CITY OF CAPE TOWN
ISIXEKO SASEKAPA
STAD KAAPSTAD

REPORT TO: **CITY MANAGER**
TO BE REFERRED BY THE OFFICIAL TO MAYCO VIA THE RELEVANT ENERGY SECTION 79 COMMITTEE [AFTER CONSIDERATION BY CITY MANAGER]

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1. ITEM NUMBER

2. SUBJECT

FEEDBACK ON THE INTERNATIONAL/OUTSIDE THE BORDERS OF THE RSA TRIP UNDERTAKEN FROM 21 OCTOBER TO 19 NOVEMBER 2023 TO ATTEND THE RENEWABLE ENERGY INTEGRATION IN POWER SYSTEMS COURSE IN DENMARK

ONDERWERP

TERUGVOERING OOR DIE REIS NA DIE BUITELAND/BUITE DIE GRENSE VAN DIE RSA ONDERNEEM VAN 21 OKTOBER TOT 19 NOVEMBER 2023 OM DIE KURSUS OOR DIE INTEGRASIE VAN HERNUBARE ENERGIE IN KRAGSTELSELS IN DENEMARKE BY TE WOON

ISIHLOKO:

INGXELO ENGOHAMBO KUMAZWE APHESHEYA/ KWIMIDA ENGAPHANDLE KWASEMZANTSI AFRIKA EQHUTYWE UKUSUSELA NGOWAMA21 KWEYEDWARHA UKUYA KOWE19 KWEYENKANGA 2023 UKUZIMASA ISIFUNDO/IKHOSI ENGEENKQUBO ZAMANDLA OMBANE OHLAZIYEKAYO NGOKUHLANGENEYO, ESE DENMARK

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3. EVENT SUMMARY

EVENT DETAILS	
CONFERENCE/SEMINAR	DANIDA FELLOWSHIP CENTRE COURSE: RENEWABLE ENERGY (RE) INTEGRATION IN POWER SYSTEMS
OTHER	N/A
DATE	21 OCTOBER TO 19 NOVEMBER 2023
VENUE	TECHNICAL UNIVERSITY OF DENMARK (DTU)
TOTAL COST TO THE CITY	R 11 552
CITY	COPENHAGEN
COUNTRY	DENMARK

ATTENDEE DETAILS	
NAME AND SURNAME	DESIGNATION
SHANNON DUNBAR	SENIOR PROFESSIONAL OFFICER
NCEDO MGUZULWA	PRINCIPAL PROFESSIONAL OFFICER
PROVIDE SUMMARY OF HOST ORGANISATION / CITY	

Danida Fellowship Centre (DFC) is financed by Denmark's development cooperation which is an area of activity under the Ministry of Foreign Affairs which offers learning opportunities to countries that have developmental and growth potential.

Our training was provided by DTU Wind and Energy Systems Department. DTU promotes technical learning in research, education, innovation and scientific advice. For two weeks we received class-based training at Lyngby campus and three days practical training at RisØ campus.

4. OBJECTIVE

The main objectives for attending the RE integration in Power Systems course was to enhance our knowledge pertaining to the possibilities, limitations and challenges of integrating renewables on both the transmission and distribution network. The aim was to gain insight on RE technologies, grid models, tools and standards to assist us in making informed decisions regarding renewables on the City's network. We hoped to gain practical skills as the course offered hand-on exercises, site visits, case studies and project work. The opportunity allowed for networking with professionals from various countries. The intent is to translate our learning into actionable plans that can be implemented within the City.

5. OUTCOMES

Our course programme can be found in Figure 5 in the annexures section. As previously mentioned our training for the first two weeks consisted of class based

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training. Thereafter we spent three days at DTU RisØ campus at their SYSLAB. The RisØ campus is supplied from the distribution grid and have ground mounted photovoltaics (PV), rooftop PV's, wind turbines and a diesel generator on the campus. Through their SYSLAB the loads consumption can be monitored. Excess renewable generation can be stored via their flow battery or lithium batteries. This excess generation could assist in peak shaving. The SYSLAB can monitor how much load the electric vehicle (EV) charging stations utilised. During our hands on training, we had to develop and test a system controller for a micro grid utilising Python interface on SYSLAB. Since renewables experience disturbances, the controller with batteries as an example can improve the performance of the system. The SYSLAB breaker overview can be seen in Figure 6 in the annexures.

After the three days on the RisØ campus, we visited Energinet. Engerginet is the Transmission System Operator (TSO) for Denmark, in which they are responsible for the transmission network. Topics discussed can be found under the general discussion section.

On Bornholm island we visited a Biogas plant. Bornholm's Bioenergi (refer to Figure 7 in the annexures section) is a waste to energy plant that produced 200 000 megawatt-hour (MWh) a year. It's a 24/7 plant that produces electricity and district heating that is sold on the market. It also produces gas for trucks, currently the company owns four gas stations and in the future want to expand the gas production. The industrial waste to energy plant has three receiving tanks (eg. food waste, butchery waste and brewery waste) as shown in Figure 8. The plant has three digesters. The first heat exchanger is up to 25 degrees. In the second heat exchanger get to 45 degrees. After the last heat exchanger its then taken up to 70 degrees. The first step is hydrolysis, the second methane formation. The biogas is 60 percent methane gas and 40 percent carbon dioxide (CO_2). The methane gas comprises of molecules of four hydrogen atoms and one carbon atom (CH_4). The gas contains a lot of sulphur and therefore goes through the sulphate filter then to the gas storage tank. The waste is burned, releasing heat. The heat turns water into steam in a boiler. The high-pressure steam turns the blades of a turbine generator to produce electricity.

Our last visitation on Bornholm island, was at the Distribution System Operator (DSO). Bornholm's electricity generation, consumption and heat generation can be seen in Figure 9 in the annexures. Bornholm has a sea cable to Sweden to assist when the consumption on the island is greater than the generation. The DSO also shared their future energy island plans which can be found under the general information section.

6. ACTIONS REQUIRED

A written feedback report to the City Manager after returning from the learning programme on the knowledge acquired (this report).

7. IMPLICATIONS

7.1 Constitutional and Policy Implications — No ☒ Yes ☐

7.2 Environmental implications — No ☒ Yes ☐

7.3 Financial Implications — No ☒ Yes ☐

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7.4 Legal Implications No ☒ Yes ☐

7.5 Staff Implications No ☒ Yes ☐

7.6 Risk Implications No ☒ Yes ☐

7.7 <u>POPIA Compliance</u>

☒ It is confirmed that this report has been checked and considered for POPIA Compliance.

NOTE: POPIA Section <u>MUST</u> be completed otherwise the report will be returned to the author for revision.

Contact your Directorate POPIA Stewards should you require assistance.

The City has a contract in place with XL Embassy Travel for the safe-keeping of Traveller's personal information as required by the POPI Act.

8. RECOMMENDATIONS

It is recommended that the feedback report on the trip Renewable Energy integration in Power Systems learning programme undertaken by Shannon Dunbar and Ncedo Mguzulwa on 21 October to 19 November 2023 **be considered and noted.**

AANBEVELING

Daar word aanbeveel dat die terugvoeringsverslag oor die reis vir bywoning van die leerprogram oor die integrasie van hernubare energie in kragstelsels onderneem deur Shannon Dunbar en Ncedo Mguzulwa van 21 Oktober tot 19 November 2023 oorweeg en daarvan kennis geneem word.

ISINDULULO:

Kundululwe ukuba makuthathelwe ingqalelo kwaye kuqwalaselwe ingxelo engasemva kohambo olujoliswe kwinkqubo engezifundo olumalunga nezaMandla oMbane oHlaziyekayo ngokuHlangeneyo kwiiNkqubo ezingezaMandla oMbane, oluqhutywe ngu Shannon Dunbar kwaye Ncedo Mguzulwa ngowama21 kweyeDwarha ukuya ngowe19 kweyeNkanga 2023.

9. GENERAL DISCUSSION

9.1. Energy Markets in Denmark

In South Africa we have a centralized power system (no market). In Europe they have an electricity market (refer to Figure 1 below). Each producer seeks to maximize their own profit by making optimal operational and planning decisions. Unlike centralized systems, there are

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multiple decision-makers. This is the “market-clearing” procedure, to be carried out by a non-profit entity, namely the market operator.
Power producers can be a conventional generation unit (nuclear, coal, gas-fired power plants, combined heat and power) or renewable power unit (wind, solar, hydro, biomass) or can be a combination of both conventional and renewable units.
The power demands are large consumers (industrial plants) or retailers. A retailer is an intermediate market actor (trader) who purchases power in a large volume from electricity markets and sell it back to a large number of small-scale demands (households). Example: Andel Energi in Denmark.
The market operator is a non-profit entity, who receives all offers from producers and bids from demands, and clears the market (by maximizing the social welfare), and eventually disseminates market-clearing outcomes, the prices and quantities.
Example: Nord Pool (https://www.nordpoolgroup.com/) in Scandinavian (and Baltic) countries
The market-clearing outcomes are indeed financial contracts, contracts for buying and selling electricity.
The system operator is in charge of the “safe” operation of the underlying power system, ensuring supply security, instantaneous power supply and demand balance, stability of the system. The transmission system operator (TSO) in the context of European electricity markets. In Denmark: Energinet.dk (https://en.energinet.dk/), who is in charge of the operation of both power and gas systems (in the transmission level).
The distribution system operator (DSO) is in charge of the “safe” operation of the underlying mid-voltage and low-voltage (radial) distribution grids. Example: Radius and Syd Energi in Denmark
Three main markets with different products are:

1) Capacity markets have been designed to ensure that sufficient generation capacity in megawatt (MW) is available in the market for supply security and reliable system operation. Every producer who submits an offer to the electricity market (either it is eventually accepted or rejected) is eligible to be paid for her availability in the market in Danish krone (DKK)/MW. Capacity payments provide an incentive for power producers to invest in new generation assets in long run.
2) Energy markets is a central marketplace for exchanging energy (in MWh), matching of electricity supply and demand. The various energy markets are to be cleared in different points of time:

2.1) Futures markets: Long-term financial contracts with a time span up to six years.

2.2) Day-ahead market: Also known as “spot” market, to be cleared 12-36 hours before actual delivery time. Example: *Nord Pool Elspot,* to be cleared in noon of day *D-1* for energy exchange during every hour of day *D* (from midnight to midnight). Different market prices and quantities for each hour.

2.3) Intra-day market: Continuous trading platform between day-ahead market and real time. This market provides an opportunity to “modify” day-ahead schedules in case there is an updated forecast or an asset failure. Example: *Nord Pool Elbas*

2.4) Balancing market: Close to the real-time operation of the system. Purpose: to ensure power supply-demand balance and safe operation of the system

3) Ancillary service markets: These markets allow the system operator to procure services required for secure and reliable operation of the system.
   Examples of such services are:
   - ✓ Primary reserves
   - ✓ Secondary reserves
   - ✓ Tertiary reserves
   - ✓ Black-start capability
   - ✓ Reactive and voltage-control reserves

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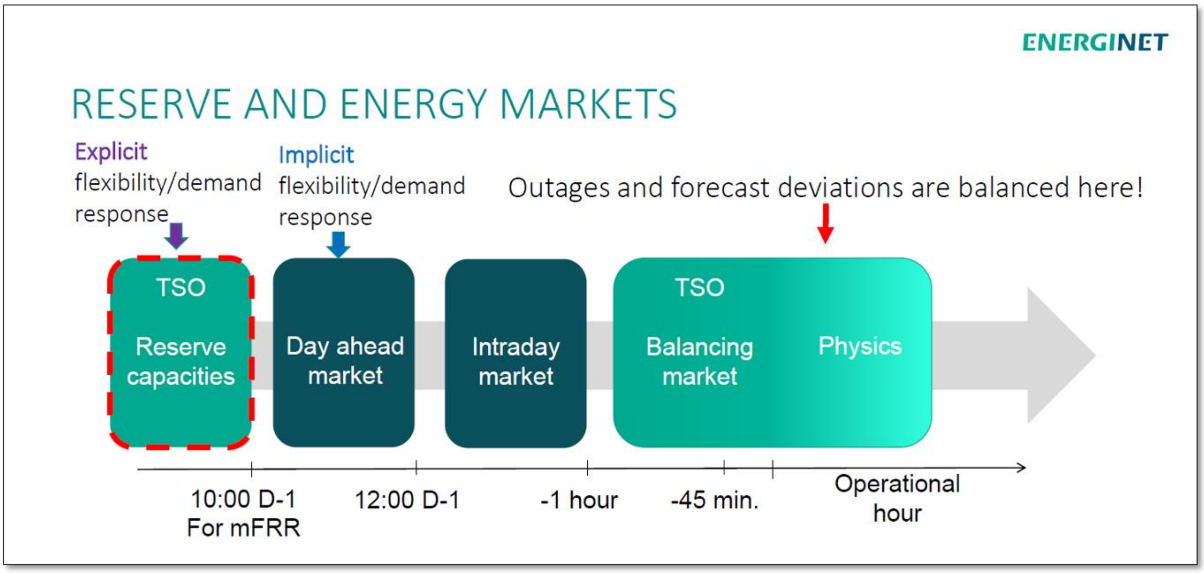

Figure 1: Energy Markets in Denmark

9.2. Energy islands

In 2022 Denmark reached 59.6 % renewables and their future plan is to in 2050 have 100 % renewables. In Denmark in the future, two energy islands will be established. Energy island are placed offshore and can generate large amounts of energy, which is transported along seabed by transmission cables. These cables also distribute the energy to other countries. The energy islands are going to play a key role in the transition to a sustainable future.

An energy island can be an artificial island or large platforms. Converter systems are placed on this island/platform (more cheaper) to convert the windmill's power from alternating current (AC) to direct current (DC). With the conversion to direct current, the current can be transported in cables over long distances with a minimal loss of energy to the benefits of consumers and the entire energy grid.

The cost estimate is 40 billion euros (EUR) in total for the 10 gigawatts (GW) in the North Sea and the 3 GW by Bornholm. This cost includes the wind turbines, power plant, artificial island in the North sea and cables between the countries involved. The North Sea project energy island will be connected to Germany, Belgium, Norway, United Kingdom (UK) and Netherlands (refer to Figure 2 below). The Bornholm project is anticipated for year 2030 and the North sea project is anticipated for year 2040.

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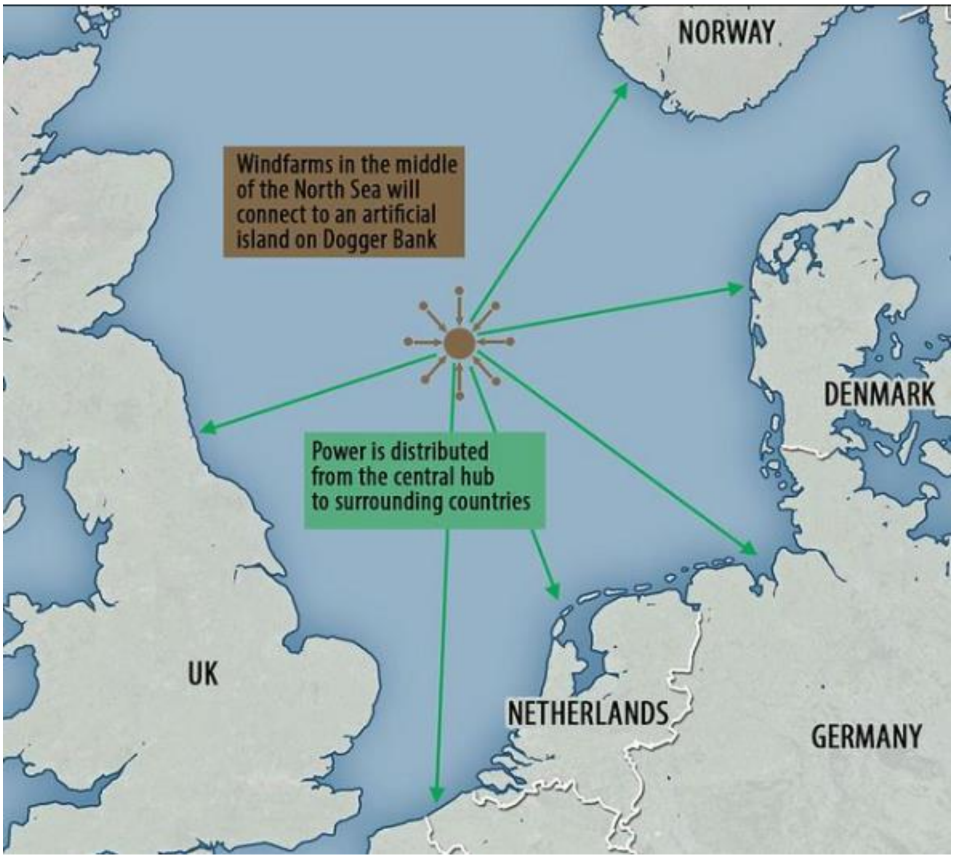

Figure 2: Energy Island on the North Sea

9.3. Power-to-X

Energinet, the TSO of Denmark, operate the transmission grids and gas pipelines, refer to Figure 3 below.

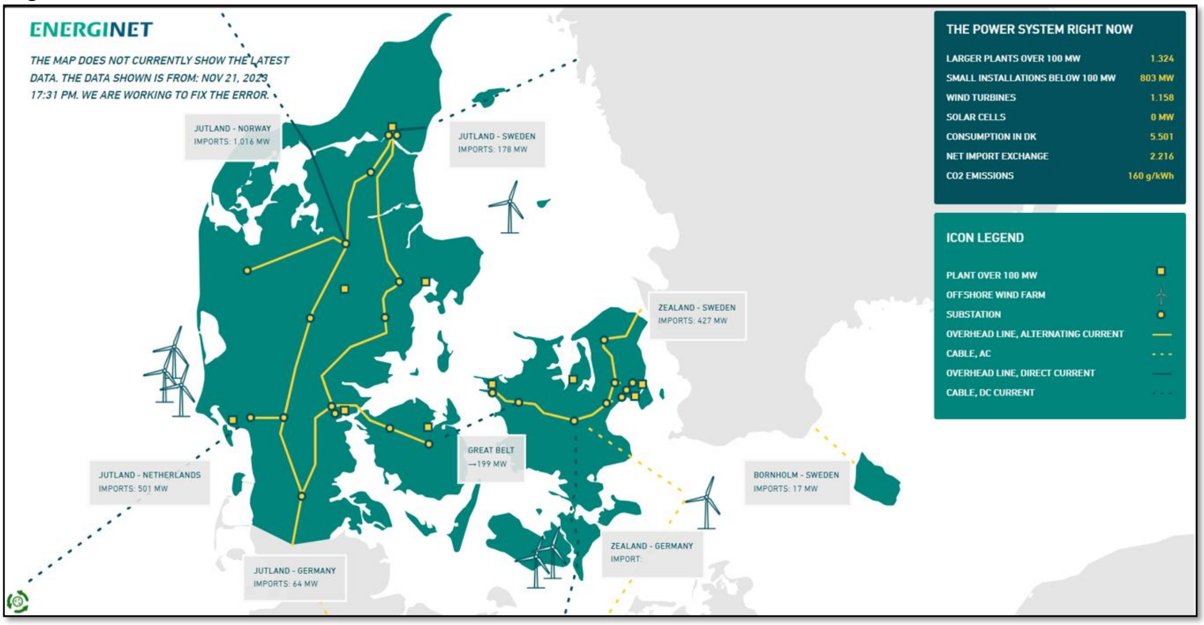

Figure 3: Energinet transmission network in Denmark

Energinet future plans is to transmit hydrogen which is less losses to transmit hydrogen instead of electricity.

Power-to-X makes it possible to convert renewable energy from solar and wind into green hydrogen and other climate-friendly fuels. This is done by means of electrolysis, a technology

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in which water is split into hydrogen and oxygen using electricity (see Figure 4 below). The hydrogen can be used directly or converted into hydrogen-based products such as ammonia, methanol, methane and diesel products, replacing fossil fuels in those sectors that cannot use the green power directly.

There are three main uses for green hydrogen:

1. Direct use of hydrogen, e.g. fuel for local transport, process industry, steel production and chemical production.
2. Green fuel in the form of ammonia for high energy consumption, e.g. shipping.
3. Green fuels where carbon-based fuels are particularly suitable, e.g. aviation fuel, chemical production and industry.

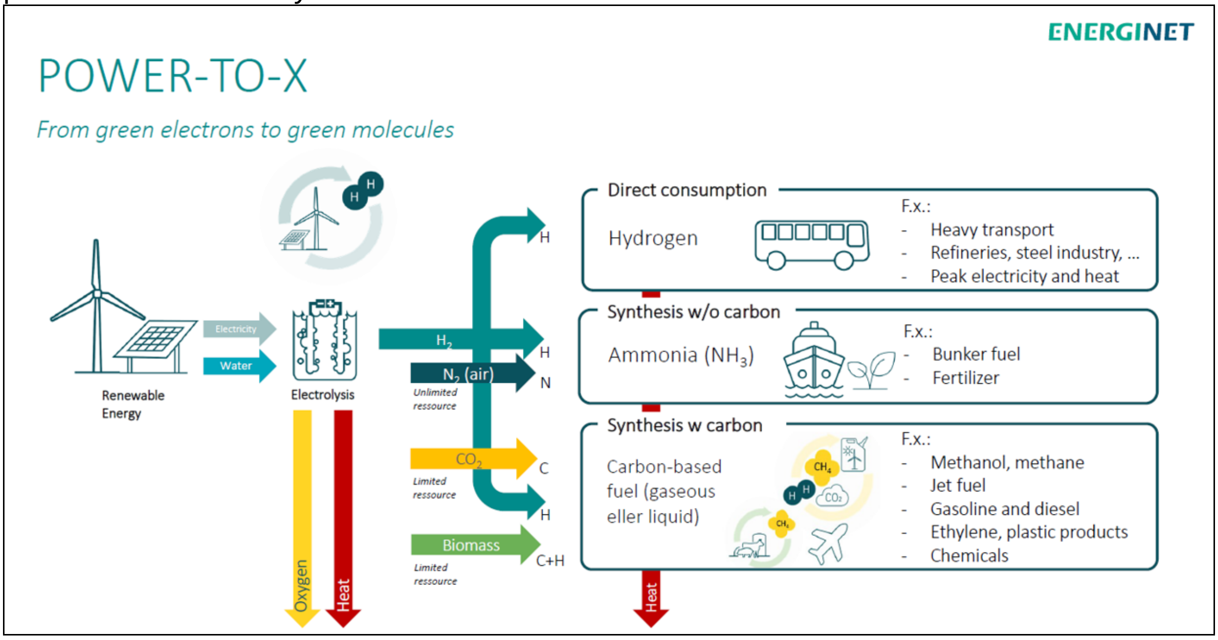

Figure 4: Power to X future plans in Denmark

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10. ANNEXURES

DTU

Department of Wind and Energy Systems

Program at a glance

Week	Monday 9 - 12	Monday 13 - 16	Tuesday 9 - 12	Tuesday 13 - 16	Wednesday 9 - 12	Wednesday 13 - 16	Thursday 9 - 12	Thursday 13 - 16	Friday 9 - 12	Friday 13 - 16
1 23. - 27. Oct.	**Welcome** (J. Holbøll) **Course information** **Students introduction** (Yi Zong)	**Course Preparation** (Yi Zong)	**L1 - Power system with RE** (Chresten Træholt)	**L1** - cont. **Assignment** (Chresten Træholt) **PowerLabDK**	**L2 - Solar energy technology** (Chresten Træholt)	**L2** - cont. **Assignment** (Chresten Træholt)	**L3 - System integration of photovoltaic systems** (Chresten Træholt)	**L3** - cont. **Assignment** (Chresten Træholt)	**L4 - Wind energy technology** (Anca Daniela Hansen)	**L4** - cont. **Assignment** (Anca Daniela Hansen)
									Sunday, 29. Oct. 23:59 Submission of project proposal	
2 30. Oct- 3. Nov.	**L5 - Variability, uncertainty and balancing of wind and solar generation** (Matti Juhani Koivisto)	**L5** - cont. **Assignment** (Matti Juhani Koivisto)	**L6 - Grid connection, grid codes and standards for test and modelling of RE generation** (Poul Ejnar Sørensen)	**L6** - cont. **Assignment** (Poul Ejnar Sørensen)	**L7 - Power markets** (Jalal Kazempour)	**L7** - cont. **Assignment** (Jalal Kazempour)	**L8 Forecasting RE generation** (Gregor Giebel)	**L8** - cont. **Assignment** (Gregor Giebel)	**Projects start-up Topic distribution Forming groups** (Yi Zong, supervisors)	**Supervision meeting with individual group**
3 6. - 10. Nov.	**SYSLAB Tour & safety instruction** (Daniel Arndt-zen//Yi Zong)	**Hands-on work with distributed energy systems** (Kai Heussen)	**Hands-on work with distributed energy systems** (Kai Heussen)		**Hands-on work with distributed energy systems** (Kai Heussen)		**Energinet:** Grid planning and operation of power system with high share of renewables (Glenn Ringgaard Haastrup)		**Project work** (supervision)	**Project work** (supervision)
4 13 - 17 Nov.	**Bornholm trip**	**Project work** (supervision)	**Project work** (supervision)		**Project work** (supervision)		**Project work** **Report hand-in**		**Final presentation** (Joachim Holbøll/Yi Zong, supervisors)	**Farewell reception** (Joachim Holbøll)

On campus Lyngby *Visits, excursions (Risø, Energinet, Nordhavn, PowerlabDK)*

Figure 5: DTU course programme for RE integration into Power Systems

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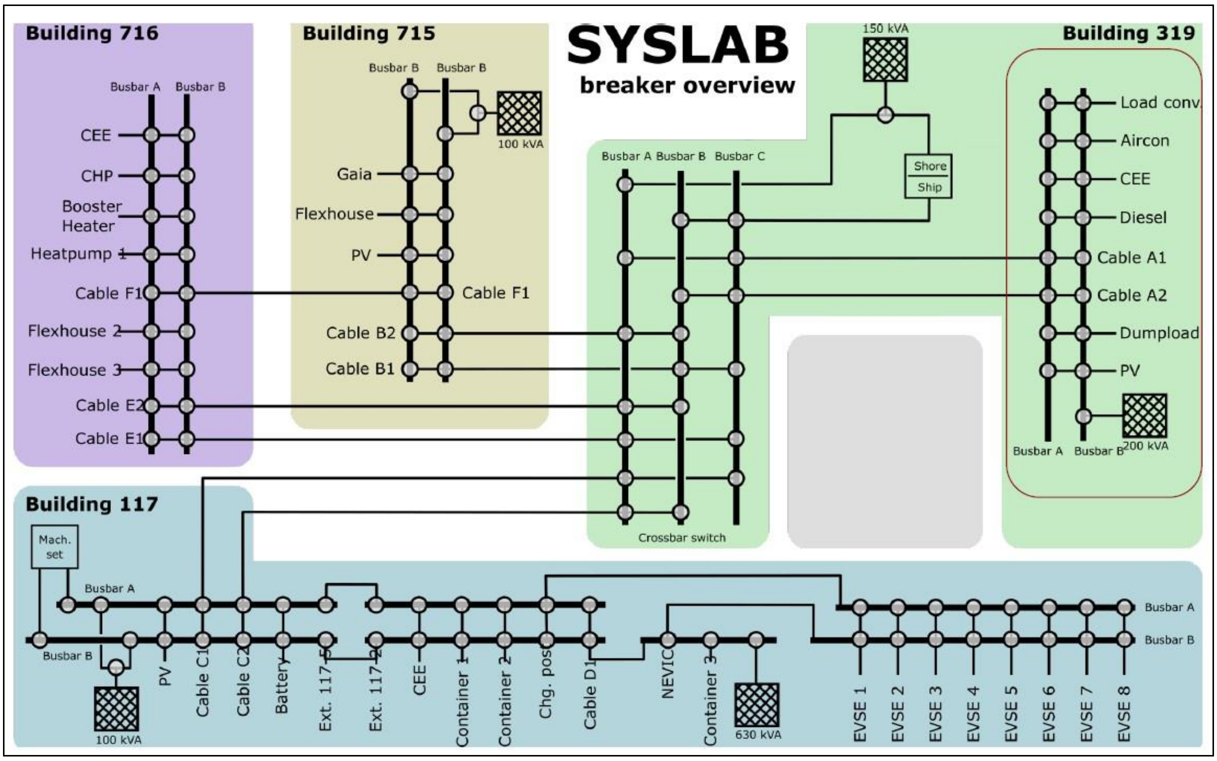

Figure 6: DTU Risø campus SYSLAB breaker overview

Figure 7: Bornholm's Bioenergi waste to energy plant

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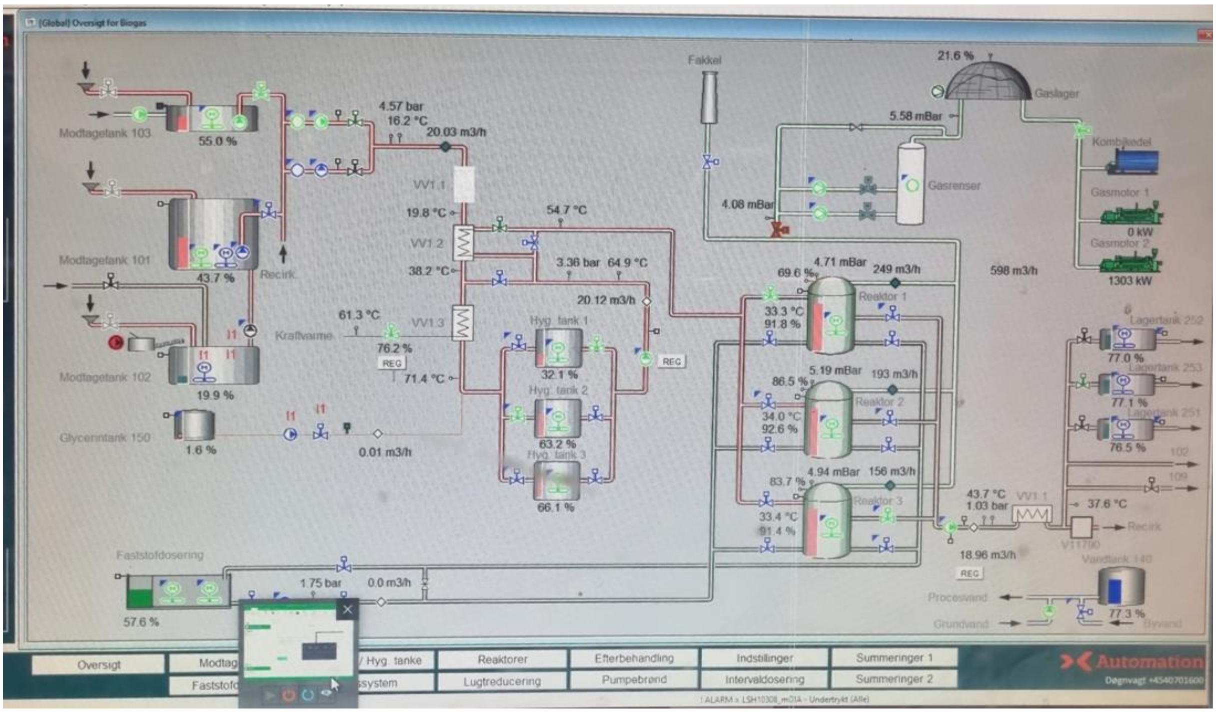

Figure 8: Bioenergi waste to energy schematic diagram

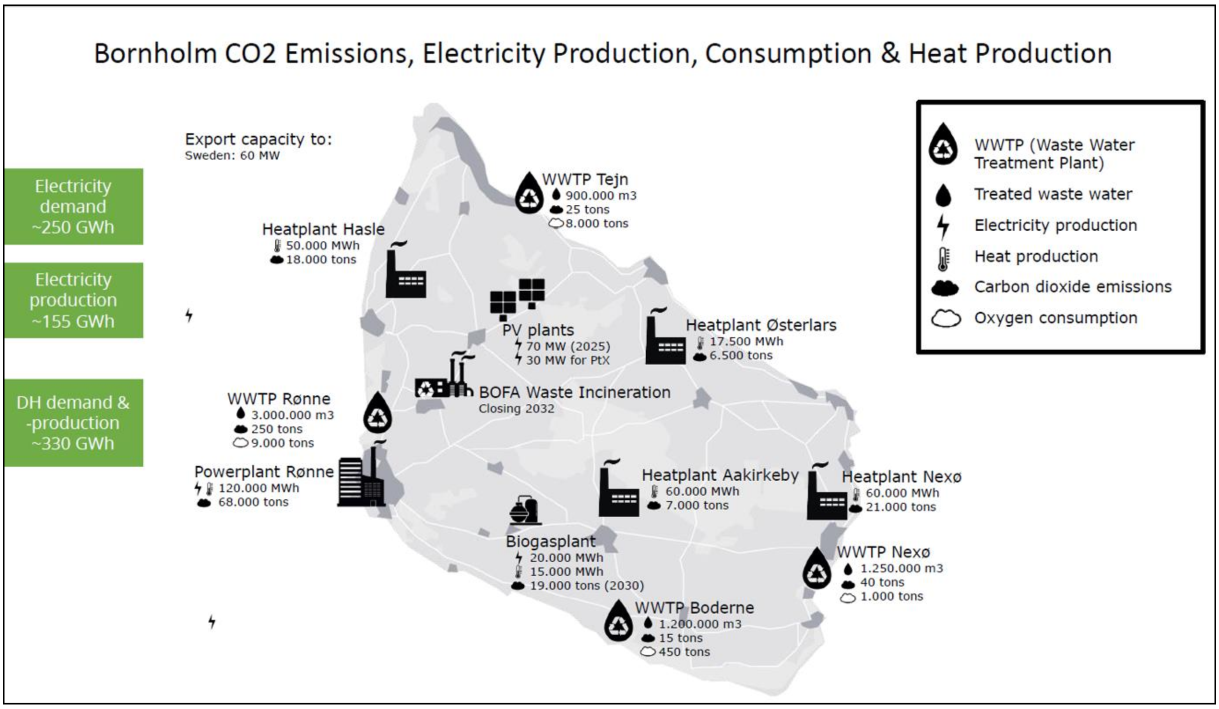

Figure 9: Bornholm Island electricity production, consumption and heat production

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FOR FURTHER DETAILS, CONTACT:

DATE	4 March 2024		
NAME	Shannon Dunbar	CONTACT NUMBER	0214002901
E-MAIL ADDRESS	shannon.dunbar@capetown.gov.za		
DIRECTORATE	Energy	FILE REF NO	
SIGNATURE :	Shannon Dunbar Digitally signed by Shannon Dunbar Date: 2024.03.04 15:57:06 +02'00'		

Edgar Capes Digitally signed by Edgar Capes Date: 2024.03.04 16:04:46 +02'00'

EXECUTIVE DIRECTOR

The ED's signature represents support for report content and confirms POPIA compliance.

SIGNATURE:

NAME

Digitally signed by Kadri Middlekoop Nassiep Date: 2024.03.08 14:15:38 +02'00'

DATE

COMMENT:

Leslie John Rencontre Digitally signed by Leslie John Rencontre Date: 2024.03.05 09:56:45 +02'00'

Please adhere to timelines for submission of feedback reports post official travel.

MANAGER: INTERNATIONAL RELATIONS

DR. DENVER VAN SCHALKWYK

SIGNATURE: Dr Denver van Schalkwyk Digitally signed by Dr Denver van Schalkwyk Date: 2024.03.08 15:54:48 +02'00'

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☐ REPORT COMPLIANT WITH THE PROVISIONS OF COUNCIL'S DELEGATIONS, POLICIES, BY-LAWS AND ALL LEGISLATION RELATING TO THE MATTER UNDER CONSIDERATION.

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LEGAL COMPLIANCE

☐ NON-COMPLIANT

COMMENT:

NAME

TEL

DATE

Certified as legally compliant based on the contents of the report.

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CITY MANAGER

☒ NOTED

☒ REFER TO THE MAYORAL COMMITTEE VIA THE RELEVANT SECTION 79 COMMITTEE

DATE

COMMENT: