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LocalRES Plan

Substitutions for technologies in Kökar's demo sites

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1 Introduction

This document provides information about the original planned demos and justifications for the substitutions that have been made in the light of newly gathered information. At first, the original plan is presented for context for the substitutions. Then, the substitutions are presented, followed by the reasoning and justification for why the substitutions have been made in the first place. The purpose of the document is to act as an assurance that the changes to the original plan have been made with careful consideration and with both the island and the project's best interest in mind. Please note, that only the parts of the original plan that are wished to be changed are presented in this document.

Summary of the amendments suggested:

1. School: Micro-CHP heating system changed to → Hybrid heating solution (including P2H storage, and utilizing the 5 kW + 10 kW microwind systems and the PV system)
2. Elderly home: Solar PV system size increased from 30kW to → 70kW + battery size increased from 50kWh → to 100kWh

Table 1: Table of estimated costs from the original application letter. Changed parts are highlighted.

Action	Responsible partner	Total invest. [€]	Private funds [€]	Public funds [€]	EC contr. [€]
1. Kökar (Finland) demo case. Demo team: FLEXENS, KÖKAR Municipality, VTT					
Micro-CHP (renovation of school's heating system).	Kökar	355,000	--	142,000	213,000
Solar panels for the school	Kökar	100,000	--	40,000	60,000
Micro-wind system for the school	Kökar	20,000	--	8,000	12,000
Public charging station for EVs	Kökar	20,000	--	8,000	12,000
Energy management system for the school	Kökar	30,000	--	12,000	18,000
Energy management system for 20 households	Flexens	60,000	--	--	60,000
Elderly home: Solar panels with battery storage system and smarter energy management system	Kökar	150,000	--	60,000	90,000
Demo coordinator and citizen engagement	Flexens	87,800	18,690	--	69,110
TOTAL		**822,800**	**18,690**	**270,000**	**534,110**

2 Kökar school

2.1 Current situation at the school

Currently, Kökar school consumes annually around 291MWh of heat, which is produced with two 90kWth oil boilers during winter and a 26kWth electric boiler during summer. The oil consumption is roughly 26500 liters per year, which costs 24 380€ and causes annual emissions of 73tCO2. In addition, the school uses around 90MWh of electricity per year, which costs 16 550€ and has a carbon footprint of 68gCO2/kWh, thus equaling annual total carbon emissions of 77tCO_2.

2.2 Original plan for the oil heating system replacement (Micro-CHP)

The original plan for LocalRES demo site in Kökar's school included replacing the old oil boiler with a 100kWth/40kWel woodchip fired micro-CHP plant, together with a 50kWel solar PV array and a 5kW micro-wind turbine as a separate investment. In addition, it was intended that the school would undergo an energy renovation where the current inefficient building automation would be updated, and a smart energy management system would be installed to increase energy efficiency as well as the self-consumption from RES and provide interface for the energy community platform.

Table 2: Micro CHP - information.

Volter 40 Outdoor	
Max heat output (water)	$100kW_{th}$
Max power output	$40kW_{el}$
Power output range	30-100%
Efficiency	75%

Max operating hours/a	7 800h
Max generation/a	312MWh
CAPEX	***325 000€***
OPEX	***31 042/a***

Summary for the school's original investment plan:

Total capex for the Micro CHP was 325 000 €, and it would have created annual energy cost savings of 9889 €/a compared to the oil heating.

2.3 Substitution for the micro-CHP

The first substitution is for the originally proposed micro-CHP. The idea is to replace it with a 100kW/10MWh sand-based high temperature thermal energy storage by Polar Night Energy, and two 25kW air-to-water heat pumps. In addition, 10kW Micro-wind system, "Aeolos-10V" would be installed. The rest of the system would stay effectively the same as in the previous plan.

Table 3: Polar Night Energy TES specs, based on an offer.

Polar Night Energy TES	
Capacity	10MWh
Max heat output	0,1MW
Annual discharge	35MWh
Efficiency	51%
Annual charge	85MWh
CAPEX	**205 000€**
OPEX	1 000€

Table 4: Air-to-water heat pump spec estimations.

Air-to-water heat pump	
Heat output	2x25kW
Power input	2x6,25kW
COP	4
Power consumption	64MWh/a
Heat production	192MWh/a
CAPEX	**40 000€**
OPEX	**600€/a**

Table 5: Aeolos-V10 VAWT specs, based on an offer.

Aeolos-V10	
Rated generation capacity	10kW
Max capacity	12kW
Approx. yield	~180MWh/a
Efficiency	~31%
Technical lifetime	20a
Sound	<45db
CAPEX	**35 000€**
OPEX	**N/A**

Summary for the school's substitutive investment plan:

The total capital cost of the school's new energy system with the proposed substitutions would be 280 000 € (75 000 € less) and the annual cost savings 21 440€ (12 300€/a more), which would lead to expected payback time of 3 years, given the possible subsidies. The system would also reduce the energy related CO_2 emissions by $67tCO_2$ annually, which is a 87% drop to the original $77tCO_2$/a.

3 Kökar elderly home

3.1 Current situation at the elderly home

At the moment, the elderly home of Kökar municipality consumes around 185MWh of electricity per year, which provides all of the energy needs as the building is heated with a ground-source heat pump.

3.2 Kökar elderly home – original investment plan

The original plan was to install 30kW$_{el}$ solar PV array with a 40kW/50kWh battery energy storage and smart energy management system. The idea was to increase the consumption of solar power and to protect the inhabitants form blackouts that are frequent in Kökar.

Table 6: Solar PV array specs, based on an estimation.

Solar PV array (GEF-280-P60)	
System capacity	29,7kWp
System yield	28MWh/a
CAPEX	**30000€**
OPEX	**150€/a**

Table 7: Battery storage specs, based on an offer.

Battery Eaton xstorage compact	
Capacity	50kWh
Max charge/discharge power	40kW
Roundtrip efficiency	>85%
CAPEX	**34 000€**
OPEX	**N/A**

Summary for the elderly home's original investment plan:

The total capital cost of the originally proposed system would have been around 72 500€ including all components and would have led to annual energy cost savings of 6 050€, accounting to a payback time of roughly 3 years given all subsidies. The annual CO_2 emission savings via reduced use of grid electricity would be around 3,4tCO_2, as 50MWh less power would be bought from the grid per year.

3.3 Kökar elderly home – substitutive investment plan

Substitutions for Kökar's elderly home are in essence that the solar PV array is upgraded from 30kW to 70kW, battery from 50kWh to 100kWh.

Table 8: Solar PV array specs, based on an estimate.

Solar PV array (GEF-280-P60)	
System capacity	70kWp
System yield	65MWh/a
CAPEX	**70 000€**
OPEX	**350€/a**

Table 9: Battery energy storage specs, based on an offer.

Battery (Eaton xstorage compact)	
Capacity	100kWh
Max charge/discharge power	60kW
Roundtrip efficiency	>85%
CAPEX	**65 000€**
OPEX	**N/A**

Summary for the elderly home's substitutive investment plan:

The total capital cost after the substitutions would be 135 000€ and the annual energy cost savings around 8 300€, accounting to a payback time of 4 years given the subsidies. Thereby, by increasing the investment by 71 000€ the system would allow the reduction of further 23MWh of power purchases from the grid and respective carbon emission reduction of roughly 1,5tCO_2 more per year.

4 Reasoning and justifications for the substitutions

4.1 School: micro-CHP → Hybrid heating solution

Since the original application, new information has come up that have impact on the made plans. Regarding the micro-CHP plant. It was discovered that the O&M costs and the wood chip fuel would be significantly more expensive than what was originally estimated, which reduced the plants feasibility substantially. In addition, a worry of sufficiency of fuel resources and impacts on natural habitat in Kökar were brought up. Also, the future of biomass is unsure in the EU green investment taxonomy.

The substitutive solution with TES and AWHPs was also found to be more affordable and feasible as well. Other factors that support the selection of this hybrid solution is the weakness of the local grid, which does not allow any surplus energy to be injected into it, as the thermal energy storage allows the excess energy to be stored as heat for later use. In other words, the thermal heat storage provides more flexibility Furthermore, the proposed solution represents sector integration's principles better, does not require combustion of fuels, and can be easily replicated to other locations that might not have woodchips available.

4.1.1 School: Additional 10 kW Micro Wind system (Aeolos-V10)

A new 10 kW micro wind system is added, as it increases the RES production all year around, and therefore reduces the amount of power bought from the grid and provides more RE for the thermal storage. The substitutive V10 is also rather quiet, which was an important issue for the locals and effectively ruled out the micro-HAWT options.

4.2 Elderly home: Solar PV array 30kW → 70kW + battery 50kWh → 100kWh

A more careful examination revealed that more PV could be installed on the roof of the elderly home than what was originally suggested. With a larger battery, the full potential of the RES production can be utilized, and a more robust backup power source can be provided for the inhabitants. In addition, the cost increase can be considered modest and reasonable.