18436  1716    36  5777 25964
December     0     0    0    0    7174    1     0    0  2707    0   4468    0   1015    -3     4513    0     0    0  1841    0   2686    0   5149    -13    27143  2527    12  5447 35128

Average      0     0    0    0    5183    6     0    0  1152    0   4027    0    555    -1     3260    0     0    0   853    0   2407    0   3280      0    17040  1586   138  6427 25191
Maximum      0     0    0    0    9667   70     0    0  9702    0   9362    0   2000  2000     6081    0     0    0  6000    0   5889    0  11924   4448    48343  4500  1031 20236 72127
Minimum      0     0    0    0     707    0     0    0     0    0      0    0      0 -6555      445    0     0    0     0    0      0    0      0  -5865       57     5     0    53   446

Total for the whole year
GWh/year  0.00  0.00 0.00 0.00   45.53  0.05  0.00 0.00 10.12 0.00  35.37 0.00        -0.01    28.64  0.00  0.00 0.00  7.49 0.00  21.15 0.00          0.00    149.68 13.93  1.21 56.45221.28

Own use of heat from industrial CH0.00 GWh/year

                                                                                          NATURAL GAS EXCHANGE
ANNUAL COSTS   (1000 EUR)                       DHP &   CHP2   PP    Indi-  Trans  Indu.  Demand  Bio-   Syn-   CO2Hy  SynHy  SynHy  Stor-   Sum     Im-     Ex-
Total Fuel ex Ngas exchange  = 26126            Boilers CHP3   CAES  vidual port   Var.   Sum     gas    gas    gas    gas    gas    age             port    port
Uranium      =          0                        kW      kW     kW    kW     kW     kW     kW      kW     kW     kW     kW     kW     kW      kW      kW      kW
Coal         =        141
FuelOil      =       8781            January      0       0    306     0      0      0     306     0      0      0      0      0      0      306     306      0
Gasoil/Diesel=      14774            February     0       0   1613     0      0      0    1613     0      0      0      0      0      0     1613    1613      0
Petrol/JP    =        528            March        0       0    721     0      0      0     721     0      0      0      0      0      0      721     721      0
Gas handling =         52            April        0       0   2612     0      0      0    2612     0      0      0      0      0      0     2612    2612      0
Biomass      =       1849            May          0       0   7389     0      0      0    7389     0      0      0      0      0      0     7389    7389      0
Food income  =          0            June         0       0   9259     0      0      0    9259     0      0      0      0      0      0     9259    9259      0
Waste        =          0            July         0       0   6567     0      0      0    6567     0      0      0      0      0      0     6567    6567      0
                                     August       0       0   1662     0      0      0    1662     0      0      0      0      0      0     1662    1662      0
Total Ngas Exchange costs =    1161  September    0       0   9305     0      0      0    9305     0      0      0      0      0      0     9305    9305      0
                                     October      0       0   3634     0      0      0    3634     0      0      0      0      0      0     3634    3634      0
Marginal operation costs  =      52  November     0       0   3561     0      0      0    3561     0      0      0      0      0      0     3561    3561      0
                                     December     0       0   1916     0      0      0    1916     0      0      0      0      0      0     1916    1916      0
Total Electricity exchange =   -804
Import       =        106            Average      0       0   4035     0      0      0    4035     0      0      0      0      0      0     4035    4035      0
Export       =       -911            Maximum      0       0  23333     0      0      0   23333     0      0      0      0      0      0    23333   23333      0
Bottleneck   =          2            Minimum      0       0      0     0      0      0       0     0      0      0      0      0      0        0       0      0
Fixed imp/ex=           0
                                     Total for the whole year
Total CO2 emission costs =     2499  GWh/year  0.00    0.00  35.45  0.00   0.00   0.00   35.45  0.00   0.00   0.00   0.00   0.00   0.00    35.45   35.45   0.00

Total variable costs  =       29034
Fixed operation costs =       10879

Annual Investment costs =     19649

TOTAL ANNUAL COSTS  =         59561

RES Share:   38.0  Percent of Primary Energ123.1  Percent of Electricity      221.3  GWh electricity from RES                      10-December-2018 [13:29]
```

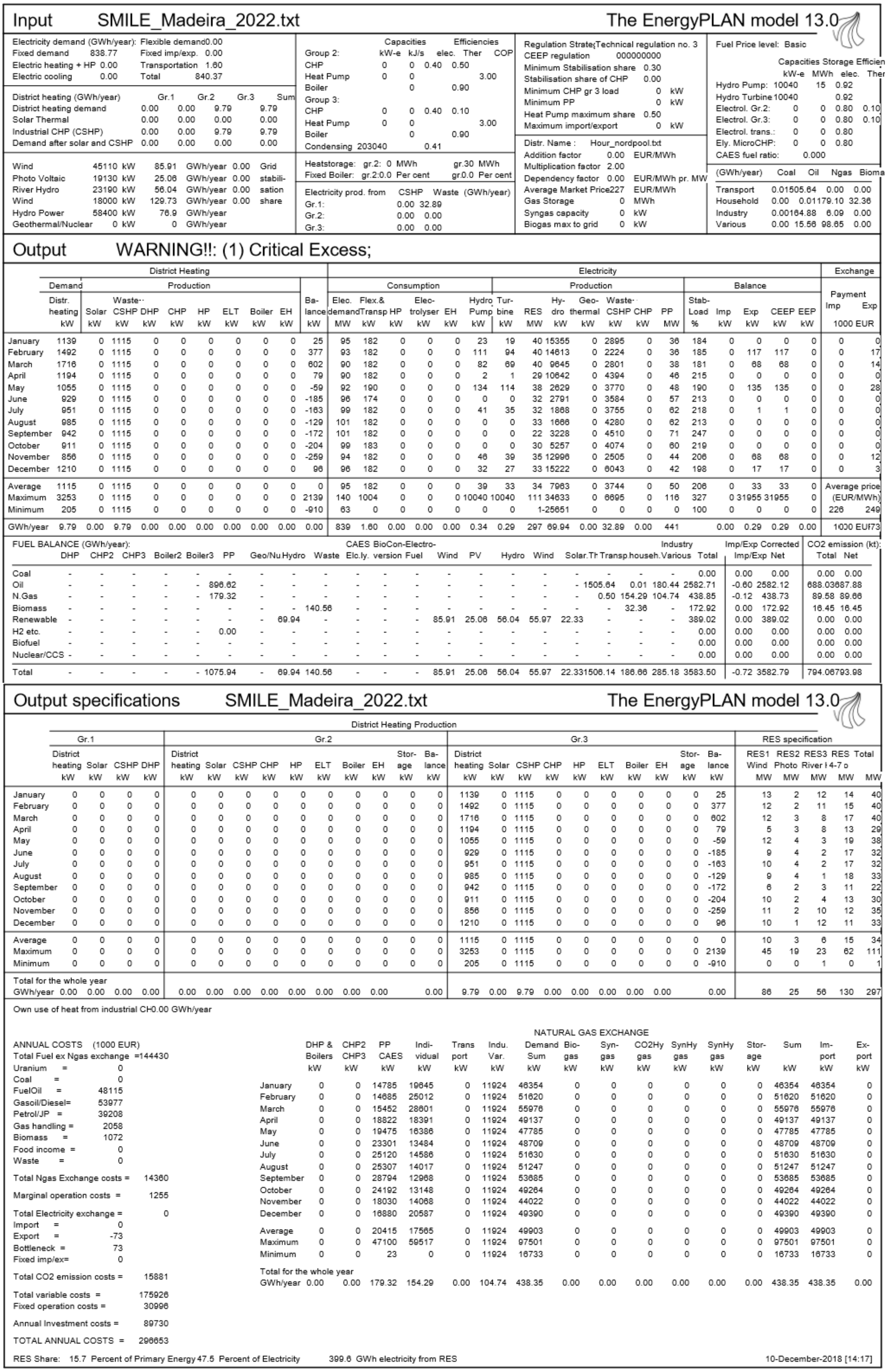
7.3 Madeira EnergyPLAN data sheets for the 2014, 2022 and 2030 scenarios



```
Input        Madeira 2014 Reference update.txt                         The EnergyPLAN model 13.0

Electricity demand (GWh/year):  Flexible demand0.00   |                    Capacities     Efficiencies     | Regulation Strate(Technical regulation no. 1 | Fuel Price level:
Fixed demand       838.78   Fixed imp/exp.   0.00     | Group 2:          kW-e  kJ/s   elec.  Ther  COP  | CEEP regulation          000000000            |
Electric heating + HP 0.00  Transportation   0.10     | CHP                 0     0   0.40   0.50       | Minimum Stabilisation share   0.30            |      Capacities Storage Efficier
Electric cooling     0.00   Total          838.88     | Heat Pump           0     0                3.00 | Stabilisation share of CHP    0.00            |         kW-e   MWh  elec.  Ther
                                                      | Boiler                    0          0.90       | Minimum CHP gr 3 load          0  kW          | Hydro Pump:      0     0   0.80
District heating (GWh/year)   Gr.1   Gr.2   Gr.3   Sum| Group 3:                                        | Minimum PP                     0  kW          | Hydro Turbine:   0         0.90
District heating demand       0.00   0.00   9.79   9.79| CHP                0     0   0.40   0.10       | Heat Pump maximum share       0.50            | Electrol. Gr.2:  0     0   0.80   0.10
Solar Thermal                 0.00   0.00   0.00   0.00| Heat Pump          0     0                3.00 | Maximum import/export          0  kW          | Electrol. Gr.3:  0     0   0.80   0.10
Industrial CHP (CSHP)         0.00   0.00   9.79   9.79| Boiler                   0          0.90       |                                               | Electrol. trans.: 0    0   0.80
Demand after solar and CSHP   0.00   0.00   0.00   0.00| Condensing  203040        0.41                 | Distr. Name :     Hour_nordpool.txt           | Ely. MicroCHP:   0     0   0.80
                                                      |                                                 | Addition factor       0.00   EUR/MWh        | CAES fuel ratio:      0.000
Wind              45110  kW   85.91  GWh/year  0.00  Grid     | Heatstorage:  gr.2:  0  MWh       gr.30  MWh  | Multiplication factor 2.00               |
Photo Voltaic     19080  kW      25  GWh/year  0.00  stabili- | Fixed Boiler:  gr.2:0.0  Per cent  gr.0.0  Per cent | Dependency factor 0.00   EUR/MWh pr. MW | (GWh/year)   Coal    Oil    Ngas   Bioma
River Hydro       26690  kW    64.5  GWh/year  0.00  sation   |                                              | Average Market Price227  EUR/MWh         | Transport    0.01510.89   0.00   0.00
River Hydro           0  kW       0  GWh/year  0.00  share    | Electricity prod. from  CSHP  Waste (GWh/year) | Gas Storage           0  MWh             | Household    0.00   0.01179.10  32.36
Hydro Power       24000  kW    30.8  GWh/year                 | Gr.1:                   0.00  32.89            | Syngas capacity       0  kW              | Industry     0.00164.88   6.09   0.00
Geothermal/Nuclear    0  kW       0  GWh/year                 | Gr.2:                   0.00   0.00            | Biogas max to grid    0  kW              | Various      0.00  15.56  98.65   0.00
                                                              | Gr.3:                   0.00   0.00            |

Output
                              District Heating                                  |                                        Electricity                                                             | Exchange
           Demand |                     Production                        |     |                Consumption                   |                    Production                       |          Balance                 |
           Distr. |       Waste··                                         | Ba- | Elec.  Flex.&      Elec-               Hydro | Tur-          Hy-   Geo-   Waste··            | Stab-                            | Payment
          heating | Solar CSHP DHP  CHP   HP   ELT  Boiler  EH            |lance|demandTransp HP trolyser  EH      Pump | bine   RES    dro  thermal CSHP  CHP    PP   | Load  Imp   Exp  CEEP  EEP       | Imp      Exp
             kW   |  kW    kW   kW   kW   kW    kW    kW    kW           |  kW |  MW    kW    kW    kW     kW      kW   |  kW    kW     kW    kW     kW    kW     MW   |   %    kW    kW    kW    kW       | 1000 EUR
January     1139     0  1115    0    0    0     0     0     0               25     95    11     0     0      0       0       0 28277  6676     0   2895     0     57    223     0     0     0     0        0        0
February    1492     0  1115    0    0    0     0     0     0              377     93    11     0     0      0       0       0 27246  6333     0   2224     0     57    227     0     0     0     0        0        0
March       1716     0  1115    0    0    0     0     0     0              602     90    11     0     0      0       0       0 24386  4477     0   2801     0     59    233     0     0     0     0        0        0
April       1194     0  1115    0    0    0     0     0     0               79     90    11     0     0      0       0       0 17346  4591     0   4394     0     63    253     0     0     0     0        0        0
May         1055     0  1115    0    0    0     0     0     0              -59     92    11     0     0      0       0       0 19657  1663     0   3770     0     67    249     0     0     0     0        0        0
June         929     0  1115    0    0    0     0     0     0             -185     96    11     0     0      0       0       0 15376  1226     0   3584     0     75    267     0     0     0     0        0        0
July         951     0  1115    0    0    0     0     0     0             -163     99    11     0     0      0       0       0 15532   923     0   3755     0     79    269     0     0     0     0        0        0
August       985     0  1115    0    0    0     0     0     0             -129    101    11     0     0      0       0       0 15093   720     0   4280     0     81    269     0     0     0     0        0        0
September    942     0  1115    0    0    0     0     0     0             -172    101    11     0     0      0       0       0 11433  1338     0   4510     0     83    280     0     0     0     0        0        0
October      911     0  1115    0    0    0     0     0     0             -204     99    11     0     0      0       0       0 17096  2195     0   4074     0     75    261     0     0     0     0        0        0
November     856     0  1115    0    0    0     0     0     0             -259     94    11     0     0      0       0       0 23858  5602     0   2505     0     62    240     0     0     0     0        0        0
December    1210     0  1115    0    0    0     0     0     0               96     96    11     0     0      0       0       0 24416  6471     0   6043     0     59    227     0     0     0     0        0        0

Average     1115     0  1115    0    0    0     0     0     0                0     95    11     0     0      0       0       0 19969  3506     0   3744     0     68    250     0     0     0     0    Average price
Maximum     3253     0  1115    0    0    0     0     0     0             2139    140    22     0     0      0       0       0 63655 14086     0   6695     0    119    327     0     0     0     0     (EUR/MWh)
Minimum      205     0  1115    0    0    0     0     0     0             -910     63     0     0     0      0       0       0  1082   401     0      0     0     27    136     0     0     0     0    232      224

GWh/year    9.79  0.00  9.79  0.00 0.00 0.00  0.00  0.00  0.00            0.00    839  0.10  0.00  0.00   0.00    0.00    0.00175.41 30.80  0.00  32.89  0.00    600          0.00  0.00  0.00  0.00     1000 EUR 0

FUEL BALANCE (GWh/year):                                            CAES BioCon-Electro-                                              Industry             Imp/Exp Corrected | CO2 emission (kt):
            DHP  CHP2  CHP3  Boiler2 Boiler3   PP     Geo/Nu.Hydro  Waste  Elc.ly. version Fuel  Wind   PV    Hydro  Hydro  Solar.Th Transp.househ.Various  Total | Imp/Exp   Net   |  Total   Net

Coal         -     -     -      -       -       -        -     -      -       -      -      -     -      -      -      -       -       -       -        -     0.00  |  0.00    0.00   |  0.00   0.00
Oil          -     -     -      -       -  1219.07       -     -      -       -      -      -     -      -      -      -       -   1510.89    0.01  180.44  2910.41 |  0.00 2910.41   | 775.33775.33
N.Gas        -     -     -      -       -   243.81       -     -      -       -      -      -     -      -      -      -       -      0.50  154.29  104.74   503.34 |  0.00  503.34   | 102.75102.85
Biomass      -     -     -      -       -       -        -     -   140.56     -      -      -     -      -      -      -       -       -     32.36       -   172.92 |  0.00  172.92   |  16.45  16.45
Renewable    -     -     -      -       -       -        -  30.80     -       -      -      -   85.91  25.00  64.50    -     22.33     -       -        -   228.54 |  0.00  228.54   |  0.00   0.00
H2 etc.      -     -     -      -       -     0.00       -     -      -       -      -      -     -      -      -      -       -       -       -        -     0.00  |  0.00    0.00   |  0.00   0.00
Biofuel      -     -     -      -       -       -        -     -      -       -      -      -     -      -      -      -       -       -       -        -     0.00  |  0.00    0.00   |  0.00   0.00
Nuclear/CCS -     -     -      -       -       -        -     -      -       -      -      -     -      -      -      -       -       -       -        -     0.00  |  0.00    0.00   |  0.00   0.00

Total        -     -     -      -       -  1462.89       -  30.80  140.56     -      -      -   85.91  25.00  64.50    -     22.331511.39  186.66  285.18  3815.21 |  0.00 3815.21   | 894.53894.63
```



```
Output specifications        Madeira 2014 Reference update.txt                      The EnergyPLAN model 13.0

                                                         District Heating Production
             Gr.1                   |                         Gr.2                                  |                         Gr.3                                  |       RES specification
          District                  | District                                      Stor-  Ba-      | District                                      Stor-  Ba-      | RES1  RES2  RES3  RES  Total
          heating Solar CSHP DHP    | heating Solar CSHP CHP  HP   ELT  Boiler EH   age   lance     | heating Solar CSHP CHP  HP   ELT  Boiler EH   age   lance     | Wind  Photo River I 4-7 o
            kW     kW    kW   kW    |   kW     kW    kW   kW  kW    kW    kW   kW   kW     kW      |   kW     kW    kW   kW  kW    kW    kW   kW   kW     kW      |  kW    kW    kW    kW    kW
January      0      0     0    0        0      0     0    0   0     0     0    0    0      0         1139     0  1115    0   0     0     0    0    0     25        12819  1845 13612     0 28277
February     0      0     0    0        0      0     0    0   0     0     0    0    0      0         1492     0  1115    0   0     0     0    0    0    377        11765  2379 13102     0 27246
March        0      0     0    0        0      0     0    0   0     0     0    0    0      0         1716     0  1115    0   0     0     0    0    0    602        11812  3170  9405     0 24386
April        0      0     0    0        0      0     0    0   0     0     0    0    0      0         1194     0  1115    0   0     0     0    0    0     79         4651  3090  9605     0 17346
May          0      0     0    0        0      0     0    0   0     0     0    0    0      0         1055     0  1115    0   0     0     0    0    0    -59        11800  4165  3692     0 19657
June         0      0     0    0        0      0     0    0   0     0     0    0    0      0          929     0  1115    0   0     0     0    0    0   -185         8896  3746  2733     0 15376
July         0      0     0    0        0      0     0    0   0     0     0    0    0      0          951     0  1115    0   0     0     0    0    0   -163         9715  3745  2072     0 15532
August       0      0     0    0        0      0     0    0   0     0     0    0    0      0          985     0  1115    0   0     0     0    0    0   -129         9223  4246  1624     0 15093
September    0      0     0    0        0      0     0    0   0     0     0    0    0      0          942     0  1115    0   0     0     0    0    0   -172         6310  2174  2949     0 11433
October      0      0     0    0        0      0     0    0   0     0     0    0    0      0          911     0  1115    0   0     0     0    0    0   -204        10013  2285  4798     0 17096
November     0      0     0    0        0      0     0    0   0     0     0    0    0      0          856     0  1115    0   0     0     0    0    0   -259        10620  1762 11476     0 23858
December     0      0     0    0        0      0     0    0   0     0     0    0    0      0         1210     0  1115    0   0     0     0    0    0     96         9586  1494 13336     0 24416

Average      0      0     0    0        0      0     0    0   0     0     0    0    0      0         1115     0  1115    0   0     0     0    0    0      0         9780  2846  7343     0 19969
Maximum      0      0     0    0        0      0     0    0   0     0     0    0    0      0         3253     0  1115    0   0     0     0    0    0   2139        45110 19080 26690     0 63655
Minimum      0      0     0    0        0      0     0    0   0     0     0    0    0      0          205     0  1115    0   0     0     0    0    0   -910           21     0   909     0  1082

Total for the whole year
GWh/year  0.00   0.00  0.00  0.00    0.00   0.00  0.00 0.00 0.00  0.00  0.00 0.00         0.00       9.79  0.00  9.79 0.00 0.00  0.00  0.00 0.00          0.00        85.91 25.00 64.50  0.00175.41

Own use of heat from industrial CH0.00 GWh/year

                                                                                              NATURAL GAS EXCHANGE
ANNUAL COSTS    (1000 EUR)                       DHP &   CHP2    PP     Indi-   Trans  Indu.  Demand  Bio-   Syn-   CO2Hy  SynHy  SynHy  Stor-   Sum    Im-    Ex-
Total Fuel ex Ngas exchange  =158982             Boilers CHP3   CAES    vidual  port   Var.    Sum    gas    gas    gas    gas    gas    age            port   port
Uranium      =            0                        kW     kW     kW      kW      kW     kW     kW     kW     kW     kW     kW     kW     kW     kW      kW     kW
Coal         =            0
FuelOil      =        62233           January       0      0   23097   19645     0   11924   54665    0      0      0      0      0      0   54665   54665    0
Gasoil/Diesel=        54045           February      0      0   23244   25012     0   11924   60179    0      0      0      0      0      0   60179   60179    0
Petrol/JP    =        39479           March         0      0   23880   28601     0   11924   64404    0      0      0      0      0      0   64404   64404    0
Gas handling =         2153           April         0      0   25809   18391     0   11924   56123    0      0      0      0      0      0   56123   56123    0
Biomass      =         1072           May           0      0   27300   16386     0   11924   55610    0      0      0      0      0      0   55610   55610    0
Food income  =            0           June          0      0   30629   13484     0   11924   56037    0      0      0      0      0      0   56037   56037    0
Waste        =            0           July          0      0   32154   14586     0   11924   58664    0      0      0      0      0      0   58664   58664    0
                                      August        0      0   32985   14017     0   11924   58925    0      0      0      0      0      0   58925   58925    0
Total Ngas Exchange costs =   16473   September     0      0   33884   12968     0   11924   58776    0      0      0      0      0      0   58776   58776    0
                                      October       0      0   30602   13148     0   11924   55673    0      0      0      0      0      0   55673   55673    0
Marginal operation costs  =    1618   November      0      0   25331   14068     0   11924   51323    0      0      0      0      0      0   51323   51323    0
                                      December      0      0   24024   20587     0   11924   56534    0      0      0      0      0      0   56534   56534    0
Total Electricity exchange =      0
Import       =            0           Average       0      0   27757   17565     0   11924   57245    0      0      0      0      0      0   57245   57245    0
Export       =            0           Maximum       0      0   48173   59517     0   11924   99435    0      0      0      0      0      0   99435   99435    0
Bottleneck   =            0           Minimum       0      0   10827       0     0   11924   27657    0      0      0      0      0      0   27657   27657    0
Fixed imp/ex=             0
                                      Total for the whole year
Total CO2 emission costs =    25583   GWh/year   0.00   0.00  243.81  154.29   0.00  104.74  502.84  0.00   0.00   0.00   0.00   0.00   0.00  502.84  502.84  0.00

Total variable costs  =      202656
Fixed operation costs =       34111

Annual Investment costs =     78954

TOTAL ANNUAL COSTS  =        315721

RES Share:   10.5  Percent of Primary Energy 28.5  Percent of Electricity      239.1  GWh electricity from RES                       06-December-2018 [13:05]
```



Input SMILE_Madeira_2022.txt

The EnergyPLAN model 13.0

Electricity demand (GWh/year): Flexible demand0.00
Fixed demand 838.77 Fixed imp/exp. 0.00
Electric heating + HP 0.00 Transportation 1.60
Electric cooling 0.00 Total 840.37

District heating (GWh/year)	Gr.1	Gr.2	Gr.3	Sum
District heating demand	0.00	0.00	9.79	9.79
Solar Thermal	0.00	0.00	0.00	0.00
Industrial CHP (CSHP)	0.00	0.00	9.79	9.79
Demand after solar and CSHP	0.00	0.00	0.00	0.00

Wind	45110	kW	85.91	GWh/year	0.00	Grid
Photo Voltaic	19130	kW	25.06	GWh/year	0.00	stabili-
River Hydro	23190	kW	56.04	GWh/year	0.00	sation
Wind	18000	kW	129.73	GWh/year	0.00	share
Hydro Power	58400	kW	76.9	GWh/year		
Geothermal/Nuclear	0	kW	0	GWh/year		

	Capacities kW-e	Capacities kJ/s	Efficiencies elec.	Efficiencies Ther	Efficiencies COP
Group 2:					
CHP	0	0	0.40	0.50	
Heat Pump	0	0			3.00
Boiler		0		0.90	
Group 3:					
CHP	0	0	0.40	0.10	
Heat Pump	0	0			3.00
Boiler		0		0.90	
Condensing	203040		0.41		

Heatstorage: gr.2: 0 MWh gr.30 MWh
Fixed Boiler: gr.2:0.0 Per cent gr.0.0 Per cent

Electricity prod. from	CSHP	Waste (GWh/year)
Gr.1:	0.00	32.89
Gr.2:	0.00	0.00
Gr.3:	0.00	0.00

Regulation Strate(Technical regulation no. 3
CEEP regulation 000000000
Minimum Stabilisation share 0.30
Stabilisation share of CHP 0.00
Minimum CHP gr 3 load 0 kW
Minimum PP 0 kW
Heat Pump maximum share 0.50
Maximum import/export 0 kW

Distr. Name : Hour_nordpool.txt
Addition factor 0.00 EUR/MWh
Multiplication factor 2.00
Dependency factor 0.00 EUR/MWh pr. MW
Average Market Price227 EUR/MWh
Gas Storage 0 MWh
Syngas capacity 0 kW
Biogas max to grid 0 kW

Fuel Price level: Basic

	Capacities kW-e	Storage MWh	Efficien elec.	Ther
Hydro Pump:	10040	15	0.92	
Hydro Turbine	10040		0.92	
Electrol. Gr.2:	0	0	0.80	0.10
Electrol. Gr.3:	0	0	0.80	0.10
Electrol. trans.:	0	0	0.80	
Ely. MicroCHP:	0	0	0.80	

CAES fuel ratio: 0.000

(GWh/year) Coal Oil Ngas Bioma
Transport 0.01505.64 0.00 0.00
Household 0.00 0.01179.10 32.36
Industry 0.00164.88 6.09 0.00
Various 0.00 15.56 98.65 0.00

Output WARNING!!: (1) Critical Excess;

District Heating

	Demand Distr. heating kW	Production Solar kW	Production Waste-CSHP kW	Production DHP kW	Production CHP kW	Production HP kW	Production ELT kW	Production Boiler kW	Production EH kW	Balance kW
January	1139	0	1115	0	0	0	0	0	0	25
February	1492	0	1115	0	0	0	0	0	0	377
March	1716	0	1115	0	0	0	0	0	0	602
April	1194	0	1115	0	0	0	0	0	0	79
May	1055	0	1115	0	0	0	0	0	0	-59
June	929	0	1115	0	0	0	0	0	0	-185
July	951	0	1115	0	0	0	0	0	0	-163
August	985	0	1115	0	0	0	0	0	0	-129
September	942	0	1115	0	0	0	0	0	0	-172
October	911	0	1115	0	0	0	0	0	0	-204
November	856	0	1115	0	0	0	0	0	0	-259
December	1210	0	1115	0	0	0	0	0	0	96
Average	1115	0	1115	0	0	0	0	0	0	0
Maximum	3253	0	1115	0	0	0	0	0	0	2139
Minimum	205	0	1115	0	0	0	0	0	0	-910
GWh/year	9.79	0.00	9.79	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Electricity

	Consumption Elec. demand MW	Consumption Flex.& Transp kW	Consumption HP kW	Consumption Elec-trolyser kW	Consumption EH kW	Consumption Hydro Pump kW	Production Tur-bine kW	Production RES MW	Production Hy-dro kW	Production Geo-thermal kW	Production Waste-CSHP kW	Production CHP kW	Production PP MW
January	95	182	0	0	0	23	19	40	15355	0	2895	0	36
February	93	182	0	0	0	111	94	40	14613	0	2224	0	36
March	90	182	0	0	0	82	69	40	9645	0	2801	0	38
April	90	182	0	0	0	2	1	29	10642	0	4394	0	46
May	92	190	0	0	0	134	114	38	2629	0	3770	0	48
June	96	174	0	0	0	0	0	32	2791	0	3584	0	57
July	99	182	0	0	0	41	35	32	1868	0	3755	0	62
August	101	182	0	0	0	0	0	33	1666	0	4280	0	62
September	101	182	0	0	0	0	0	22	3228	0	4510	0	71
October	99	183	0	0	0	0	0	30	5257	0	4074	0	60
November	94	182	0	0	0	46	39	35	12996	0	2505	0	44
December	96	182	0	0	0	32	27	33	15222	0	6043	0	42
Average	95	182	0	0	0	39	33	34	7963	0	3744	0	50
Maximum	140	1004	0	0	0	10040	10040	111	34633	0	6695	0	116
Minimum	63	0	0	0	0	0	0	1	-25651	0	0	0	0
GWh/year	839	1.60	0.00	0.00	0.00	0.34	0.29	297	69.94	0.00	32.89	0.00	441

	Balance Stab-Load %	Balance Imp kW	Balance Exp kW	Balance CEEP kW	Balance EEP kW	Exchange Payment Imp 1000 EUR	Exchange Payment Exp 1000 EUR
January	184	0	0	0	0	0	0
February	185	0	117	117	0	0	17
March	181	0	68	68	0	0	14
April	215	0	0	0	0	0	0
May	190	0	135	135	0	0	28
June	213	0	0	0	0	0	0
July	218	0	1	1	0	0	0
August	213	0	0	0	0	0	0
September	247	0	0	0	0	0	0
October	219	0	0	0	0	0	0
November	206	0	68	68	0	0	12
December	198	0	17	17	0	0	3
Average	206	0	33	33	0	Average price	
Maximum	327	0	31955	31955	0	(EUR/MWh)	
Minimum	100	0	0	0	0	226	249
GWh/year		0.00	0.29	0.29	0.00	1000 EUF73	

FUEL BALANCE (GWh/year):

	DHP	CHP2	CHP3	Boiler2	Boiler3	PP	Geo/Nu.	Hydro	Waste	CAES Elc.ly.	BioCon-version	Electro-Fuel	Wind	PV	Hydro	Wind	Solar.Th	Transp.	househ.	Industry Various	Total	Imp/Exp Corrected Imp/Exp	Net	CO2 emission (kt): Total	Net
Coal	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.00	0.00	0.00	0.00	0.00
Oil	-	-	-	-	-	896.62	-	-	-	-	-	-	-	-	-	-	-	1505.64	0.01	180.44	2582.71	-0.60	2582.12	688.03	687.88
N.Gas	-	-	-	-	-	179.32	-	-	-	-	-	-	-	-	-	-	-	0.50	154.29	104.74	438.85	-0.12	438.73	89.58	89.66
Biomass	-	-	-	-	-	-	-	-	140.56	-	-	-	-	-	-	-	-	-	32.36	-	172.92	0.00	172.92	16.45	16.45
Renewable	-	-	-	-	-	-	-	69.94	-	-	-	-	85.91	25.06	56.04	55.97	22.33	-	-	-	389.02	0.00	389.02	0.00	0.00
H2 etc.	-	-	-	-	-	0.00	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.00	0.00	0.00	0.00	0.00
Biofuel	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.00	0.00	0.00	0.00	0.00
Nuclear/CCS	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.00	0.00	0.00	0.00	0.00
Total	-	-	-	-	-	1075.94	-	69.94	140.56	-	-	-	85.91	25.06	56.04	55.97	22.33	1506.14	186.66	285.18	3583.50	-0.72	3582.79	794.06	793.98

Output specifications SMILE_Madeira_2022.txt

The EnergyPLAN model 13.0

District Heating Production

	Gr.1 District heating kW	Gr.1 Solar kW	Gr.1 CSHP kW	Gr.1 DHP kW	Gr.2 District heating kW	Gr.2 Solar kW	Gr.2 CSHP kW	Gr.2 CHP kW	Gr.2 HP kW	Gr.2 ELT kW	Gr.2 Boiler kW	Gr.2 EH kW	Gr.2 Stor-age kW	Gr.2 Ba-lance kW
January	0	0	0	0	0	0	0	0	0	0	0	0	0	0
February	0	0	0	0	0	0	0	0	0	0	0	0	0	0
March	0	0	0	0	0	0	0	0	0	0	0	0	0	0
April	0	0	0	0	0	0	0	0	0	0	0	0	0	0
May	0	0	0	0	0	0	0	0	0	0	0	0	0	0
June	0	0	0	0	0	0	0	0	0	0	0	0	0	0
July	0	0	0	0	0	0	0	0	0	0	0	0	0	0
August	0	0	0	0	0	0	0	0	0	0	0	0	0	0
September	0	0	0	0	0	0	0	0	0	0	0	0	0	0
October	0	0	0	0	0	0	0	0	0	0	0	0	0	0
November	0	0	0	0	0	0	0	0	0	0	0	0	0	0
December	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Average	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Maximum	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Minimum	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total for the whole year GWh/year	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		0.00

	Gr.3 District heating kW	Gr.3 Solar kW	Gr.3 CSHP kW	Gr.3 CHP kW	Gr.3 HP kW	Gr.3 ELT kW	Gr.3 Boiler kW	Gr.3 EH kW	Gr.3 Stor-age kW	Gr.3 Ba-lance kW	RES specification RES1 Wind MW	RES2 Photo MW	RES3 River I MW	RES 4-7 MW	Total o MW
January	1139	0	1115	0	0	0	0	0	0	25	13	2	12	14	40
February	1492	0	1115	0	0	0	0	0	0	377	12	2	11	15	40
March	1716	0	1115	0	0	0	0	0	0	602	12	3	8	17	40
April	1194	0	1115	0	0	0	0	0	0	79	5	3	8	13	29
May	1055	0	1115	0	0	0	0	0	0	-59	12	4	3	19	38
June	929	0	1115	0	0	0	0	0	0	-185	9	4	2	17	32
July	951	0	1115	0	0	0	0	0	0	-163	10	4	2	17	32
August	985	0	1115	0	0	0	0	0	0	-129	9	4	1	18	33
September	942	0	1115	0	0	0	0	0	0	-172	6	2	3	11	22
October	911	0	1115	0	0	0	0	0	0	-204	10	2	4	13	30
November	856	0	1115	0	0	0	0	0	0	-259	11	2	10	12	35
December	1210	0	1115	0	0	0	0	0	0	96	10	1	12	11	33
Average	1115	0	1115	0	0	0	0	0	0	0	10	3	6	15	34
Maximum	3253	0	1115	0	0	0	0	0	0	2139	45	19	23	62	111
Minimum	205	0	1115	0	0	0	0	0	0	-910	0	0	1	0	1
Total for the whole year GWh/year	9.79	0.00	9.79	0.00	0.00	0.00	0.00	0.00		0.00	86	25	56	130	297

Own use of heat from industrial CH0.00 GWh/year

ANNUAL COSTS (1000 EUR)
Total Fuel ex Ngas exchange =144430
Uranium = 0
Coal = 0
FuelOil = 48115
Gasoil/Diesel= 53977
Petrol/JP = 39208
Gas handling = 2058
Biomass = 1072
Food income = 0
Waste = 0

Total Ngas Exchange costs = 14360

Marginal operation costs = 1255

Total Electricity exchange = 0
Import = 0
Export = -73
Bottleneck = 73
Fixed imp/ex= 0

Total CO2 emission costs = 15881

Total variable costs = 175926
Fixed operation costs = 30996

Annual Investment costs = 89730

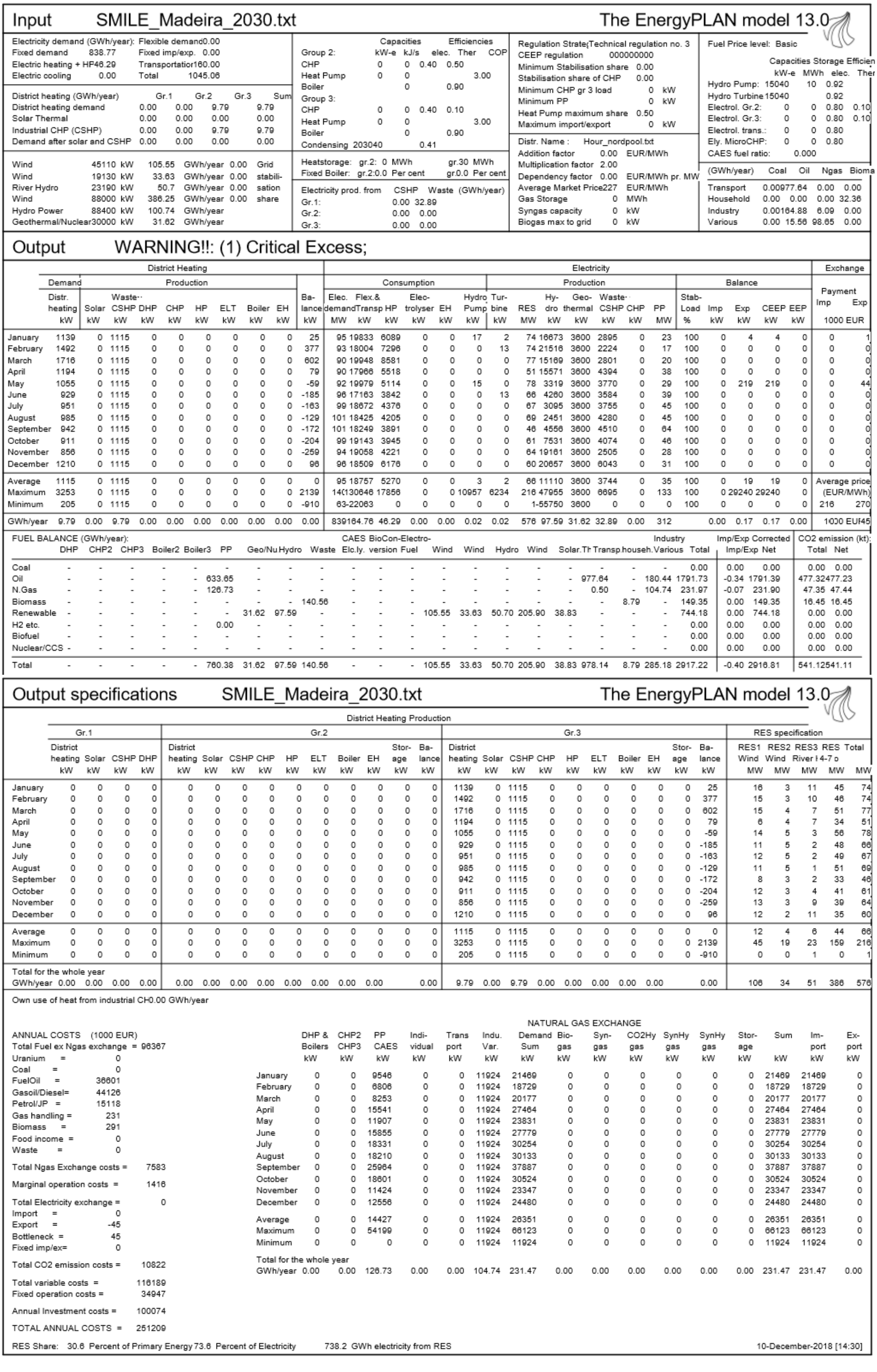
TOTAL ANNUAL COSTS = 296653

NATURAL GAS EXCHANGE

	DHP & Boilers kW	CHP2 CHP3 kW	PP CAES kW	Indi-vidual kW	Trans port kW	Indu. Var. kW	Demand Sum kW	Bio-gas kW	Syn-gas kW	CO2Hy gas kW	SynHy gas kW	SynHy gas kW	Stor-age kW	Sum kW	Im-port kW	Ex-port kW
January	0	0	14785	19645	0	11924	46354	0	0	0	0	0	0	46354	46354	0
February	0	0	14685	25012	0	11924	51620	0	0	0	0	0	0	51620	51620	0
March	0	0	15452	28601	0	11924	55976	0	0	0	0	0	0	55976	55976	0
April	0	0	18822	18391	0	11924	49137	0	0	0	0	0	0	49137	49137	0
May	0	0	19475	16386	0	11924	47785	0	0	0	0	0	0	47785	47785	0
June	0	0	23301	13484	0	11924	48709	0	0	0	0	0	0	48709	48709	0
July	0	0	25120	14586	0	11924	51630	0	0	0	0	0	0	51630	51630	0
August	0	0	25307	14017	0	11924	51247	0	0	0	0	0	0	51247	51247	0
September	0	0	28794	12968	0	11924	53685	0	0	0	0	0	0	53685	53685	0
October	0	0	24192	13148	0	11924	49264	0	0	0	0	0	0	49264	49264	0
November	0	0	18030	14068	0	11924	44022	0	0	0	0	0	0	44022	44022	0
December	0	0	16880	20587	0	11924	49390	0	0	0	0	0	0	49390	49390	0
Average	0	0	20415	17565	0	11924	49903	0	0	0	0	0	0	49903	49903	0
Maximum	0	0	47100	59517	0	11924	97501	0	0	0	0	0	0	97501	97501	0
Minimum	0	0	23	0	0	11924	16733	0	0	0	0	0	0	16733	16733	0
Total for the whole year GWh/year	0.00	0.00	179.32	154.29	0.00	104.74	438.35	0.00	0.00	0.00	0.00	0.00	0.00	438.35	438.35	0.00

RES Share: 15.7 Percent of Primary Energy 47.5 Percent of Electricity 399.6 GWh electricity from RES

10-December-2018 [14:17]



Input SMILE_Madeira_2030.txt — The EnergyPLAN model 13.0

Electricity demand (GWh/year):		Flexible demand	0.00
Fixed demand	838.77	Fixed imp/exp.	0.00
Electric heating + HP	46.29	Transportatior	160.00
Electric cooling	0.00	Total	1045.06

District heating (GWh/year)	Gr.1	Gr.2	Gr.3	Sum
District heating demand	0.00	0.00	9.79	9.79
Solar Thermal	0.00	0.00	0.00	0.00
Industrial CHP (CSHP)	0.00	0.00	9.79	9.79
Demand after solar and CSHP	0.00	0.00	0.00	0.00

Wind	45110	kW	105.55	GWh/year	0.00	Grid
Wind	19130	kW	33.63	GWh/year	0.00	stabili-
River Hydro	23190	kW	50.7	GWh/year	0.00	sation
Wind	88000	kW	386.25	GWh/year	0.00	share
Hydro Power	88400	kW	100.74	GWh/year		
Geothermal/Nuclear	30000	kW	31.62	GWh/year		

	Capacities kW-e	Capacities kJ/s	Efficiencies elec.	Efficiencies Ther	COP
Group 2:					
CHP	0	0	0.40	0.50	
Heat Pump	0	0			3.00
Boiler		0		0.90	
Group 3:					
CHP	0	0	0.40	0.10	
Heat Pump	0	0			3.00
Boiler		0		0.90	
Condensing	203040		0.41		

Heatstorage: gr.2: 0 MWh gr.30 MWh

Fixed Boiler: gr.2:0.0 Per cent gr.0.0 Per cent

Electricity prod. from	CSHP	Waste (GWh/year)
Gr.1:	0.00	32.89
Gr.2:	0.00	0.00
Gr.3:	0.00	0.00

Regulation Strate;Technical regulation no. 3		
CEEP regulation	000000000	
Minimum Stabilisation share	0.00	
Stabilisation share of CHP	0.00	
Minimum CHP gr 3 load	0	kW
Minimum PP	0	kW
Heat Pump maximum share	0.50	
Maximum import/export	0	kW

Distr. Name :	Hour_nordpool.txt	
Addition factor	0.00	EUR/MWh
Multiplication factor	2.00	
Dependency factor	0.00	EUR/MWh pr. MW
Average Market Price	227	EUR/MWh
Gas Storage	0	MWh
Syngas capacity	0	kW
Biogas max to grid	0	kW

Fuel Price level: Basic

	Capacities kW-e	Storage MWh	Efficien elec.	Ther
Hydro Pump:	15040	10	0.92	
Hydro Turbine	15040		0.92	
Electrol. Gr.2:	0	0	0.80	0.10
Electrol. Gr.3:	0	0	0.80	0.10
Electrol. trans.:	0	0	0.80	
Ely. MicroCHP:	0	0	0.80	
CAES fuel ratio:		0.000		

(GWh/year)	Coal	Oil	Ngas	Bioma
Transport	0.00	977.64	0.00	0.00
Household	0.00	0.00	0.00	32.36
Industry	0.00	164.88	6.09	0.00
Various	0.00	15.56	98.65	0.00

Output WARNING!!: (1) Critical Excess;

	District Heating										Electricity																		Exchange	
	Demand	Production									Consumption						Production							Balance					Payment	
	Distr. heating kW	Solar kW	Waste-CSHP kW	DHP kW	CHP kW	HP kW	ELT kW	Boiler kW	EH kW	Ba-lance kW	Elec. demand MW	Flex.& Transp kW	HP kW	Elec-trolyser kW	EH kW	Hydro Pump kW	Tur-bine kW	RES MW	Hy-dro kW	Geo-thermal kW	Waste-CSHP kW	CHP kW	PP MW	Stab-Load %	Imp kW	Exp kW	CEEP kW	EEP kW	Imp 1000 EUR	Exp
January	1139	0	1115	0	0	0	0	0	0	25	95	19833	6089	0	0	17	2	74	16673	3600	2895	0	23	100	0	4	4	0	0	1
February	1492	0	1115	0	0	0	0	0	0	377	93	18004	7296	0	0	0	13	74	21516	3600	2224	0	17	100	0	0	0	0	0	0
March	1716	0	1115	0	0	0	0	0	0	602	90	19948	8581	0	0	0	0	77	15169	3600	2801	0	20	100	0	0	0	0	0	0
April	1194	0	1115	0	0	0	0	0	0	79	90	17966	5518	0	0	0	0	51	15571	3600	4394	0	38	100	0	0	0	0	0	0
May	1055	0	1115	0	0	0	0	0	0	-59	92	19979	5114	0	0	15	0	78	3319	3600	3770	0	29	100	0	219	219	0	0	44
June	929	0	1115	0	0	0	0	0	0	-185	96	17163	3842	0	0	0	13	66	4260	3600	3584	0	39	100	0	0	0	0	0	0
July	951	0	1115	0	0	0	0	0	0	-163	99	18672	4376	0	0	0	0	67	3095	3600	3755	0	45	100	0	0	0	0	0	0
August	985	0	1115	0	0	0	0	0	0	-129	101	18425	4205	0	0	0	0	69	2451	3600	4280	0	45	100	0	0	0	0	0	0
September	942	0	1115	0	0	0	0	0	0	-172	101	18249	3891	0	0	0	0	46	4556	3600	4510	0	64	100	0	0	0	0	0	0
October	911	0	1115	0	0	0	0	0	0	-204	99	19143	3945	0	0	0	0	61	7531	3600	4074	0	46	100	0	0	0	0	0	0
November	856	0	1115	0	0	0	0	0	0	-259	94	19058	4221	0	0	0	0	64	19161	3600	2505	0	28	100	0	0	0	0	0	0
December	1210	0	1115	0	0	0	0	0	0	96	96	18509	6176	0	0	0	0	60	20657	3600	6043	0	31	100	0	0	0	0	0	0
Average	1115	0	1115	0	0	0	0	0	0	0	95	18757	5270	0	0	3	2	66	11110	3600	3744	0	35	100	0	19	19	0	Average price	
Maximum	3253	0	1115	0	0	0	0	0	0	2139	14(	130646	17856	0	0	10957	6234	216	47955	3600	6695	0	133	100	0	29240	29240	0	(EUR/MWh)	
Minimum	205	0	1115	0	0	0	0	0	0	-910	63	-22063	0	0	0	0	0	1	-55750	3600	0	0	0	100	0	0	0	0	216	270
GWh/year	9.79	0.00	9.79	0.00	0.00	0.00	0.00	0.00	0.00	0.00	839	164.76	46.29	0.00	0.00	0.02	0.02	576	97.59	31.62	32.89	0.00	312		0.00	0.17	0.17	0.00	1000 EUF	45

FUEL BALANCE (GWh/year):

	DHP	CHP2	CHP3	Boiler2	Boiler3	PP	Geo/Nu.	Hydro	Waste	CAES Elc.ly.	BioCon-version	Electro-Fuel	Wind	Wind	Hydro	Wind	Solar.Th	Transp.	Industry househ.	Various	Total	Imp/Exp Corrected Imp/Exp	Net	CO2 emission (kt): Total	Net
Coal	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.00	0.00	0.00	0.00	0.00
Oil	-	-	-	-	-	633.65	-	-	-	-	-	-	-	-	-	-	-	977.64	-	180.44	1791.73	-0.34	1791.39	477.32	477.23
N.Gas	-	-	-	-	-	126.73	-	-	-	-	-	-	-	-	-	-	-	0.50	-	104.74	231.97	-0.07	231.90	47.35	47.44
Biomass	-	-	-	-	-	-	-	-	140.56	-	-	-	-	-	-	-	-	-	8.79	-	149.35	0.00	149.35	16.45	16.45
Renewable	-	-	-	-	-	-	31.62	97.59	-	-	-	-	105.55	33.63	50.70	205.90	38.83	-	-	-	744.18	0.00	744.18	0.00	0.00
H2 etc.	-	-	-	-	-	0.00	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.00	0.00	0.00	0.00	0.00
Biofuel	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.00	0.00	0.00	0.00	0.00
Nuclear/CCS	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.00	0.00	0.00	0.00	0.00
Total	-	-	-	-	-	760.38	31.62	97.59	140.56	-	-	-	105.55	33.63	50.70	205.90	38.83	978.14	8.79	285.18	2917.22	-0.40	2916.81	541.12	541.11

Output specifications SMILE_Madeira_2030.txt — The EnergyPLAN model 13.0

District Heating Production

	Gr.1				Gr.2										Gr.3										RES specification				
	District heating kW	Solar kW	CSHP kW	DHP kW	District heating kW	Solar kW	CSHP kW	CHP kW	HP kW	ELT kW	Boiler kW	EH kW	Stor-age kW	Ba-lance kW	District heating kW	Solar kW	CSHP kW	CHP kW	HP kW	ELT kW	Boiler kW	EH kW	Stor-age kW	Ba-lance kW	RES1 Wind MW	RES2 Wind MW	RES3 River I MW	RES 4-7 o MW	Total MW
January	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1139	0	1115	0	0	0	0	0	0	25	16	3	11	45	74
February	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1492	0	1115	0	0	0	0	0	0	377	15	3	10	46	74
March	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1716	0	1115	0	0	0	0	0	0	602	15	4	7	51	77
April	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1194	0	1115	0	0	0	0	0	0	79	6	4	7	34	51
May	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1055	0	1115	0	0	0	0	0	0	-59	14	5	3	56	78
June	0	0	0	0	0	0	0	0	0	0	0	0	0	0	929	0	1115	0	0	0	0	0	0	-185	11	5	2	48	66
July	0	0	0	0	0	0	0	0	0	0	0	0	0	0	951	0	1115	0	0	0	0	0	0	-163	12	5	2	49	67
August	0	0	0	0	0	0	0	0	0	0	0	0	0	0	985	0	1115	0	0	0	0	0	0	-129	11	5	1	51	69
September	0	0	0	0	0	0	0	0	0	0	0	0	0	0	942	0	1115	0	0	0	0	0	0	-172	8	3	2	33	46
October	0	0	0	0	0	0	0	0	0	0	0	0	0	0	911	0	1115	0	0	0	0	0	0	-204	12	3	4	41	61
November	0	0	0	0	0	0	0	0	0	0	0	0	0	0	856	0	1115	0	0	0	0	0	0	-259	13	3	9	39	64
December	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1210	0	1115	0	0	0	0	0	0	96	12	2	11	35	60
Average	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1115	0	1115	0	0	0	0	0	0	0	12	4	6	44	66
Maximum	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3253	0	1115	0	0	0	0	0	0	2139	45	19	23	159	216
Minimum	0	0	0	0	0	0	0	0	0	0	0	0	0	0	205	0	1115	0	0	0	0	0	0	-910	0	0	1	0	1
Total for the whole year GWh/year	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		0.00	9.79	0.00	9.79	0.00	0.00	0.00	0.00	0.00		0.00	106	34	51	386	576

Own use of heat from industrial CH0.00 GWh/year

ANNUAL COSTS (1000 EUR)

Total Fuel ex Ngas exchange = 96367

Uranium	=	0
Coal	=	0
FuelOil	=	36601
Gasoil/Diesel	=	44126
Petrol/JP	=	15118
Gas handling	=	231
Biomass	=	291
Food income	=	0
Waste	=	0

Total Ngas Exchange costs = 7583

Marginal operation costs = 1416

Total Electricity exchange = 0

Import	=	0
Export	=	-45
Bottleneck	=	45
Fixed imp/ex	=	0

Total CO2 emission costs = 10822

Total variable costs = 116189

Fixed operation costs = 34947

Annual Investment costs = 100074

TOTAL ANNUAL COSTS = 251209

NATURAL GAS EXCHANGE

	DHP & Boilers kW	CHP2 CHP3 kW	PP CAES kW	Indi-vidual kW	Trans port kW	Indu. Var. kW	Demand Sum kW	Bio-gas kW	Syn-gas kW	CO2Hy gas kW	SynHy gas kW	SynHy gas kW	Stor-age kW	Sum kW	Im-port kW	Ex-port kW
January	0	0	9546	0	0	11924	21469	0	0	0	0	0	0	21469	21469	0
February	0	0	6806	0	0	11924	18729	0	0	0	0	0	0	18729	18729	0
March	0	0	8253	0	0	11924	20177	0	0	0	0	0	0	20177	20177	0
April	0	0	15541	0	0	11924	27464	0	0	0	0	0	0	27464	27464	0
May	0	0	11907	0	0	11924	23831	0	0	0	0	0	0	23831	23831	0
June	0	0	15855	0	0	11924	27779	0	0	0	0	0	0	27779	27779	0
July	0	0	18331	0	0	11924	30254	0	0	0	0	0	0	30254	30254	0
August	0	0	18210	0	0	11924	30133	0	0	0	0	0	0	30133	30133	0
September	0	0	25964	0	0	11924	37887	0	0	0	0	0	0	37887	37887	0
October	0	0	18601	0	0	11924	30524	0	0	0	0	0	0	30524	30524	0
November	0	0	11424	0	0	11924	23347	0	0	0	0	0	0	23347	23347	0
December	0	0	12556	0	0	11924	24480	0	0	0	0	0	0	24480	24480	0
Average	0	0	14427	0	0	11924	26351	0	0	0	0	0	0	26351	26351	0
Maximum	0	0	54199	0	0	11924	66123	0	0	0	0	0	0	66123	66123	0
Minimum	0	0	0	0	0	11924	11924	0	0	0	0	0	0	11924	11924	0
Total for the whole year GWh/year	0.00	0.00	126.73	0.00	0.00	104.74	231.47	0.00	0.00	0.00	0.00	0.00	0.00	231.47	231.47	0.00

RES Share: 30.6 Percent of Primary Energy 73.6 Percent of Electricity 738.2 GWh electricity from RES

10-December-2018 [14:30]