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## **Reaching 10% renewable transportation fuels in 2020 by electric-vehicles in Styria/Austria**

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### **Abstract**

Electric-vehicles have the potential for a significant substitution of diesel and gasoline vehicles, and contribute to a reduction of greenhouse gas (GHG) and particulate matter emissions. According to the European Renewable Energy Directive, the share of renewable transportation fuels should be 10% in 2020. In the project “Styrian e-mobility in 2020” the potential for reaching the target of 10% renewable fuels in 2020 has been determined by analysing different implementation scenarios. Based on a life cycle analysis, GHG and particulate matter emissions from transport services have been calculated and their potential reductions in emissions by the introduction of electric vehicles by 2020 have been determined. Reaching the European target of 10% renewable fuels in the passenger car sector by 2020 is possible with 30,700 electric-vehicles (5% of passenger cars) if the share of the additional electricity is above 50% from renewable energy and the same amount of transportation biofuel of 7% used as today.

*Keywords: LCA (Life Cycle Assessment), EV (electric vehicle), infrastructure, market introduction*

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## **1 Motivation**

Electric-vehicles, as well as biofuels, have the potential for a significant substitution of diesel and gasoline vehicles. They can contribute to a reduction of greenhouse gas emissions (GHG) and particulate matter emissions in the transport sector, especially if they are powered by additional renewable electricity. In Austria (fuel consumption: 320 PJ/a) and Styria (fuel consumption: 43 PJ/a of which 16 PJ/a for passenger cars) the amount of transportation biofuels, especially biodiesel and bioethanol blended to gasoline and diesel, was about 7% in 2009. According to the European Renewable Energy Directive, the share of renewable fuels should be 10% in 2020, where renewable electricity is counted with a factor of 2.5.

## **2 Content and objectives**

The GHG emissions in Styria in 2007 were 14.1 million tons CO<sub>2</sub> equivalent (Mt CO<sub>2</sub>-eq) (transport 1.7 Mt CO<sub>2</sub>-eq, energy supply: 1.9 Mt CO<sub>2</sub>-eq). The particulate matter emissions in 2007 were about 7,500 tons per year; of which 19% were emitted by the transport sector. In 2009 the Styrian passenger car stock was about 664,000 of which 43,529 were new passenger cars. The electricity demand in the year 2009 was about 8,300 GWh/a, of which 61% was generated by renewable sources. The maximum power demand on a winter day at 11:00 clock was about 1,429 MW in the Styrian electricity grid. Due to the fact that Styria has a great additional potential of biomass and renewable electricity, biofuels and

electric-vehicles can significantly contribute to a future sustainable transport sector in Styria.

The objective of “Styrian e-mobility in 2020” (Jungmeier et al., 2011) was to analyze the future prospects for the introduction of electric vehicles in Styria. Scenarios for electric vehicles were developed based on scenarios for the introduction of electric vehicles in Austria. The model “e-mobility Styria 2020” was developed to investigate the possible implementation of electric-vehicles in Styria until 2020.

Furthermore, the 17 Styrian districts were assessed by their characteristics. Districts with “very good” and “good” framework conditions for the early introduction of electric-vehicles were identified. With the model “e-drive” the additional power and electricity demand was calculated. Moreover, the costs for transportation services were determined. Furthermore, based on a life cycle analysis, GHG and particulate matter emissions from transport services and their potential reductions in emissions by the introduction of electric-vehicles by 2020 were calculated.

In the analysis, four groups of early adopters of electric-vehicles were identified:

1. Daily passenger car commuters,
2. Business vehicle and public transportation fleets,
3. Private car users and
4. Users of the second car in a two-car household.

### 3 Results and Discussion

The analysis of five scenarios with three different types of electricity generation (“electricity mix Austria”, “electricity from natural gas”, “electricity mix renewable”) and two charging strategies (“uncontrolled”, “controlled”) lead to the following results:

- Under favourable conditions, up to 30,700 electric-vehicles are possible in Styria by 2020 (i.e. 4.6% of the total car stock in 2009).
- The following six districts have “very good” framework conditions for the early introduction of electric-vehicles:
  - Deutschlandsberg,
  - Feldbach,
  - Graz,
  - Graz-Umgebung,
  - Leibnitz and
  - Weiz.
- A reduction of the total energy demand for passenger cars in Styria from 4,481 GWh/a (16 PJ/a) to 4,331 GWh/a (15.65 PJ/a) is possible.
- The electricity demand for 30,700 electric-vehicles is 98 GWh/a, i.e. 1.2% of the current electricity demand in Styria.
- The maximum power demand in the Styrian electricity grid of about 1,429 MW at 11:00 clock is raised by 2,8 MW for charging 30,700 electric-vehicles, i.e. 0,19% of the maximum power demand.
- The additional power demand during the evening peak at 17:45 is about 15.4 MW, increasing the current power demand at this time to 1,371 MW. This is still a little less than the current maximum power demand at 11:00.
- The maximum additional power demand is about 75 MW in the night at about 22:45 clock.
- 30,700 electric-vehicles require about 38,500 charging stations by 2020.
- The number of power plants required for the additional renewable electricity is:
  - 1 large 20 MW hydro power plant or
  - 3 small hydro power plants each with 7 MW or
  - 23 wind turbines each with 2 MW or
  - 19 biogas plants each with 1 MW or
  - 500 large PV systems each with 200 kW or
  - 24,000 small PV systems each with 15 kW.
- The analysis of the currently built and planned new power plants in Styria by 2015 showed:
  - 95% of the additional produced electricity will be generated by natural gas and
  - 5% of the additional produced electricity will be generated by renewable energy.
- The possible annual GHG emission reduction is (Figure 1) :
  - 30,000 t CO<sub>2</sub>-eq/yr using “electricity from natural gas”,
  - 50,000 t CO<sub>2</sub>-eq using an “electricity mix Austria” with 54% renewable electricity and
  - 75,000 t CO<sub>2</sub>-eq/yr an “electricity mix renewable”.

- These correspond to between 1.7 to 4.4% of the current GHG emissions from the transport sector in Styria.

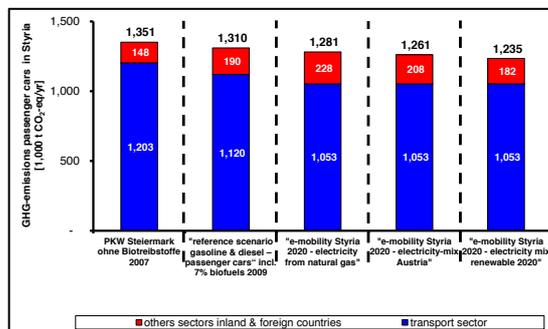


Figure 1: GHG-emissions by passenger cars in Styria

- The annual reduction of particulate matter emissions by replacing each 15,350 diesel and 15,350 gasoline passenger cars by 30,700 electric vehicles is estimated as 9.3 t PM10/yr (8.8 t/yr from diesel and 0.5 t/yr from gasoline cars). This is 4% of current particulate matter emissions from passenger cars in Styria.
- Reaching the European target of 10% renewable fuels in the passenger car sector by 2020 is possible with 30,700 electric-vehicles, if the share of the additional electricity is above 50% from renewable energy and the same amount of transportation biofuel used as today. This is possible because the renewable electricity is counted with a factor of 2.5.
- The Styrian economy has a great potential for job creation (e.g., "Green Jobs") in all areas of the value chain during the life cycle of an electric-vehicle. The areas where job creation will be particularly interesting are:
  - Automotive/Mobility,
  - Energy and Environmental Technology and Renewable Energy,
  - Engineering/Construction and

## Authors

Highlights of professional experiences:

- life cycle assessment of bioenergy for transport, electricity, heat and biorefineries
- greenhouse gas assessment of products and services
- sustainability assessment and future scenarios for transportation fuels of the future – biofuels, e-mobility and hydrogen.

Present Positions:

- Area Manager at JOANNEUM RESEARCH "Energy Systems and Strategies"
- Lecturer: Vienna University of Technology; University of Graz; University of Applied Science, University of Applied Science Kapfenberg, Danube University Krems
- Austrian Team Leader in IEA Bioenergy Task 42 "Biorefinery"



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