Clean energy
for EU islands

CLEAN ENERGY TRANSITION AGENDA

Flexens
FLEXIBLE ENERGY SOLUTIONS

New Energy Solutions Optimised for Islands
NESOI
EUROPEAN ISLANDS FACILITY

NAGU

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Preface

This Island Clean Energy Transition Agenda for Nagu is the strategic and tactical roadmap for the transition process towards clean energy as desired by the stakeholders on the island.

This CETA was developed jointly by ProNagu rf, City of Pargas and Flexens Ltd

Nagu has an ambitious goal to strive towards clean energy. Flexens has thus gotten the opportunity to assist Nagu with creating a plan, including goals and visions.

The CETA is divided in to two parts, where the first part is a summary of the current energy situation on Nagu, and the second part presents visions and possible implementations for a clean energy transition.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N° 864266 - European Islands Facility NESOI.

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Part I: Island Dynamics

List of Abbreviations

CETA	Clean Energy Transition Agenda
CO_2	Carbon dioxide
DSO	Distribution system operator
EV	Electric vehicle
GWh	Gigawatt hours
kWh	Kilowatt hours
MDO	Marine diesel oil
MWh	Megawatt hours
n/a	Not applicaple
PV	Solar photovoltiac

Methodology

To gain a good understanding about the current energy situation in Nagu, a data gathering list was created categorizing the energy demand and source for the different categories. It turned out that this data is not available for Nagu. Partly because Nagu is part of the municipality of Pargas, and data for Nagu is not separately reported. Part of the data requested is not available even on community level. Therefore, it was decided to apply a bottom-up method instead. A residential survey was created with questions regarding both current energy systems and the thoughts about the future. Information gained about current energy system was then extrapolated to the whole of Nagu. This methodology has its weaknesses. It is unsure if the people answering the survey are representing an average household.

The survey got a total of 102 respondents, from both permanent and summer residents, and the gathered results have been used as a base for the energy calculations in the CETA. The percentages presented in the “Energy System Description” paragraph have been converted to match the actual number of residents on Nagu.

For further developing the initial learnings from the survey, Flexens arranged a workshop together with the interest group Pro Nagu rf. A joint vision for the future Nagu was formed during the workshop, the results can be seen under the “Vision” paragraph.

Geography, Economy & Population

Geographic Situation

Nagu is an island located in the southwest of Finland, and that since 2009 belongs to the municipality of Pargas. It has a total area of 1698 km^2, of which 246,8 km^2 is land-area. It consists of two main islands, Storlandet and Lillandet, but has around 3000 smaller islands as well. Nagu has a population of 1336 individuals (2019), but with a significant increase during the summer months. The two official languages are Swedish (majority) and Finnish (minority). With its close connection to the sea and beautiful archipelago, Nagu is a popular holiday resort - not least for boaters. Nagu´s coordinates are 60°11´35” N 21°54´25” E

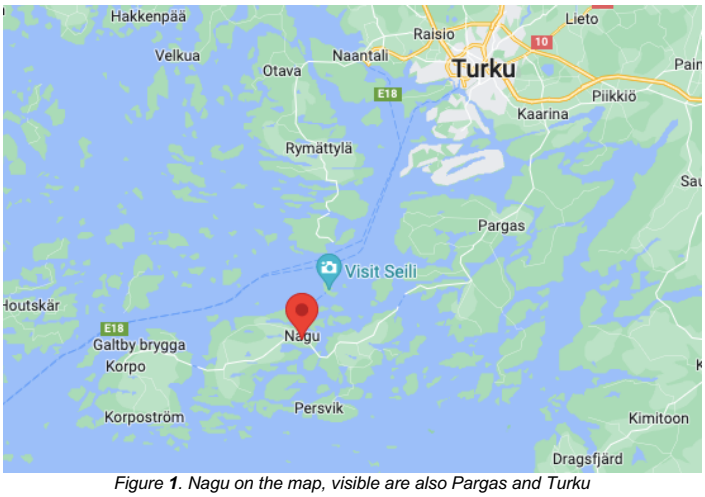

*Figure **1**. Nagu on the map, visible are also Pargas and Turku*

Demographic Situation

According to the Pargas population statistic (2019), the population is somewhat elderly. There is a slump in the ages of 20-40, most likely because many seek to the major cities due to the lack of universities in the area. The population increases significantly again after the age of 40, and peaks in the ages of 65-69, for both males and females.

Local Government

As previously stated, Nagu is a part of the Pargas municipality, which in turn belongs to the district of Southwest Finland. The municipality is led by the municipal director and the Pargas city council, of which 4 of the 35 members (2017-2021) were residents of Nagu. Nagu also has an area committee that works as an advisory body in the Pargas city council. The municipality of Pargas supports Nagu in the clean energy transition.

Economic Activities

Since Nagu is populated all year round there are multiple services on the islands including restaurants, supermarkets, health station, library etc. However, it is a summer resort and is therefore dependent on a thriving summer season since much of its livelihood comes from the tourists. According to a mobile data analysis (Nordic archipelago cooperation, 2020) Nagu island had 631 000 visitors. The data includes seasonal inhabitants.

Besides tourism, Nagu is also dependent on its agriculture and local food production, which is known for its very good quality.

There are currently 145 registered private services and companies on Nagu, together with 21 municipal services.

Connection to the mainland

The island is connected to the mainland by a small ferry, which can be boarded either by car, bus, bicycle or by foot. The ride to Pargas takes about 10 minutes and thereafter Turku can be easily accessed by car or bus.

In 2017 one of the two operating ferries got upgraded to an electric hybrid ferry, equipped with a 1 MWh battery pack. Whilst running on electricity, the emissions from the ferry equals almost to zero, since the Finnish electricity mix is rather clean (89g CO2 eqv/kWh, ref: Motiva). In case of need, the ferry can also be fuelled by diesel.

There is a bus connection to Turku and to Helsinki, the capital city. The connection to Turku is rather good with 9 tours per weekday. The direct connection to Helsinki operates only a few times per week.

The DSO Caruna is responsible for Nagu´s electricity supply by an underwater cable from the mainland.

Energy System Description

There are currently no data available on how many houses there are on Nagu. The data presented below is based on the survey, which is presented further under the “Methodology” paragraph.

According to the Pargas population statistics (2019) Nagu has 1336 inhabitants permanently, and an addition of approximately 10 000 during the summer season.

Single family houses

According to the statistic central in Finland, the average number of individuals per house in Pargas is 2,3, from which we can conclude that there could be a total of 581 permanently inhabited houses on Nagu.

The average electricity consumption on Nagu is 13 513 kWh per year per house, which equals to a combined electricity consumption of 7 851 MWh /a.

A noticeable point is that the share of oil has dropped from 75 % in 2015 to 9 % today, meanwhile the direct electricity has increased from approximately 5 % to 38 % (Pleijel, C. *Energisyn på Nagu, 2015*, updated 2022. & Survey results.)

Thanks to the survey (see the “Methodology” paragraph), a greater perspective on the distribution of different heating systems utilized was gained and is presented below. This does not take the difference between permanent and non-permanent residents into consideration.

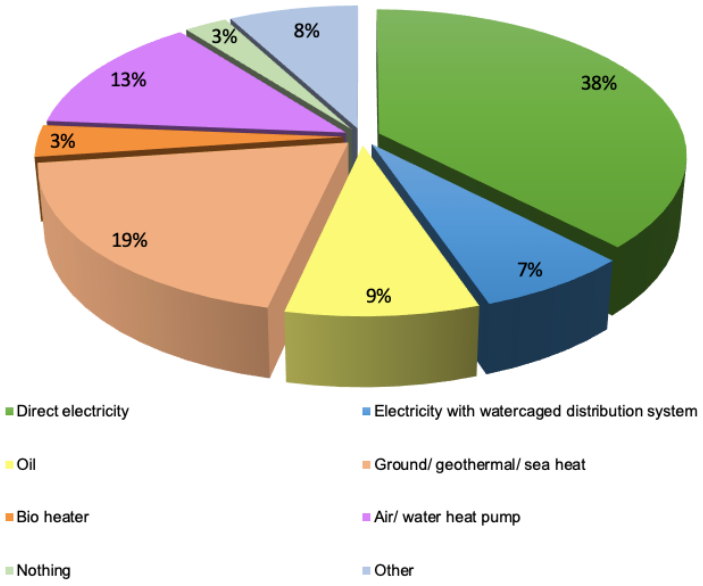

*Figure **2.** Distribution of main heating sources according to the survey results*

95 % of the houses also uses some kind of supplementary heating source, with the majority having a fireplace. The distribution is presented below in Figure 3.

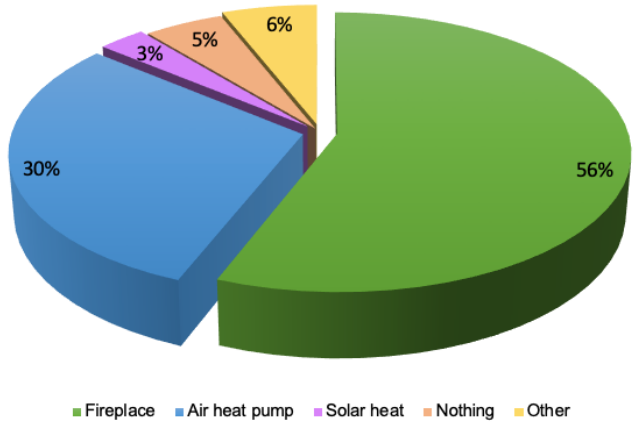

*Figure **3.** Distribution of supplementary heating sources according to the survey results*

The total oil and wood consumption has been calculated by multiplying the average annual consumption – which is 2 580,8 litres of oil and 6,2 m^3 of wood/ house respectively (survey results) – by the percentage of houses that utilizes these fuels, which is 9 % for oil and 56 % for wood (see the figures 2 and 3).

Summer cottages

Nagu has a summer population of about 10 000 people, which correlates with 4 348 houses, if the factor 2,3 individuals/ house is used. The annual electricity consumption of non-permanent residents is 8 554,4 kWh/ a. Furthermore, the non-permanent residents spend on average 155 days in their summer cottages, which means that their total electricity consumption can be calculated to 15 770 MWh/ a.

Communal

The total electricity consumption of the communal buildings has been estimated to 700 MWh/ a (Pleijel, C. *Energisyn på Nagu, 2015,* updated 2022).

Marine transportation

Ferries

There are currently 3 ferries available on the route Nagu-Pargas, of which two are constantly in service. The route is operated by an electric hybrid ferry named Elektra, and a diesel fuelled ferry called Sterna. The third ferry, named Falco, is also diesel fuelled and can be taken into service in case of need.

Alongside the connection ferry Elektra, a similar hybrid ferry will be added in 2022, named Altera.
Altera will be replacing Sterna, which means that the route solely will be operated by electric hybrid ferries. The new ferry will have roughly the same features as Elektra, e.g., propulsion power of 2 x 950kW and a battery pack of 2 x 0,6 MWh. It will also be able to carry the same number of vehicles and passengers.

Elektra's greenhouse gas emissions are only 15 % in comparison with its fossil fuelled forerunner, although the vehicle capacity is 50 % bigger (Finferries, 2021). Elektra is charged on each side of the route with electricity from the national grid.

The annual fuel consumption of Sterna has been estimated to 1,45 million litres of marine diesel oil (MDO) per year, which equals to 14 629 MWh. However, it can be assumed that only half of the consumption is allocated to Nagu, and the other half to Pargas. The annual consumption of the diesel fuelled ferry Sterna is therefore calculated to 7 314 MWh. (Pleijel, C. *Energisyn på Nagu, 2015*, updated 2022.).

There are no data available regarding Elektra's electricity consumption, therefore it has been calculated in two ways for the best possible estimation. First, Elektra has a propulsion power of 2 x 900 kW, and we can assume that she uses about 80 % of the power while operating. Thereafter, we know that the route from Pargas to Nagu is 10 minutes, which means that Elektra uses 240 kWh/ route. The ferry operates an average of 68 routes/ day. The routes are a bit fewer during the winter, however, it most likely uses more energy while breaking ice, so this factor has been neglected. This gives us a total electricity consumption of 2978,2 MWh/ a. We also calculated the difference in efficiency between electricity and diesel, and thereafter divided Sterna's consumption with the efficiency factor, leaving us with 2 742,8 MWh, which correlates with the conclusion from the previous calculation.

The total consumption of Elektra and Sterna together is 10 292,4 MWh/ a.

However, Sterna is about to be replaced with Altera later this year, and if it is assumed that Altera has a similar consumption as Elektra, the total electricity consumption of the two hybrid ferries will be approximately 5 956,8 MWh. This can be compared with previously having two diesel ferries in service consuming 14 628 MWh together.

With two hybrid ferries, the annual energy consumption decreases with 60 %, due to higher energy efficiency in electricity compared to diesel.

A third ferry of the hybrid kind will be implemented on the other side of Nagu, operating the route Nagu - Korpo. The ferry will begin its service in 2023. The name is yet unknown. The route is currently operated by a diesel fuelled ferry, driving the same number of times per day as Elektra and Sterna. It has been assumed that the fuel consumption is equal to Sterna´s, however the route is only half the distance. The annual fuel consumption is therefore assumed to be 3 657 MWh. The route is also equipped with another ferry in case of high pressure; however, it has not been included in the total emissions due to the difficulties of calculating the number of routes.

There are also a few taxi boats operating in Nagu, however the emissions from these have been neglected due to irregular driving patterns. Most of the boats are only in service when prebooked.

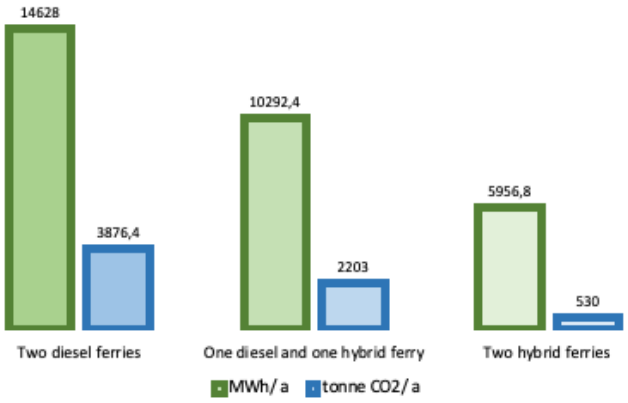

*Figure **4**. Consumption and emissions from various ferry combinations*

Private boats

There are a lot of smaller boats on Nagu, however the annual driving distance is not very long. We assume an annual consumption of approximately 20 000 litres, which equals to 179,2 MWh. The marina in Nagu hosts 9 300 boats overnight. These are however almost to 100% visitors from outside of Nagu and the energy consumption and emissions of these boats have therefore been left outside the scope.

Land transportation

There are no data available of the vehicle status on Nagu, and therefore the total number of vehicles have been calculated by dividing the percent of inhabitants on Nagu with the number of registered vehicles in Pargas.

It was estimated that there are around 1200 cars on Nagu, which drives approximately 1500 km each on Nagu, which equals to a total of 1,8 million km/ a. It was assumed that half of the cars are petrol fuelled and half are diesel fuelled. The following calculations are made with an energy content of 8,96 kWh/ litre in petrol, and 10,05 kWh/ litre in diesel. It was also estimated that the average fuel consumption of a petrol fuelled car is 0,65 litres/ 10 km and 0,5 litres/ 10 km of a diesel fuelled car. There was no information available regarding electric cars so it was assumed that there are no EVs on Nagu at the moment, but it is foreseen that there will be a significant increase in the near future. E-charging stations will then be needed.

In this case, the total energy consumption of the petrol fuelled cars is 524,16 MWh, and 452,25 MWh for the diesel fuelled cars.

It was also estimated that around 300 000 tourists drive either to or through Nagu per year. It was assumed that an average driving distance could be 14 km/ car (Pleijel, C. *Energisyn på Nagu, 2015*, updated 2022.). The calculations are made with the same energy content and average fuel consumption.

The total energy consumption is then 1 123 MWh for petrol cars, and 1 055 MWh for diesel cars.

It was assumed that the fuel consumption of mopeds and quad bikes is 0,2 litres/ 10 km and 0,3 litres for motorcycles. The total estimated fuel consumption is 32,4 MWh/ a.

The bus lines connecting Nagu with Turku and Helsinki, drives in Nagu about 45 minutes 14 times per day, with an estimated fuel consumption of 2,5 litres/ 10 km. The total consumption has thus been calculated to 351,8 MWh/ a.

The tractors have been estimated to drive an average of approximately 400 km/a, in 20km/ h, with a fuel consumption of 1,7 litres/ 10 km. The total energy consumption has therefore been calculated to 254,4 MWh.

*Table **1**. Estimated number of vehicles and their fuel type*

Type	Estimated number of vehicles	Fuel type	Estimated fuel	Estimated driving distance

			consumption litres/ 10 km	km/ a/ vehicle
Passenger cars	600	Gasoline	0,65	750
Passenger cars	600	Diesel	0,5	750
Motorcycles	65	Gasoline	0,3	730
Mopeds	137	Gasoline	0,2	730
Quad bikes (all sizes)	13	Gasoline	0,2	730
Tractors	205	Diesel	1,75	400
Bus	1	Diesel	2,5	140 000

*Table **2**. The total energy consumption and CO_2 emissions on Nagu*

Data for year [2022]	**Final energy consumption [MWh]**	**CO_2 emissions [tonne]**

Electricity consumption*		
Residential (including electrical heating)	*23 621*	*2 102,3*
Primary sector	*n/a*	*n/a*
Communal	*700*	*62,3*
Tertiary sector	*n/a*	*n/a*
Transport on the island**		
Cars	*3 154,4*	*836*
Bus	*351,8*	*93,2*
Motorcykles + mopeds	*30,7*	*8,1*
Quad bikes	*1,7*	*0,45*
Tractors	*254,4*	*67,4*
Transport to and from the island		
Maritime transport	*13 949,4*	*3 172*
Aviation	*n/a*	*n/a*
Heating and cooling***		
Gas boilers	*n/a*	*n/a*
Wood	*25 669,9*	*0*
Oil	*11 481,7*	*3 065,6*
TOTAL	**78 442**	**9 455**

*The factor for purchased electricity is 89g CO_2/kWh (Motiva)

**The factor for both gasoline and diesel is 265g CO_2/kWh (Motiva)

***The factor for firewood is 1500 kWh/ m^3 (Motiva)

As an addition, 3 % of the houses uses solar panels and the average production is 6 433,3 kWh/ year (survey results), which equals to a total production of 952,1 MWh per year. This has been extracted from the total energy consumption in table 2 above.

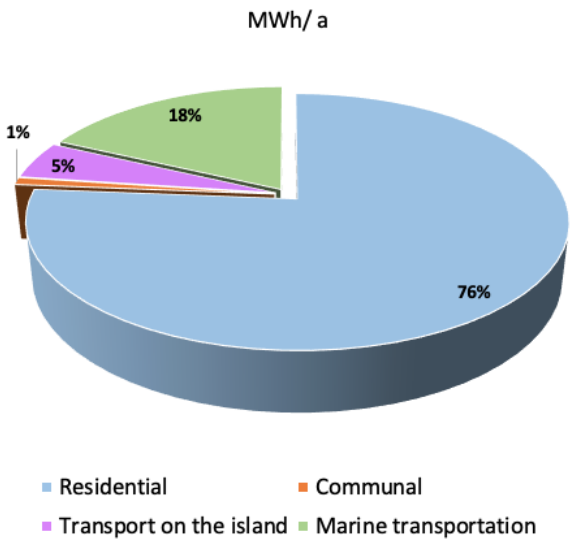

*Figure **5**. Total energy consumption /a per sector*

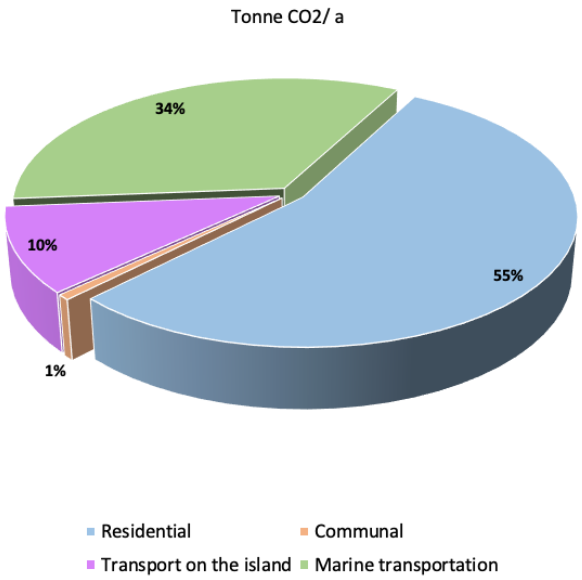

*Figure **6.** Total CO_2 emissions/a per sector*

In the figures above (figures 5 and 6), the residential sector consitsts of all electricity, heating and cooling in residential buildings. The transport on the island sector includes every land vehicle, and the maritime transportation sector includes both connection ferries and small boats. The communal sector consists of the electricty, heating and cooling in the communal buildings.

Stakeholder mapping

Civil society organisations

Pro Nagu rf.

Pro Nagu rf. is an interest organisation established by locals. The organisation gathers locals, other organisations and entrepreneurs to strive for the best of Nagu´s interest. The goal is that Nagu keeps its charm and develops its livelihood, and that both locals and summer guests get to be a part of the influence. Pro Nagu has an email address to where any questions or suggestions may be written. The address is info@pronagu.fi. Pro Nagu rf has been the initiator

to developing the CETA plan. They have been active with the survey and with arranging the practicalities for the workshop.

Businesses

Caruna

The DSO Caruna is an important stakeholder since they are responsible for Nagu´s electricity supply. Since a PV park implementation is planned on Nagu, it is necessary that Caruna is involved in the plan and process.

AL-tec

AL-tec is a company from Pargas specialised in solar power and consulting. The company sells, delivers and installs solar power in the Turku archipelago, including Nagu. AL-tec are also retailers for other companies, such as Salo Solar etc. André Lindholm from AL-tec participated in the workshop that Flexens hosted together with Pro Nagu rf. (see the "methodology" paragraph).

Skärgårdens brunnsborrning

The company is family owned and the employees are experts at geo engineering, who delivers local and clean energy solutions and perform drilling jobs. They have performed their services in the archipelago since 1970. Their e-mail address is info@kaivonporaus.com.

Skärgårdens elservice Ab

The company is based in Korpo but perform electrical services within the whole archipelago. They have over 10 years of experience, and also retails solar panels. Their e-mail address is info@saaristonsahko.fi.

Public Sector

Governmental Actors

The Pargas municipality is an important stakeholder in the clean energy transition on Nagu. Since Pargas has a loose agreement with the district of Southwest Finland to become more renewable and energy efficient, it is in their interest that Nagu also develops, since it belongs to Pargas. The municipality has already taken many actions to become more energy efficient. Patrik Nygrén is the city director in Pargas. Pargas has been active during the CETA development in developing the content to the survey and in attracting local companies to the workshop. The email address for the municipality is pargas@pargas.fi.

Policy and Regulation

Local policy and regulation

The Pargas municipality has already come a long way in improving their energy system. In 2018 it got decided that Pargas would enter the municipal sectors energy efficiency agreement, with a target to decrease the energy consumption with 4 % in 2020 and 7,5 % in 2025. This later got rejected due to the administerial responsibilities and they never entered the agreement.

However, the municipality has indeed kept their "promise" and taken measures anyway. The city has recently renewed its electricity agreement, stating that all purchased electricity shall be 100 % renewable. The heat distributed in the district heating network is produced 50 % from biobased sources, and another 46 % constitutes of waste heat from for example industries. The road lighting has been changed to energy efficient LED lights. The roofs of the Pargas city hall and the Nagu area committee building have been equipped with solar panels. Additionally, a mobile sun powerplant has been built in Pargas, which will provide for example events with energy.

Regional policy and regulation

The district of Southwest Finland has a goal to become carbon neutral before 2035. Several measures on how to achieve that have been established. In 2021 the district contacted the involved municipalities to determine individual plans. The plans contain e.g., improved bicycle roads in order to minimize traffic, depart from fossil heating sources and improved utilization of waste heat.

In 2019, heating accounted for 32 % of the greenhouse gas emissions and the electricity consumption for 11 %. In the Turku area, the specific emissions from the district heating network were 80 kg CO_2/ MWh in 2021 and is predicted to decrease to 18 kg CO_2/ MWh in 2025, and further decrease to 0 kg CO_2/ MWh by 2030 (Turku Energia, 2022).

National policy and regulation

Finland has an ambitious attitude towards clean energy and has already invested a lot in renewable energy on a national level, not least in wind power. The development of clean energy on islands has the same regulations and policies as on the mainland.

Finland has three main national targets for clean energy before 2030. The first target is that the local consumption of electricity originated from renewable energy sources shall rise from 41 % (today) to 53 %. The second and third targets are that renewable energy as a main heating source shall rise from 54 % to 61 %, and that the share of biofuels in the fuel mix shall rise from 20 % to 30 %.

Finland supports the implementation of renewable energy in many forms, for example, financial support is offered to those who wants to replace their fossil fuelled heating system. This privilege applies to both residential- and apartment buildings. The investment subsidy is 4000e/one family house and 4000-6000e/apartment in apartment buildings. Subsidy can not be over 50% of the total costs.

Commented [AC1]: If available, please provide more information on this support scheme?

Commented [ÅH2R1]: Is this enough information?

European policy and regulation

Energy & climate actions

Energy is one of several shared competences between the European Union (EU) and the Member States. EU policy is currently based on three pillars (known as the “energy trilemma”):

- Competition;
- Sustainability;
- Security of supply

Through policy and regulation, the EU promotes the interconnection of energy networks and energy efficiency. It deals with energy sources ranging from fossil fuels, through nuclear power, to renewables (solar, wind, biomass, geothermal, hydro-electric and tidal). Three legislative packages were adopted to harmonize and liberalize the internal European energy market between 1996 and 2009. These addressed issues of market access, transparency and regulation, consumer protection, supporting interconnection, and adequate levels of supply.

For a while now, the EU is actively promoting Europe’s transition to a low-carbon society and is regularly updating its rules to facilitate the necessary private and public investment in the clean energy transition.

A variety of measures aiming to achieve an integrated energy market, the security of energy supply and a sustainable energy sector are at the core of the EU’s energy policy:

- Renewables Directive: mandatory targets, national plans grid rules.
- Emission Trading Scheme (ETS), reflecting a carbon price to achieve the cap.
- Energy Union: secure, sustainable, competitive, and affordable energy.
- 3rd energy package: unbundling, harmonised grid operation rules, network codes etc.
- Energy Efficiency Measures.
- Institutional measures: ENTSOs, ACER, CEER.
- Development of the longer-term framework: 2020, 2030, 2050.

Latest EU legislation on energy environment and climate

On 11 December 2019, the European Commission presented its Communication ‘**The European Green Deal**, setting a new growth strategy that aims to transform the EU into a fair and prosperous society, with a modern, resource-efficient, and competitive economy, where

there are no net emissions of greenhouse gases in 2050 and where economic growth is decoupled from resource use.

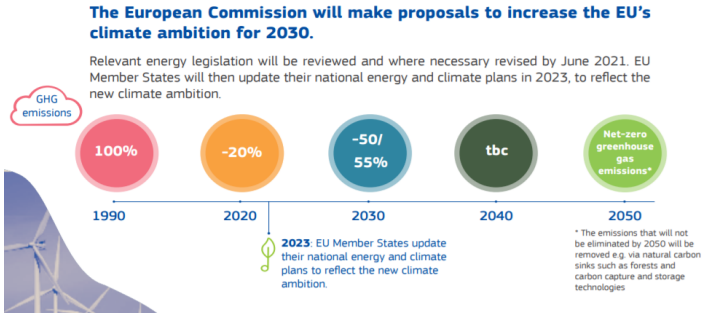

*Figure **7**. Clean energy targets Green Deal*

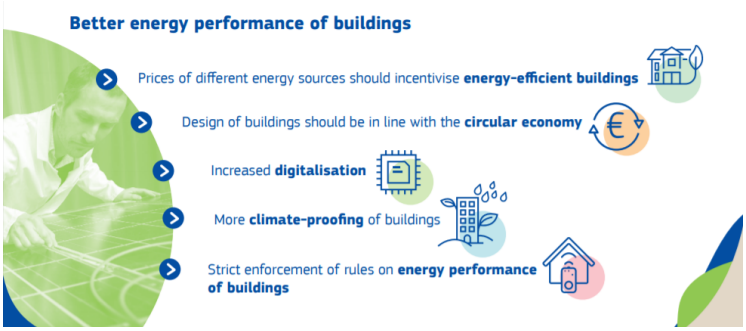

*Figure **8**. Building and Renovation targets Green Deal*

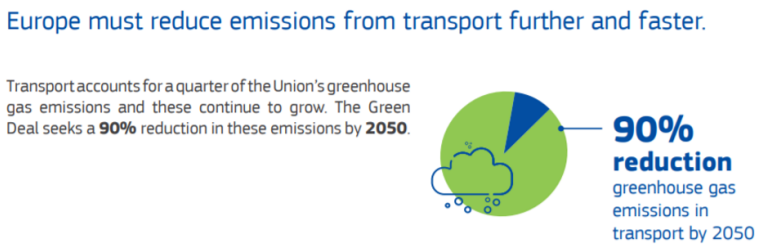

*Figure **9**. Sustainable mobility targets Green deal*

The Commission stated that the European Green Deal will reflect this growth strategy in its long-term vision for rural areas. It will pay particular attention to the role of outermost regions in the European Green Deal, considering their vulnerability to climate change and natural disasters and their unique assets: biodiversity and renewable energy sources. The Commission will take forward the work on the Clean Energy for EU Islands Initiative to develop a long-term framework to accelerate the clean energy transition on all EU islands.

On the 4th of March 2020 the European Commission unveiled the **European Climate Law** proposal aiming at cutting greenhouse gas emissions to zero by 2050 and making it legally-binding for all member states. The European Commission is proposing a mechanism for regularly raising the EU's emissions reduction target over the next three decades. By September 2020, the Commission shall review the Union's 2030 target for climate in light of the climate-neutrality objective and explore options for a new 2030 target of 50 to 55% emission reductions compared to 1990. The European Commission stressed that it will engage with all parts of society to enable and empower them to take action towards a climate-neutral and climate-resilient society, including through launching a European Climate Pact.

In the autumn of 2018 and spring of 2019, several directives were adopted under the **Clean Energy for all Europeans Package**. The eight legislation measures can be placed in four groupings:

1. Energy Efficiency:
    - The Energy Efficiency Directive; and
    - The Energy Performance in Buildings Directive
2. Internal Energy Market Reform:
    - The Internal Electricity Market Design Regulation;

- The Internal Electricity Market Design Directive;
- The Agency for the Cooperation of Energy Regulators (ACER) Regulation; and
- The Risk Preparedness in the Electricity Sector Regulation.

3. Renewable Energy:
   - The Renewable Energy Directive;
4. Governance:
   - The Governance of the Energy Union and Climate Action Regulation.

These Electricity Market Design (EMD) rules make the energy market fit for the future and place the consumer at the center of the clean energy transition. The rules are designed to empower energy consumers to play an active role in driving the energy transition and to fully benefit from a less centralized, and more digitalized and sustainable energy system. The rules enable the active participation of consumers whilst putting in place a strong framework for consumer protection.

Energy communities

For EU Islands the most important new rules are those that empower citizens and small producers under the new concept of Renewable (REDII) or Citizens (EMD) Energy Communities. These are groups of citizens, social entrepreneurs, public authorities and community organizations participating directly in the energy transition by jointly investing in, producing, selling and distributing renewable energy. The produced renewable energy can be shared within the community. The community can also access all suitable energy markets both directly and or through aggregation in a non-discriminatory manner.

Part II: Island transition path

Vision

The inhabitants' visions emerged during the workshop that Flexens hosted together with Pro Nagu rf. The audience was asked what the future of Nagu means to them, and they had answers such as, forerunners within energy solutions, more circular economy, carbon dioxide neutral district, a bridge between Nagu and Pargas etc. To the question regarding what they would like to see more of on Nagu, they answered more wind- and solar power, more children, more local production, more bioenergy, more bridges, a collection point for plastic garbage etc.

It can be concluded that self-sufficiency is important as well as sustainable living including clean energy.

Commented [AC3]: And yet there is no reference to wind in the rest of the document and the transition's pillars/pathways.

We had discussed in a progress update meeting that one medium scale wind turbine on land or potentially in shallow waters, possibly owned by residents, could provide most of the electricity needed and create a green brand name for Nagu.

Has the technology been rejected for some reason by the experts or the community?

Commented [ÅH4R3]: yes, this should be mentioned somehow. It was concluded that building wind farms in Nagu would be extremely difficult due to nature protective reasons and tourism. I will add this.

Transition Governance

The transition governance can be rather simple in the Nagu case. The proposed solutions are such that it is easy to identify which stakeholders that are relevant for the successful implementation of the suggested solutions.

An energy transition team will be formed, led by Pro Nagu rf. It is suggested that other members in the team are the following stakeholders: city of Pargas, DSO Caruna, and a project developer.

The city of Pargas has a central role in the implementation due to its role as giving building permits and facilitating a good planning and implementation process.

The DSO Caruna has a central role when it comes to PV parks since it is essential that the project is planned together with the DSO to enable a functional result with low curtailment levels of the PV parks.

To involve a project developer that understands the special features of smaller islands is essential for a good result. Flexens Ltd is one candidate for this.

The inhabitants of Nagu have a central role and their involvement is facilitated by Pro Nagu rf. Inhabitants need to be involved from the very beginning, especially the PV parks and the centralised heating system are projects that need local approval to avoid any lengthy and costly legal processes.

Pathways

When developing the pathways for the transition all renewable energy solutions were considered and the input from the inhabitants was considered. Wind energy was an energy source that was raised and it could be concluded that the vision for Nagu was to have more wind energy. However, it turned out that the Nagu area is a difficult place for windfarms. The areas nature is very fragile, there are residential houses scattered around Nagu and there is a wide debate about windfarms effect on tourism, which is very important for Nagu. Since it turned out that the PV potential is very good on Nagu, it was decided to focus on solar energy related solutions for electricity production.

For heating energy the focus was put on a centralised heating system in the centre of Nagu and on supporting private households in changing their heating systems from fossil fuels to renewables.

For the transportation sector, the concrete measure was to propose EV charging stations.

Commented [ÅH5]: I added this section

PV park

One of the biggest pathways to clean energy on Nagu is large scale PV parks. Numerous areas have been appointed as building opportunities, with a total area of 270 ha. If all the areas would be utilized, a total electricity production of 270 GWh /a could be achieved. It is however estimated that up to 100 ha would be a maximum amount of realistically achievable potential. The next steps for this project are further analysis of the possibilities, as well as an investigation of the ownership of the most suitable areas.

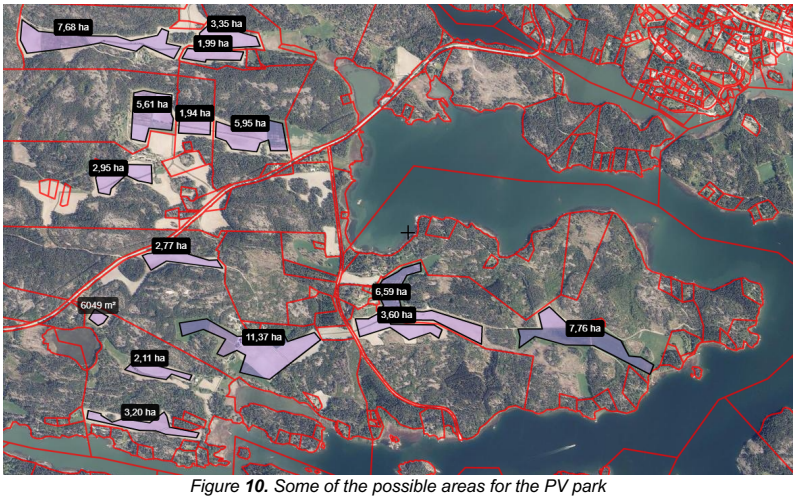

*Figure **10.** Some of the possible areas for the PV park*

Centralised heating system

A centralised heating system in the main village is also a feasible project to implement. There are around 500 inhabitants living in the main village, and it is home for most of the public service buildings. The buildings are currently heated with light fuel oil or electricity. At the moment there are two possible technologies under investigation. The first one is a ground heat based heat pump, connected to the possible PV park. The other one is a power to heat storage system, also connected to the possible PV park.

Charging station

An implementation of a charging station in the main village could be a way to attract more electrical vehicles to the islands. A charging station would also be beneficial for the tourism. This could in turn, over time, decrease the number of fossil fuelled vehicles.

Assistance from the municipality

Another idea for Nagu could be to implement more easily accessed help from the municipality for the planning- and implementation of building specific renewable systems in private houses. Arranging a joint purchase, adding many separate houses into one bigger order, could not only save time but also money.

Pillars of the Energy Transition

The most important sectors towards clean energy are known as the pillars of the energy transition, these include:

- Electricity generation,
- Heating and cooling,
- Transport on the island,
- Transport to and from the island

Electricity generation

Nagu has no big scale electricity production on its own, the electricity currently comes from the mainland. However, there are a few private households that produce renewable electricity from for instance solar panels and sells the abundance to the grid. If the PV park gets implemented, a lot of Nagu´s consumed electricity will be renewable, which would be a great step towards clean energy.

Heating and cooling

The heating and cooling pillar is already on the road to improvement. Oil as the main heating source has decreased significantly during the past years, while direct electricity has increased. It should not be overlooked that direct electricity consumes a lot of electricity and is sensitive to raising electricity prices, therefore, a centralised heating system could be a good improvement for Nagu.

Transport on the island

The distances on Nagu are not very big, so the diesel and petrol consumption are not too high. However, they could be further decreased if there were more electric vehicles (EVs) on Nagu. To have more EVs, charging stations would need to be implemented. The electricity consumption would rise a bit, however the carbon dioxide emissions would decrease, given that the electricity used for charging is produced from renewable energy.

Transport to and from the island

The transportation to and from the island is perhaps the most advanced pillar. There is currently one electric hybrid ferry trafficking to and from Nagu, and already this year Nagu will be provided with two more. This an enormous aspect, considering that Nagu is dependent on marine traffic to and from the island. The ferry emissions are therefore naturally a big contributor of Nagu´s total energy consumption. With exchanging three diesel fuelled ferries to electric hybrid ferries the total emissions will decrease significantly.

Monitoring

The clean energy transition process is under constant monitoring in order to achieve the best possible outcome. Monitoring the process is an important part of the development, and also to be able to reflect on the previous steps. The monitoring is done by a team consisting of representatives from Pro Nagu rf and the city of Pargas. The team can invite other stakeholders, such as local companies, project developers or the DSO for example. The team gathers at least once per year for a review.

The review is done with help of a self-assessment tool of which nine indicators are processed. Each of the indicators are provided with a score from 1-5. A low number indicates that more time and effort are required in that particular area. A high number on the other hand, represents a good development and that things are under control.

*Figure **11**. The scores of the indicator*

INDICATOR 1: CLEAN ENERGY TRANSITION AGENDA

Score: 4

The transition agenda, that is in its finalisation stage is clear and concrete. It contains concrete actions that lead toward the vision. However, the project specific next steps are not yet defined in detail.

INDICATOR 2: VISION

Score: 4
The vision has been developed together with local inhabitants and companies and the local authorities and interest groups. It is clear and easy to understand. However, it focuses on energy mainly and other sustainability and habitability issues are not included.

INDICATOR 3: COMMUNITY – STAKEHOLDERS

Score: 3
The Pro Nagu rf has been the organisation representing the community. It is not clear how well the association really represents the inhabitants broadly enough. Some companies were involved in the workshop as well, but local businesses involvement could have been stronger, and should be increased in the future.

INDICATOR 4: COMMUNITY – ORGANISATION

Score: 4
The city of Pargas represents the local authority and the Pro Nagu rf represents the local community. This is a clear division of roles. See indicator 3 for further reflections.

INDICATOR 5: FINANCING CONCEPT

Score: 4
The proposed concrete projects are according to initial analysis bankable and there will not be difficulties finding financing for them. The EV-charging station might be a bit weak in this aspect and might require some further business plan development.

INDICATOR 6: DECARBONISATION PLAN – ISLAND DIAGNOSIS

Score:4
Several sectors such as heating, transportation, marine traffic etc. are covered with relevant data, which is included in the CETA report.

INDICATOR 7: DECARBONISATION PLAN – DATA

Score: 4
A lot of data regarding several relevant sectors have been calculated in the CETA to get an as good as possible overview on Nagu´s energy consumption.

INDICATOR 8: DECARBONISATION PLAN – ACTION PLAN

Score: 3

A plan has been made for Nagu, however there are only a few concrete possibilities at the moment. For a full score it would be valuable with a few more pathways in order to gain more flexibility in the clean energy transition process.

INDICATOR 9: MULTI-LEVEL GOVERNANCE

Score: 3
Some teamwork with other levels of governance is undergoing.

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