AN ASSESSMENT OF 100% RENEWABLES IN ELECTRICITY AND HEAT IN ARAN ISLANDS BY 2030

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Motivation and core objectives

Decarbonisation of geographical islands are gaining more attention within the European climate and energy targets. The islands are either depended on mainland through grid or they face high dependency on fossil fuels. In this respect the Project React [1] focuses on the achievement of island energy independency by joining renewable energy sources (RES) and storages, a demand response platform and promote user engagement in a local energy community for the three pilot and five follower islands. This paper presents a long-term techno-economic assessment of covering of 100% of total electricity and heat demand from RES by 2030 for the Irish Aran Islands. The main goal is to find suitable renewable energy mix for the year 2030 by considering local circumstances.

Methodology

The Aran Islands are a group of three limestone islands with around 1,226 inhabitants, located in Galway Bay. Currently generation from RES is very limited accounting only few PV and heat pumps installations. The target of 100% energy autonomy for the islands means an ambitious uptake of RES. We assumed for the energy autonomy, electricity generation from local renewables shall cover 100% of total electricity and heat consumption and partially the transport energy demand in an annual balance.

The future demand projections for electricity, heat and fossil fuel for road transport are estimated up to 2030. In 2017, the electricity demand is accounted about 2,993 MWh. The total annual electricity demand is assumed to be at 4,712 MWh by 2030, including 1,585 MWh demanded by the heat pumps and 104 MWh by electric vehicles (7% of total vehicle stock).

For the assessment the open source energy system modelling tool Balmorel [2] has been used. Balmorel is optimizing the generation investments in different scenarios that minimizes the total investment and operational costs of the energy systems. It considers the balance of supply and demand of electricity and heat reserve power demand, possible investment in new generation and transmission capacity, power plant and transmission line capacity restrictions and efficiencies. For this work, the model has been calibrated to and adapted for the electricity and heat system for Aran Islands. Furthermore, following assumptions have been made based on local conditions.

- **Electricity exchange** has been included between Aran islands and the mainland by considering 3 MW connection (assumed also as maximal transmission limit) and 7% transmission losses [3] Exchange occurs price dependently based on the electricity day-ahead prices for Ireland in 2030. It is assumed that the prices in Ireland will be about 10 % higher in 2030 [4] in comparison to 2016 level [5].
- **PV and batteries installation:** It is assumed that Aran island will have at least 300 kWh batteries (30 houses each with a 10 kWh capacity) and 120 kW_p building integrated PV (30 houses each with an 2 kW_p capacity) in 2030, based on the activities ongoing for the use of these technologies.
- **Wind turbine installation:** The possibility to install on-shore wind turbines was included following existing local plans.

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Results and Conclusions

The results of the model-based analysis show that a wind turbine of 2.2 MW, with an average yearly electricity generation at 6,562 MWh, may cover 100% of the domestic electricity demand. This includes also the demand driven by the presumed heat pumps that, in turn, meets 100% of the domestic heat demand. The generation surplus from wind power can then be exported and, in the hours, when local generation lies below local demand, import from the mainland seems to be necessary flexibility option as a backup.

Table 1 shows the electricity generation and consumption categories by 2030. With this result we can claim that a full decarbonisation of the Aran Islands by 2030 can be achieved for the electricity sector, and, additionally, also for the heat sector (by using electric heat pumps). Furthermore, Aran islands will act as a net exporter thanks to a 2,010 MWh surplus in electricity supply. If a wind turbine with about 2.2 MW rated capacity is installed, this surplus may also cover the overall local passenger transport demand.

Table 1: Electricity generation and consumption in 2030

Generation technologies	**Generation (in MWh)**	**Consumption categories**	**Consumption (in MWh)**
Wind	6,552	Load	4712
Solar PV	102	From Heat Pump	1,585
Battery	69	From Battery	83
Import	1,306	Export	3,317
Total	8,029	Total	8,029

Besides pre-given battery installation there is no additional battery capacity required according to modelling results. In modelling their operation appears sensitive to price signals in the overall electricity market but is hardly driven by system needs from a local perspective. This argument holds also for solar PV which is modelled at 0.12 MWp pre-given capacity. Today small-scale battery systems applied at end user level cannot benefit from price fluctuations at the wholesale market since end users generally face flat tariffs for their consumed or produced electricity. Thus, in order to be able to operate these systems in an economic manner (as modelled) a change in end user tariff design appears necessary, so that end users have the possibility to react to price signals also in reality.

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Referenzen

[1] „REACT 2020 – Renewable Energy for Self-Sustainable Island Communties, https://react2020.eu/

[2] H. Ravn, „The Balmorel Model Structure ", Version 3.03, Juni 2016.

[3] SEAI, „All Electric Aran Islands Concept. A Design for a Wind and Ocean powered system supplying electricity, Heat and Transport, 2015", SEAI – Sustainable Energy Authority of Island, 2015.

[4] P. Capros u. a., „Technology pathways in decarbonisation scenarios ", European Commission, Directorate-General for Energy, Contract no. ENER/C2/2016-489/SI2.742171., S. 62, 2018.

[5] „European Network of Transmission System Operators for Electricity (ENTSO-E)". [Online]. Verfügbar unter: https://www.emissions-euets.com/internal-electricity-market-glossary/894-european-network-of-transmission-system-operators-for-electricity-entso-e. [zugegriffen: 15-Nov-2019].