MID-TO-LONG TERM ENERGY TRANSITION PERSPECTIVE FOR SMALL AUSTRIAN CITIES.

Nicolás PARDO GARCÍA[1], Christian SAKULIN[2], Viktorija DOBRAVEC[3], Eva VOLKAR[4], Helfried KREITER[5]

Many cities are setting action plans and strategies to address mid-to-long term targets (2030-2050) e.g. climate change, air quality, energy security or use of renewable energy sources (RES). These activities are supported by several European and national initiatives such as the Covenant of Mayor with the development of the Sustainable Energy Action Plans (SEAP) for commitments before 2016 and Sustainable Energy and Climate Action Plan (SECAP) after 2016, the European Energy Award (called e5 program in Austria) and several EU Directives. This paper analyses the energy and decarbonization transition paths for small and medium cities. The model was tested on the case study of the city of Judenburg in Austria.

Judenburg is a medium size historic town located in the Aichfeld-Murboden basin. It accounts for 10,072 inhabitants. The Municipality of Judenburg is owner of the ESCO Stadtwerke Judenburg AG which generates 100% Renewable energy source (RES) electricity being able to cover the overall electricity demand of the city [1]. District heating imported to the town represents also 100% renewable heat as the heating sources are waste heat from a pulp and paper mill of the Zellstoff Pöls company combined with 20 MW biomass of CHP plant [2]. The city accounts a total energy consumption of 1,066 TJ and 47.5 kt CO_2 emissions (excluding industry sector). The residential sector is the most energy intensive sector accounting for 42% of total energy consumption. It is followed by the commercial sector with 20% and transport sector with 36%. The municipal sector covers the remaining share. In the residential, commercial and municipal buildings, electricity is the main energy carrier with 38% of the total consumption, followed by natural gas with 34% and district heating with 15% and heating oil with 9%. The remaining part is covered by coal, biomass and thermal solar panels. In the transport sector, diesel and gasoline are the main fuels with 61% and 34% of the total energy consumption, blended biofuel amounts to around 4% and the remaining part is covered by e-vehicles.

The assessment of the energy and environmental mid-to-long term strategies in the city of Judenburg was carried out through a modelling framework based on the integration of the TIMES-city model with an extended Environmental Assessment Model (EAM) [3]. TIMES-city model is based on the TIMES/MARKAL energy system optimization framework. It generates cost-efficient optimal scenarios to evaluate the future development of the urban energy system by using comprehensive city level techno-techonomic data at sectoral level including demand and supply. This includes existing and new technological options to meet future needs of energy-related goods and services. In parallel, the EAM estimates the environmental impacts for each strategy in terms of greenhouse gases emissions, air pollutants, as well as upstream land and water use.

To analyse the energy and environmental mid-to-long term transition seven scenarios were defined. **REF scenario** is the reference scenario and assumes no significant measures and policies are applied [1], [2]. **SEAP scenario** is based on the goals of the Sustainable Energy Action Plan for the city of

[1] AIT Austrian Institute of Technology GmbH, Address: Giefinggasse 2 - 1210 Vienna (Austria), T: +43 664 210 2415, E-Mail: nicolas.pardo-garcia@ait.ac.at, Web: www.ait.ac.at
[2] EASt Energie Agentur Steiermark, Address: Nikolaiplatz 4a 8020 Graz (Austria), T: +43 316 269 70032, E-Mail: christian.sakulin@ea-stmk.at, Web: www.ea-stmk.at
[3] EASt Energie Agentur Steiermark, Address: Nikolaiplatz 4a 8020 Graz (Austria), T: +43 316 269 70032, E-Mail: viktorija.dobravec@ea-stmk.at, Web: www.ea-stmk.at
[4] Municipality of Judenburg / Stadtgemeinde Judenburg, Address: Hauptplatz 1, 8750 Judenburg (Austria), T: +43 3572 83141-276, e.volkar@judenburg.at, Web: www.judenburg.at
[5] Municipality of Judenburg / Stadtgemeinde Judenburg, Address: Hauptplatz 1, 8750 Judenburg (Austria), T: +43 3572 83141-278, h.kreiter@judenburg.at, Web: www.judenburg.at

Judenburg (SEAP) [3]. **RES scenario** is designed with a focus on the increase of the use of renewable energy technologies, **RES DH scenario** is based on the measures from RES scenario with addition of medium expansion of district heating and energy efficiency in residential buildings. **HIGH CO2 scenario** is focused on a high CO2 emission reduction for the whole city and municipal sector with high expansion of district heating. **MUN scenario** is based on REF scenario with additional focus on municipal sector and it connects all municipal buildings to district heating. **DH CENTRE scenario** is based on MUN scenario with additional measure of high DH expansion that includes the connection of most of the residential and commercial buildings of the city centre to the district heating network.

All scenarios have a common tendency in terms of the energy consumption reduction with an overall average reduction of 46% in 2050. The average shares of energy consumption by sector are as 60% in residential, 18% in transport, 19% in commercial and 3% in municipal. The significant reduction of the final energy consumption is mainly a result of the technology replacement, building refurbishment together with an expected reduction of the population of 16% in 2050. The highest impact on energy reduction by technology replacement had the replacement of combustion engines by electric motors and conventional gas boilers by air and ground heat pumps.

In the residential, commercial and municipal sector all representing building sector, scenarios reflect a clear competition between heat pumps and district heating. In the scenario for 2050 which represents the most cost-effective solution heat pumps have a higher penetration and will be able to cover around 37% of the energy demand whereas district heating covers around 14%. In scenarios where district heating is promoted by a political decision, this technology represents the first option with a share of around 37% in 2050. The share of heat pumps in this case falls under 9%. It is important to note that the model does not capture external benefits of district heating out of the city of Judenburg. The district heating network interlinks several municipalities and it is feed mainly by waste heat giving an overall improvement in energy efficiency at regional level. Biomass boilers play an important role in covering the heating demand accounting for around 10% of the total energy demand in 2050. The penetration of solar thermal systems is low, covering in average 4% of the energy demand.

The transport sector shows a strong decarbonisation and decrease of the final energy consumption. This is due to the increase of e-vehicles, with higher efficiencies than the conventional ones', and the decrease of the population. In 2050 e-vehicles represent around 86% of the total energy consumption. Biofuels and hydrogen have an important role in the mid-term perspective covering around 47% and 3% respectively in 2030 but are not competitive technologies in the long-term. It is important to note that promotion of the transport electrification is often done from the national level. However, the city can strongly support this transition with actions implemented in their local policies.

The results show a tendency of CO_2 emission reduction in all scenarios at city level which leads to a total CO_2 emission reduction of 95% compared to 2015. Full decarbonisation of the residential and municipal sector takes place in all scenarios. CO_2 emissions of transport sector account for 0.27 ktCO2 which is less than 1% compared with the level of 2015. In all the scenarios, except for DH CENTRE scenario, CO_2 emissions account for around 1.7 ktCO2 which is 68% less compared to 2015. In the DH CENTRE scenario, decarbonisation of the whole city is achieved. This is due to an additional set of measures introduced to the commercial sector.

Reference

[1] Stadwerke Judenburg AG, 2019, available at: https://stadtwerke.co.at/

[2] Zellstoff-Poels, 2019, available at: https://www.zellstoff-poels.at/

[3] Krook-Rieffola, B. Unluturk, J. Forberg, S. Simoes, L. Dias, N. Pardo García, Outline of city-level modelling framework, 2018, JPI-Urban, SureCity Project.

[4] T. Krutzler et al., Energiewirtschaftliche Szenarien im Hinblick auf die Klimaziele 2030 und 2050. 2015.

[5] Maurer et al., “Grünbuch für eine integrierte Energie- und Klimastrategie,” 2016.