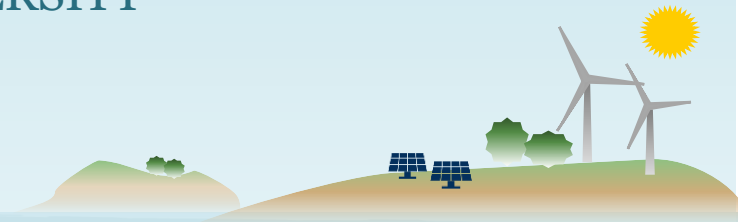


# Modelling Renewable Energy for Islands

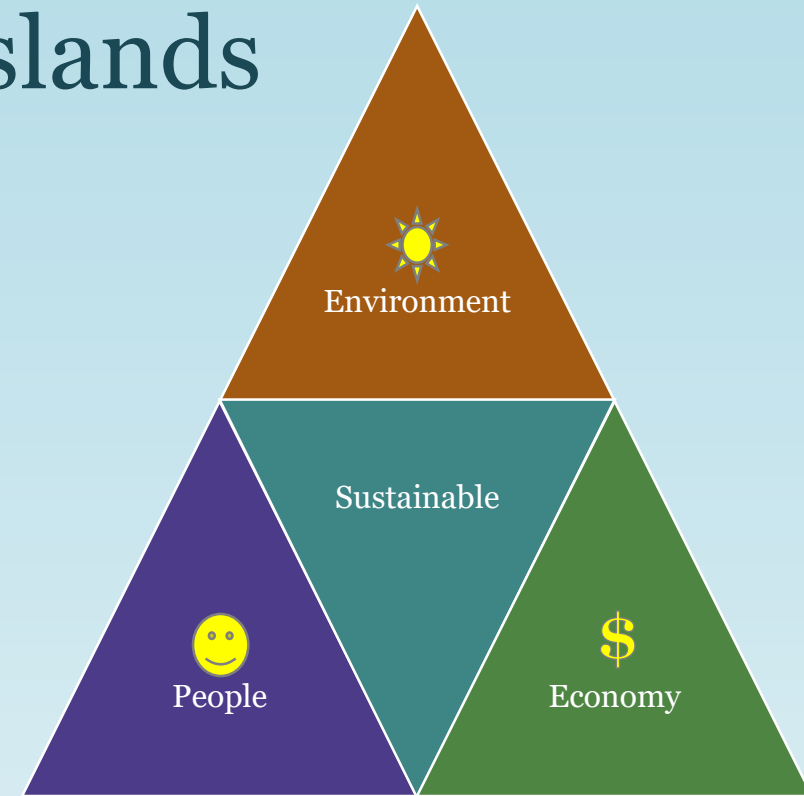
SUSTAINABLE ENERGY PLANNING, AALBORG UNIVERSITY

Hannah Marczinkowski



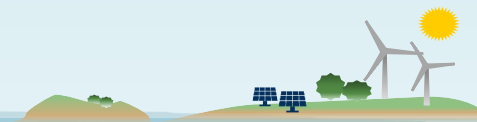
# Sustainable Energy Planning for Islands

- **Sustainable** for environment, people and economically
- **Energy** for electricity, heat, industry and transport
- **Planning** through consideration of local opportunities, limits and ideas
- **Islands** are especially effected by climate change and require support



# PhD Overview

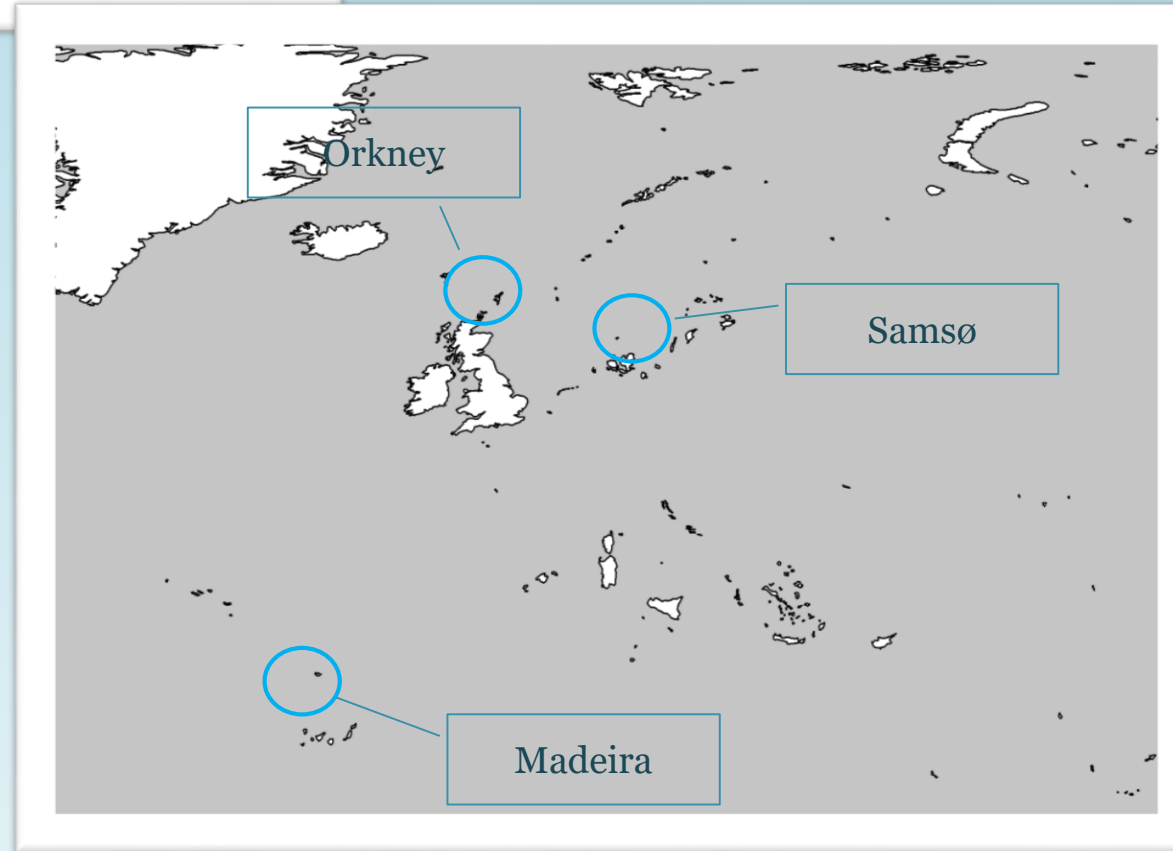
- Small and/or secluded communities and islands
- Transition to sustainable, smart renewable energy systems
  - From challenges and opportunities
  - To strategies and recommendations
- Focus on Samsø, Orkney and Madeira (& explore further islands)
  - Test and integration of their energy systems
  - Observe and optimize electrification
  - Sustainable use of local resources
- Technical analyses and models of islands and their comparison
- Conclusions on Sustainable Energy Planning for Islands



# Islands



- Remote
- Isolated
- Limited
- Complex
- Dependent
- Import
- Bottlenecks



- Potentials
- Weather
- Resources
- Dependency
- Small
- Test size
- Focus



How are the current situations, trends, challenges and opportunities for island energy systems?

How can the transition of islands towards smart renewable energy systems be assisted and replicated?

# Specific Islands

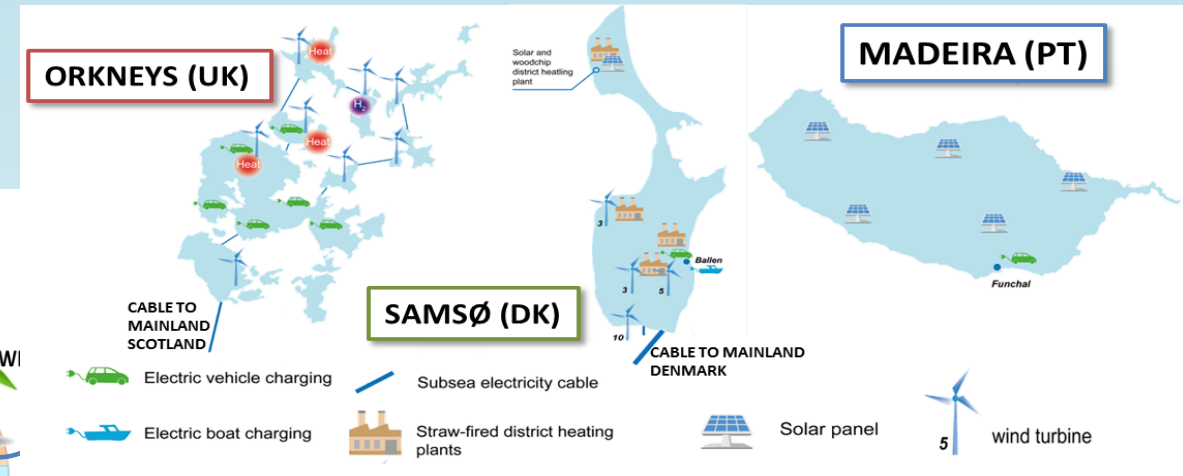
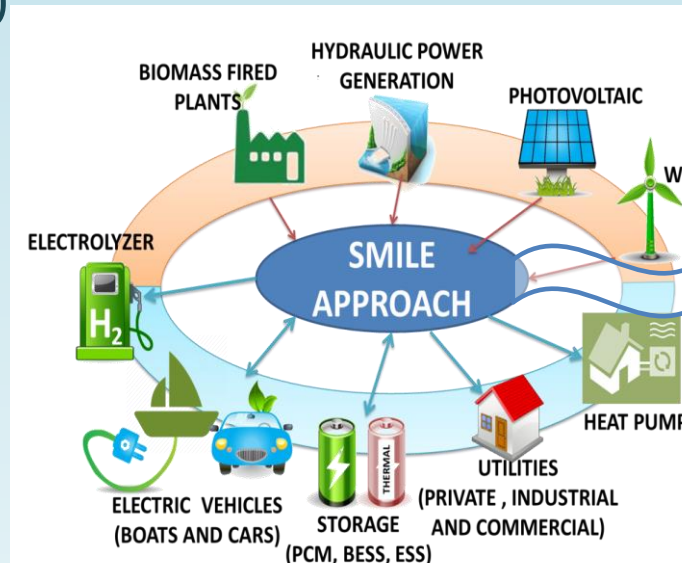
- Three case studies/islands
  - SMILE
  - Visits, cooperation, discussion ongoing
- Technical scenario analyses
  - Energyplan
  - Reference and future scenarios
- Comparison and study of further islands and experiences
  - Germany, Greece, Spain, ...

Island	Size	Population	RE share
Samsø, DK	114 km <sup>2</sup>	3,700	60%
Orkney islands, UK	975 km <sup>2</sup>	22,000	18%
Madeira, PT	741 km <sup>2</sup>	250,000	31%
<i>Germany</i>			
<i>Föhr</i>	82 km <sup>2</sup>	8,600	
<i>Pellworm</i>	37 km <sup>2</sup>	1,100	
<i>Helgoland</i>	4 km <sup>2</sup>	1,200	
<i>Greece</i>			
?			?
<i>Spain</i>			
?			



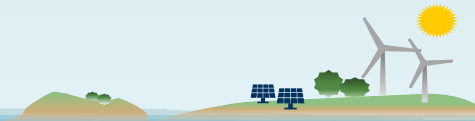
# H2020 SMILE Project Involvement

- SMart IsLand Energy systems (SMILE Grant Agreement 731249)
- May 2017 – April 2021
- [www.h2020smile.eu](http://www.h2020smile.eu)
- (Work package 8)



# Aim

- Improve conditions, sustainable development
- Overcome challenges and barriers
- Coordination and cooperation of several islands
- Technical, market and policy evaluation
- Suggestions, strategies, guidelines
- = Understand and support transition towards 100% renewable energy systems



# Specific research so far...

Document Details	
Due date	31-01-2018
Actual delivery date	30-01-2018
Lead Contractor	AAU Plan (Aalborg University)
Version	Final rev0
Prepared by	AAU Plan
Input from	AAU, SK, SE, SEL, CES, ACP
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



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

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



## Residential versus communal combination of photovoltaic and battery in smart energy systems

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Department of Planning, Aalborg University, Rindøvangsgade 14, 9000, Aalborg, Denmark

### ARTICLE INFO

Article history:  
Available online 26 March 2018

Keywords:  
Photovoltaic  
Battery  
Smart energy system  
Residential versus communal regulation  
Demand side management

### ABSTRACT

This paper presents an analysis of small consumers' freedom of choice on the technical flexibility of photovoltaic (PV) system approaches may be observed in the literature: the operational self-adjustment versus coordinated and collective technologies at energy centers. Thus, for household systems, the placed commercial or residential – creates the basis for this investigation. Danish island Samsø for which the two battery approaches simulation model EnergyPLAN. Results indicate a tendency favorable from a systems perspective – while on the other hand, evaluating and involving the consumers. The importance of choice of fluctuating energy resources is addressed in both approaches: individual household electricity supply, a communal battery, demands.

### 1. Introduction

Europe has ambitious energy targets with a 40% CO<sub>2</sub> emission reduction before 2030 with respect to 1990 levels [1]. The electricity sector, being a key element in the energy system, will need to play a key role in meeting this reduction target; thus a modernization of the electricity system is required and as part of this, flexible smart energy systems are required in academia [2,3]. In addition, while an increasing influx of fluctuating renewable electricity production combined with a growing electricity demand from the transport and heating sector stresses the load-following capability of the electricity system, the very same technologies in a coordinated smart energy system approach can in fact help establish balance between production and demand and reduce problematic peak demands. Main technological solutions for this approach include wind power [4,5], photovoltaic (PV) [6,7], power-to-heat [8,9], power-to-gas [10,11], and battery technologies [12,13].

The role of battery systems in smart energy systems is also a

local point in e.g. the ERA-N which investigates the electricity generation and local generation through e.g. PV on simple home batteries, at regional Union Nations2020 systems [14] also address more with the aim to go islands.

Targeting the various projects focus on smart in small communities, islands, which direction the do common technological mind sets and individual points of departure in the communal versus individual investment on the energy.

The island Samsø is the Energy Island in terms of energy solutions [15].

The island Samsø is the Energy Island in terms of energy solutions [15].

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## Evaluation of electricity storage versus thermal storage as part of two different energy planning approaches for the islands Samsø and Orkney

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Department of Planning, Aalborg University, Rindøvangsgade 14, 9000, Aalborg, Denmark

### ARTICLE INFO

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Keywords:  
Battery energy storage system  
Thermal energy storage  
Electricity heating  
Integrating energy sectors  
Smart energy system  
EnergyPLAN analysis

### ABSTRACT

Island energy systems should aim for a better integration of local resources and exploit their potential for local energy supply to increase their independence and security of supply besides other benefits. Two trends addressing this problem can be observed. On the one hand, increasing the local use of renewable electricity in the electricity sector by investing in Battery Energy Storage Systems (BESS). On the other hand, the integration of all energy sectors into a Smart Energy System (SES) with the conversion of renewable electricity to heat – thus enabling the usage of Thermal Energy Storage (TES). In this paper, these two potential approaches are investigated through energy system analyses using EnergyPLAN for the Danish island Samsø and the Orkney islands in Scotland. This investigation shows that BESS tend to address only the electricity sector, while TES furthermore improves issues in the heating sector and enables possibilities in the transport sector. The TES approach results in overall reduced energy system costs, while the BESS has a stronger effect on the exchange of electricity. Depending on the various energy systems, both approaches present potential solutions, while the SES approach with the use of TES demonstrates more advantages for the whole energy system.

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### 1. Introduction

Islands present special energy systems particularly when either completely disconnected from a larger electricity grid or when having a poor or limited connection, making them vulnerable and dependent on that connection. With or without this connection, islands are generally further more dependent on other imports to supply the transport or heating sector with the required fuels. Locally produced electricity or biomass barely support these needs for most of the European islands and energy autonomy is rarely reached. Thus, from an economic perspective, islands that may be under economic pressure already need to buy energy and resources from other places.

To address this situation, islands should be encouraged to utilize as much local resources as possible, focusing on renewable energy source (RES)-based electricity production due to a usual abundance of wind and/or solar resources [1]. They should also aim for higher

efficiencies and the integration of all energy sectors into a smart energy system (SES) [1] to reduce overall primary energy consumption. This suggested holistic view on energy system planning contradicts the focus of recent cases of island energy planning, which to a large extent focus only on the electricity sector and in relation to this on batteries as the solution to fluctuating electricity production [8–11].

To understand the challenges and opportunities of islands, as well as to increase the shares of RES, they must be investigated and compared. Therefore, the European Union is founding various projects under the Horizon 2020 research programme to study islands, such as the Smart Island Energy systems (SMILE) project. In the SMILE project, the focus lies on the electricity sector. To form SES, however, the transition of islands should entail the integration of all energy sectors – electricity, heating, cooling, industry and transport, specifically making use of the access to the RES [1]. With the electricity focus, a core element in the SMILE project is to address electricity storage to improve the integration of locally produced RES. To achieve a SES, however, thermal storage can also be of importance and could be given more attention.

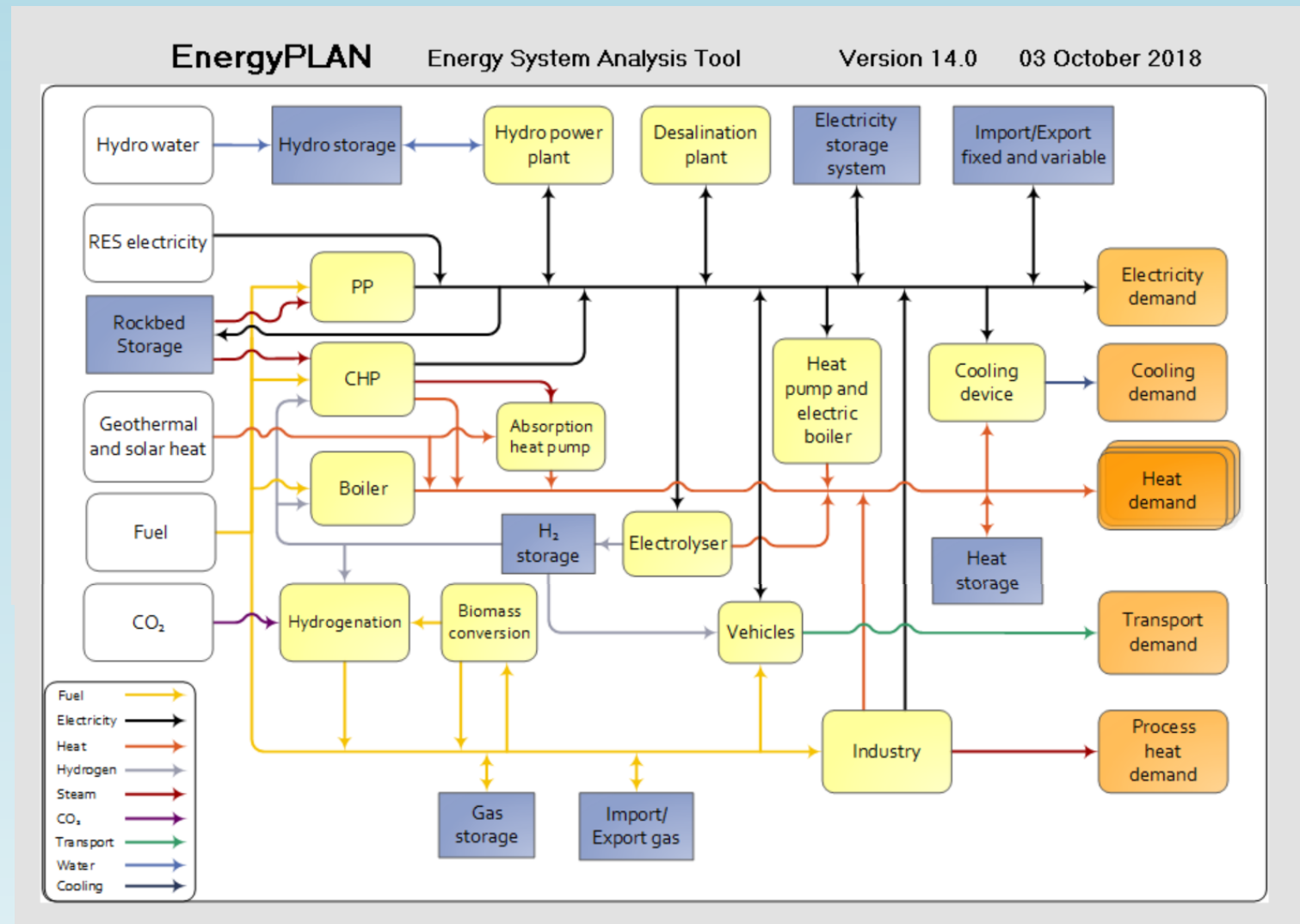
\* Corresponding author.  
E-mail address: hmarcinkowski@plan.aau.dk (H.M. Marcinkowski), poul@plan.aau.dk (P.A. Østergaard).

https://doi.org/10.1016/j.energy.2019.03.103  
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# Research done:

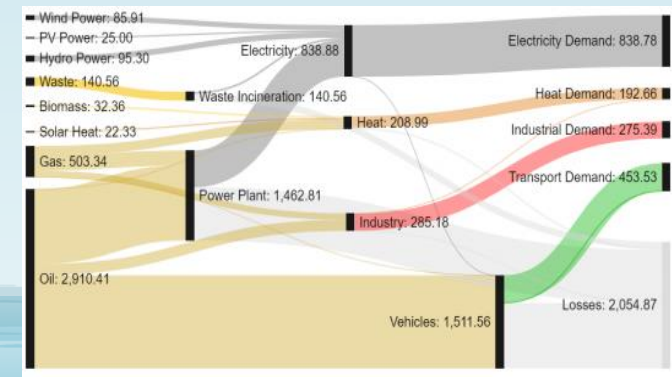
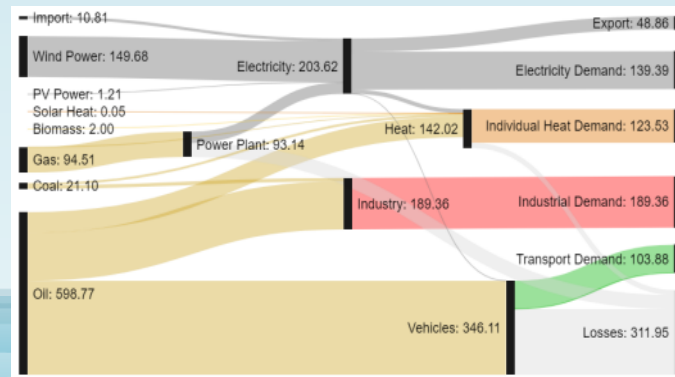
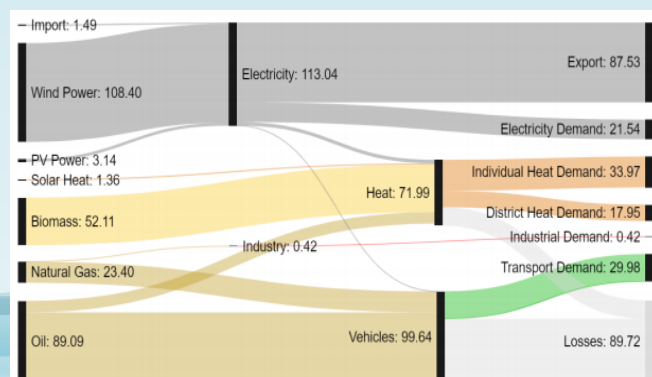
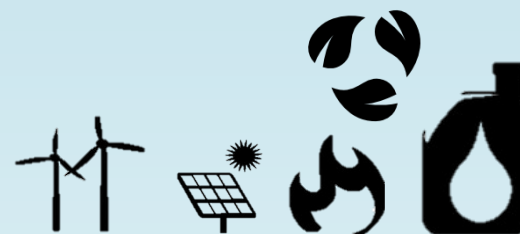
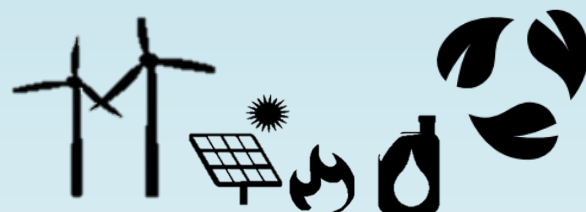
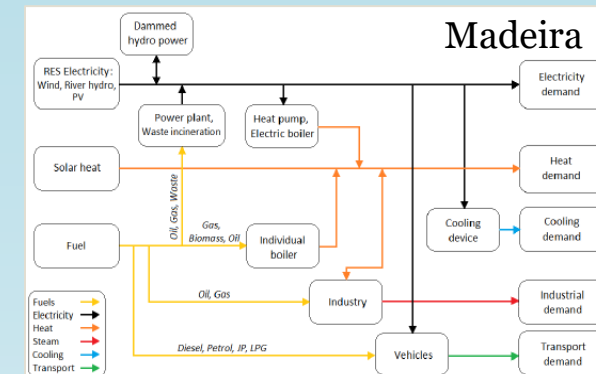
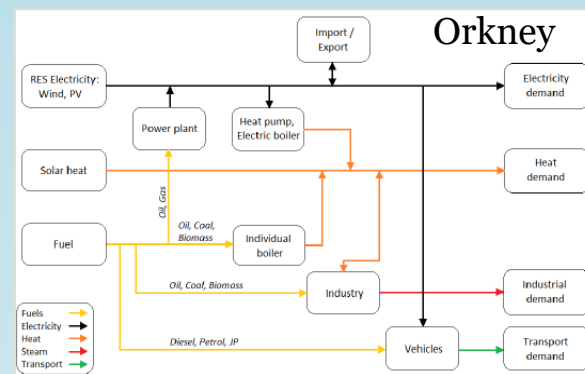
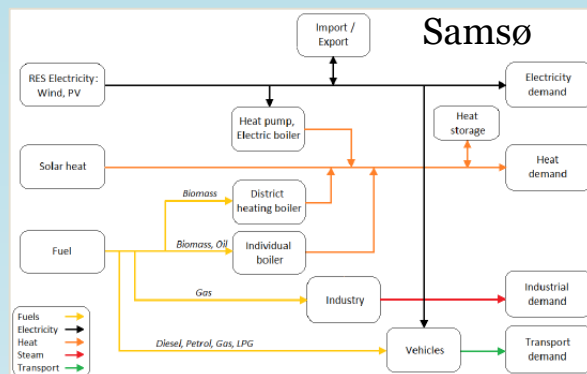
- <https://www.energyplan.eu/>
- Energy system analysis
- Hourly for one year
- Holistic, aggregated, technical



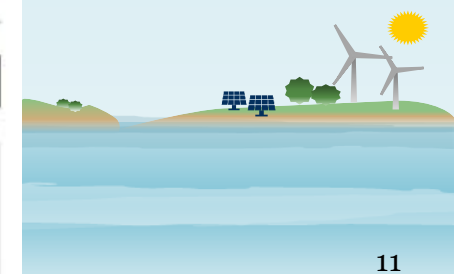
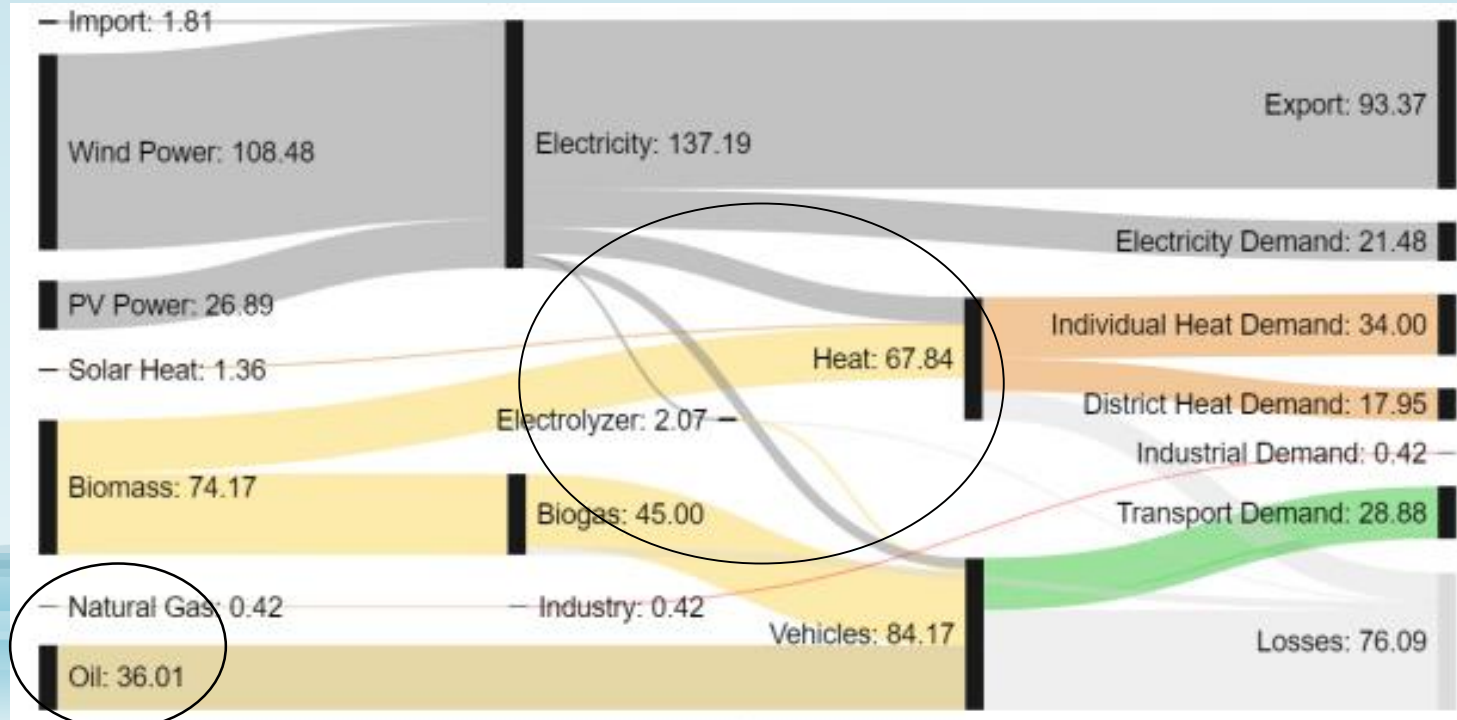
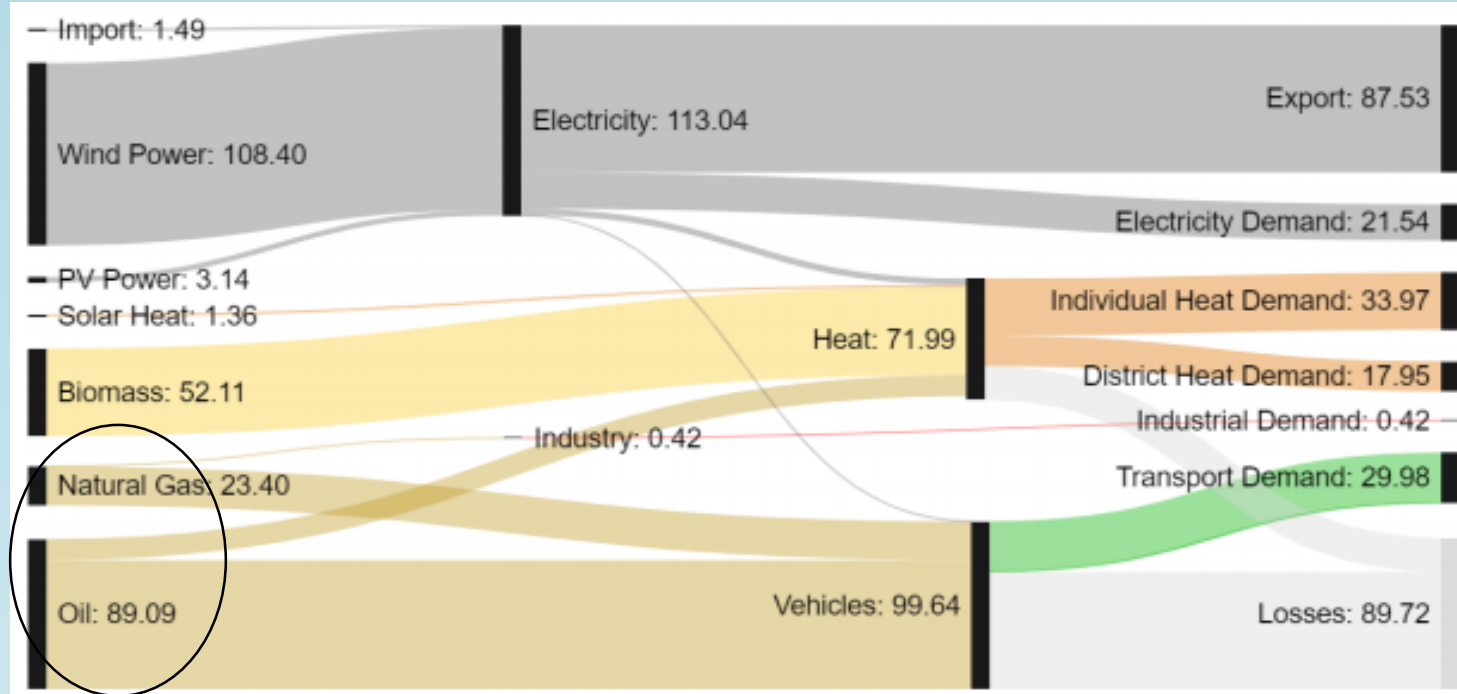
**EnergyPLAN**

Advanced energy  
system analysis  
computer model

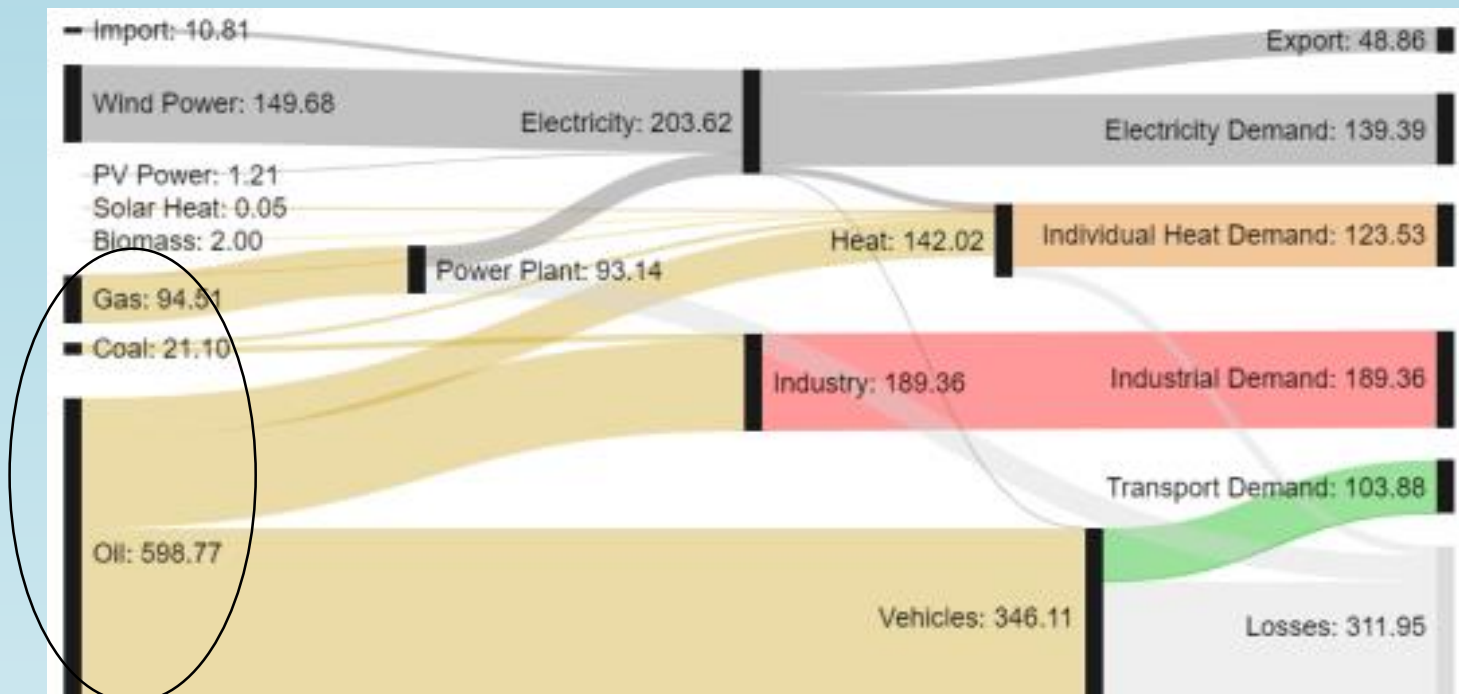
Specific research so far  
... on the RE transition (today & future) of Samsø, Orkney and Madeira



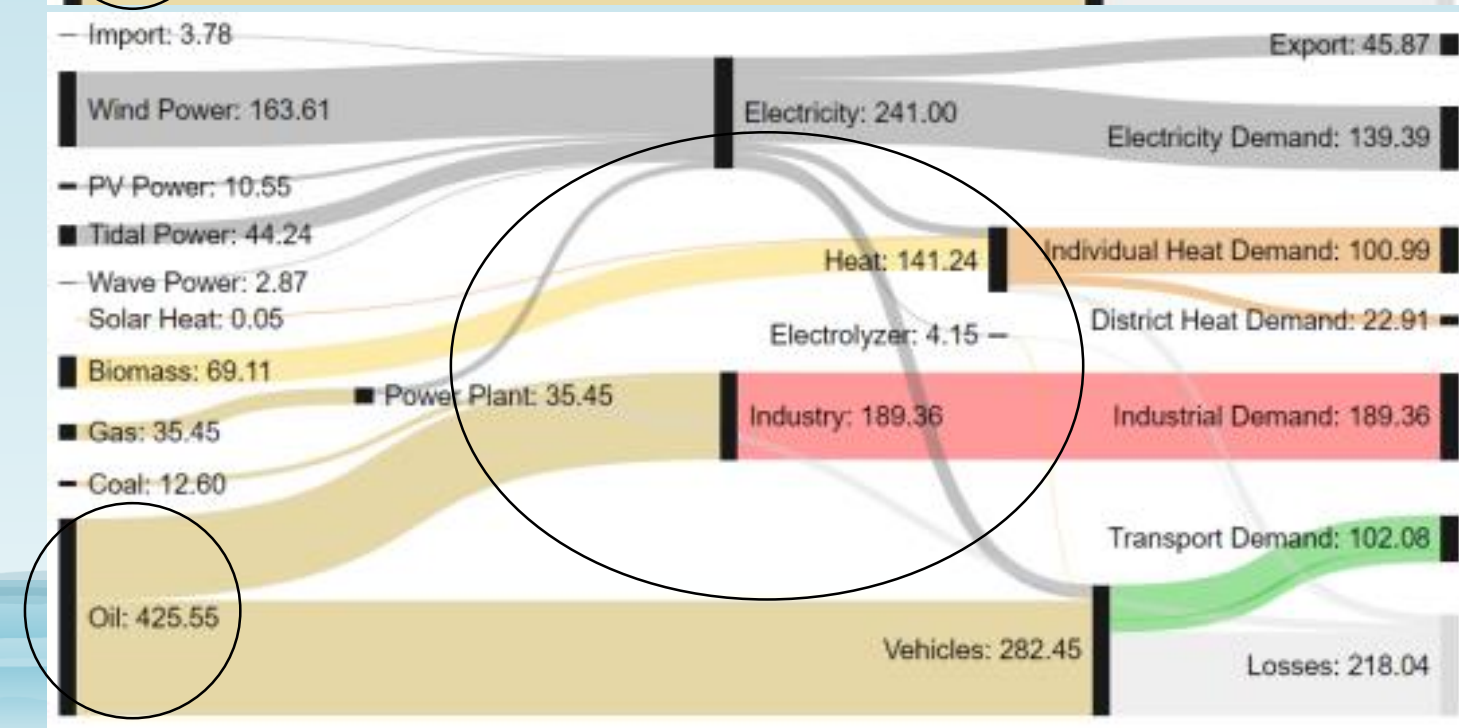
# ... the RE transition: Samsø



# ... the RE transition: Orkney



2015 &

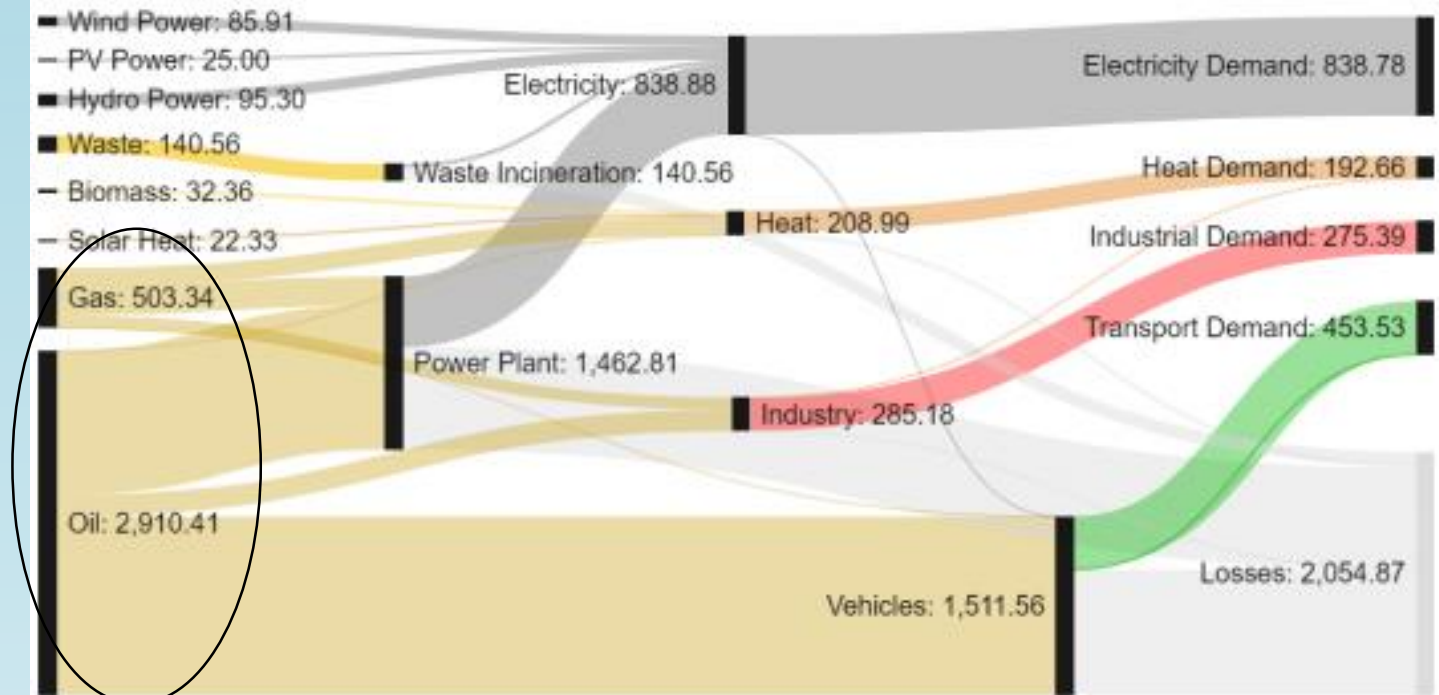


2030?

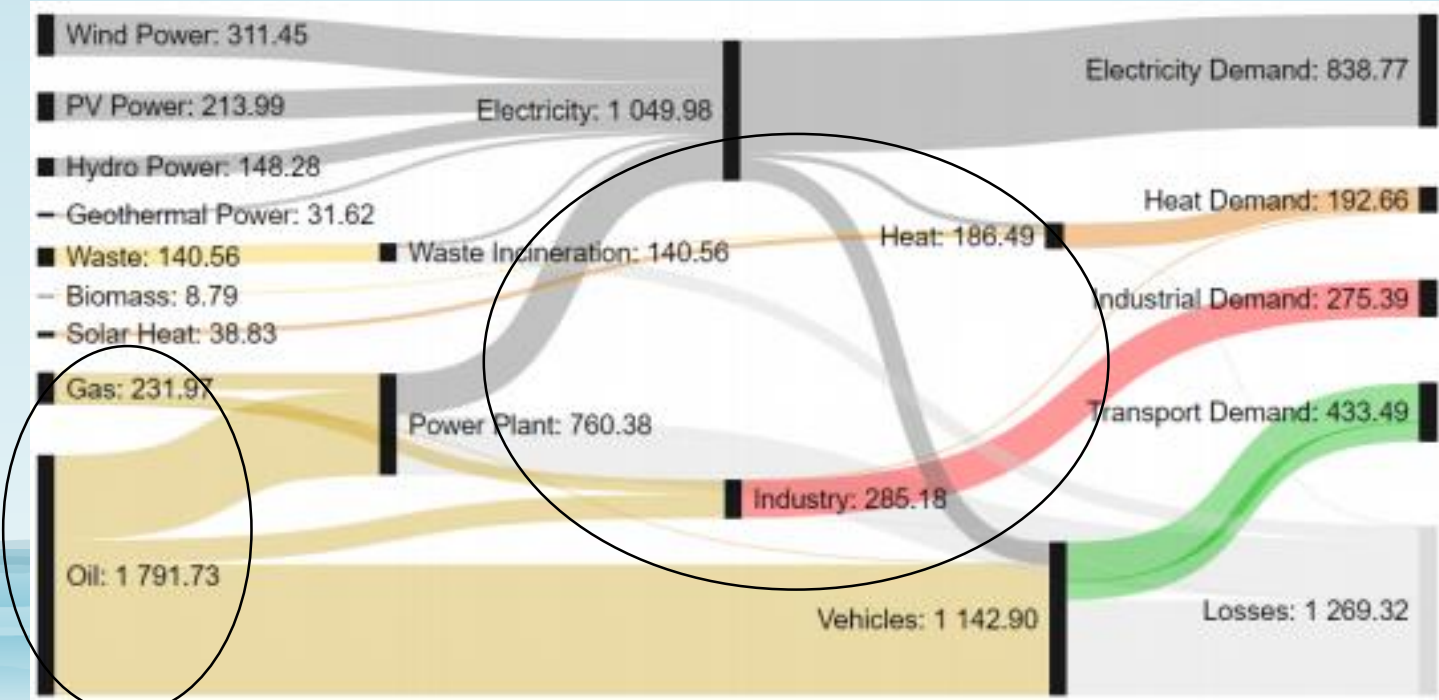




# ... the RE transition: Madeira



2015 &

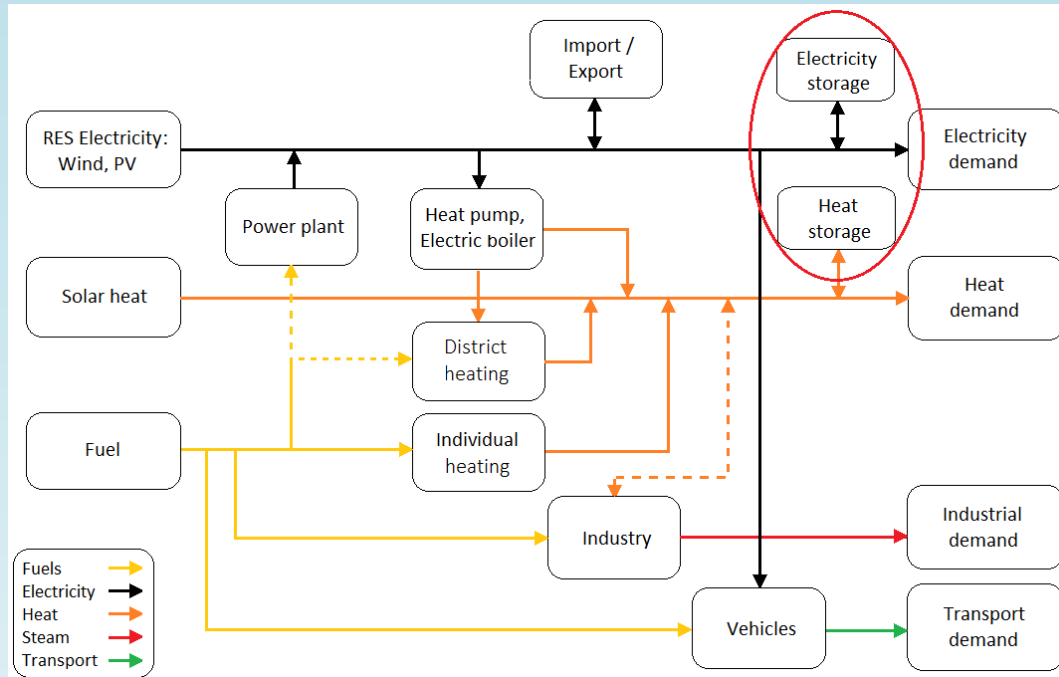


2030?

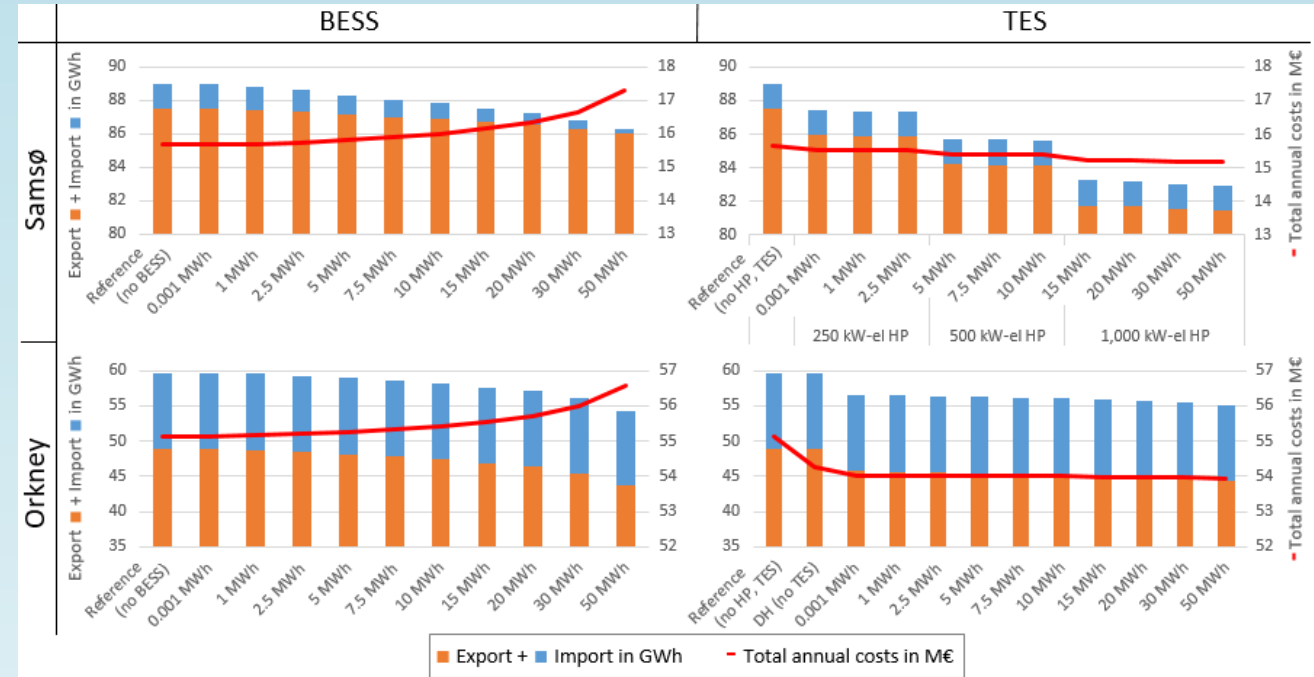


# Specific research so far

## ... on storages on Samsø and Orkney

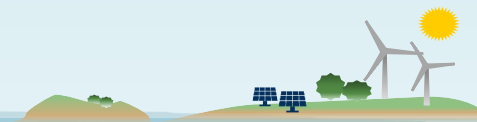


## Battery Electricity (BESS) vs. Thermal Energy Storage (TES)



# Dissemination

- SDEWES conferences 2017, 2018 (2019 invitation to special session on smart islands)
  - <http://www.sdewes.org/>
- AAU conference on 4GDH and Smart Energy Systems
  - <https://smartenergysystems.eu/>
- Green Island Conference Germany
  - <http://greenicon.de/>
- International Hybrid Power Systems workshop
  - <http://hybridpowersystems.org/>



# Towards a sustainable future for islands

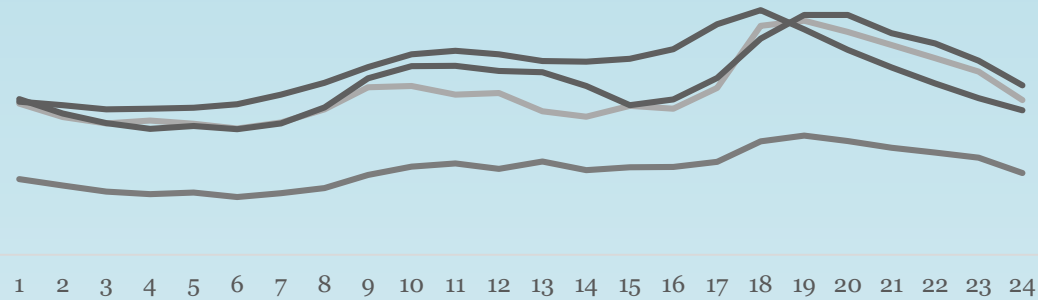
- Study and compare more islands
- Evaluate trends and solutions
  - Marine Energy!?
- Assess energy markets and policies
- Analyse, consult and guide interested people
- Listen, learn and repeat
- Ask questions



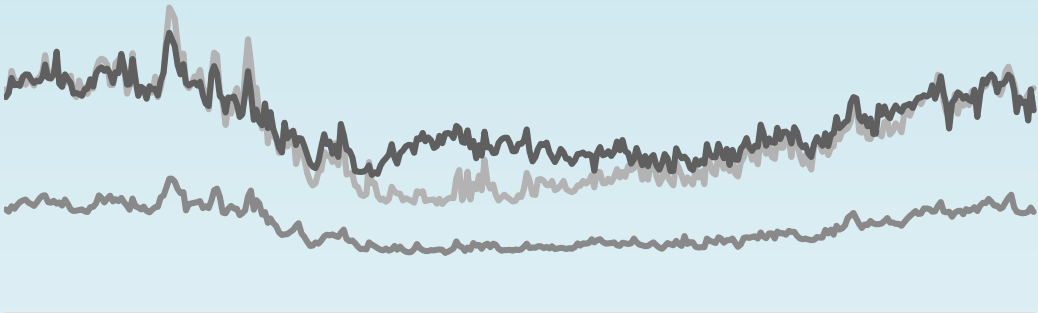


# Towards a sustainable future for islands: electricity

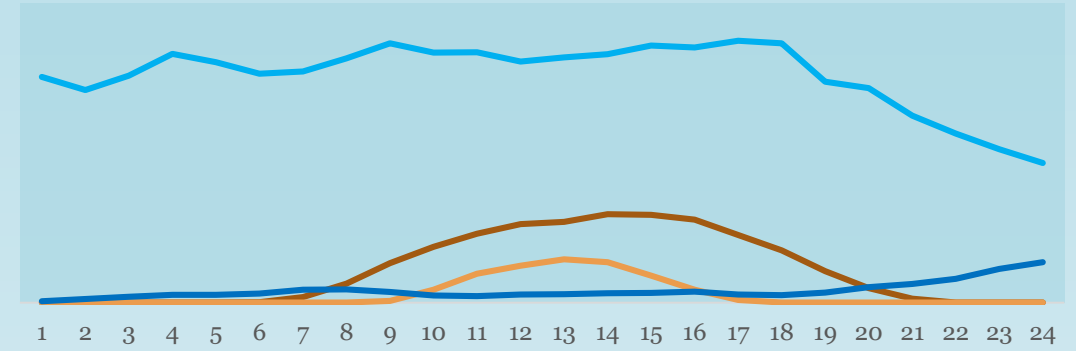
Electricity demand 24 hours



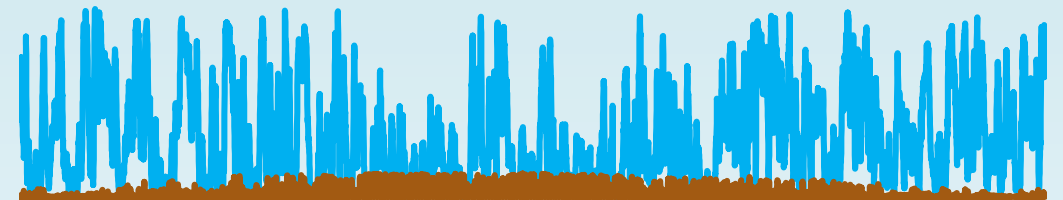
Electricity demand 365 days



Electricity production 24 hours (wind and solar)



Electricity production 365 days (wind and solar)



# Towards a sustainable future for islands: heating

- Demand reductions, efficiency increase, insulation, etc.
- District heating
- <https://heatroadmap.eu/peta4/>
- Solar heat
- Heat pumps
- ...



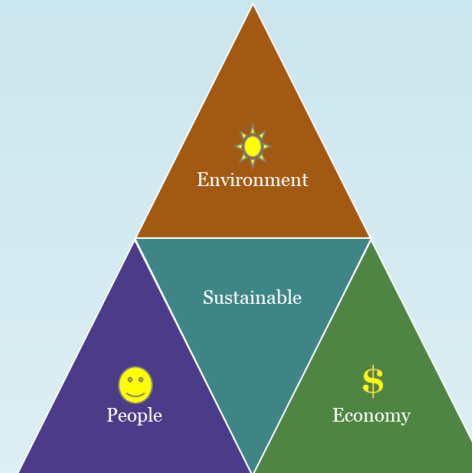
# Towards a sustainable future for islands: transport

- Reductions
- Electric vehicles
- Biofuels
- ...



# Sustainable Energy Planning for Islands

- Combining/Coupling electricity, heating, industry and transport
- Education and information
- Step by step suggestions to solutions
- Support, participation (both ways)
- Sustainable



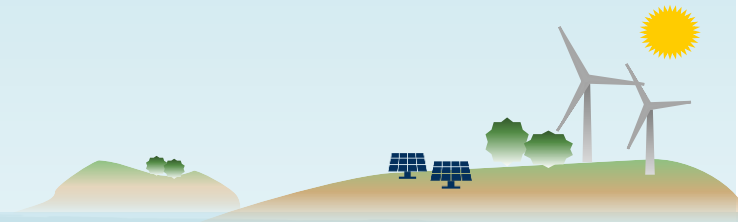
# Thank you for listening!

## Modelling Renewable Energy for Islands

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[hmm@plan.aau.dk](mailto:hmm@plan.aau.dk)

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[WWW.ENERGYPLAN.EU](http://WWW.ENERGYPLAN.EU)

[WWW.SMARTENERGYSYSTEMS.EU](http://WWW.SMARTENERGYSYSTEMS.EU)