GHG-Emissions of Additional Renewable Electricity in Austria and its Consequences on the Introduction of Electric Vehicles in a Dynamic LCA

(10) Sozioökonomische und gesellschaftliche Aspekte: Lebenszyklusanalysen

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Motivation and Central Question

It is relevant to analyze and assess the environmental effect of the increasing generation of renewable electricity and its use, e.g. in BEV, based on Life Cycle Assessment (LCA). The environmental effects, e.g, GHG emissions, of electricity from hydro, wind and solar power plants mainly occur in the construction and the end of life phases. Related to these investments significant environmental effects are taking place with these investments, but the substitution of conventional electricity generation will lead to a reduction of environmental effects in the coming years.
Since 2014, IEA HEV Task 30 estimates the LCA based environmental effects of increasing renewable electricity generation and the worldwide EV fleet using the different national framework conditions and the substituted conventional ICE vehicles.
The possible environmental effects of an energy system occur at different times during their lifetime. In LCA, the environmental effects are analysed for the three phases separately – production (for vehicles) or construction (for power plants), operation and end of life – over the whole lifetime of a system. The cumulated environmental effects over the lifetime are allocated to the service provided by the system during the operation phase, which is the functional unit in LCA, e.g. per kilometre driven for vehicles and kWh generated for power plants. Therefore, the functional unit gives the average environmental effects over lifetime by allocating the environmental effects for production and end of life over the lifetime to the service provided independent of the time when they occur.
A new approach for dynamic LCA is developed for the additional generation of renewable electricity and the increasing EV fleet, and this approach is applied to the Austrian situation up to 2030 on GHG emissions.

Methodoloical Approach

Issues on dynamic LCA, e.g. annual environmental effects, become relevant for the rapidly increasing of EV-fleets combined with an additional generation of renewable electricity. The main methodological aspects are:

- timing of environmental effects in the three lifecycle phases: production, operation, end of life,
- timing of environmental effects of increasing supply of renewable electricity,
- timing of environmental effects of EVs using increasing supply of renewable electricity, and
- substitution effects and timing of environmental effects of EVs substituting for ICE vehicles.

Another approach considered in the Task is to reflect and keep the time depending course of the environmental effects in the life cycle and compare the absolute cumulated environmental effects in a dynamic LCA.
In Figure 1, the possible courses of the cumulated environmental effects of three systems in their lifetime are shown for production, operation and end of life. All the three systems have the same lifetime and provide the same service but the courses of the environmental effects are quite different. This timing of the environmental effects becomes more relevant in future, when new innovative systems substitute for conventional systems to reduce the overall environmental effects. However, it might take some time (t_1, t_2) until the real reduction of environmental effects takes place by the new innovative system. This aspect becomes more and more relevant in the context e.g. of the global necessary reduction of GHG emissions with increasing energy efficiency and renewable energy. Therefore, in dynamic LCA the course of the cumulated environmental effects have to be considered and addressed more adequately.

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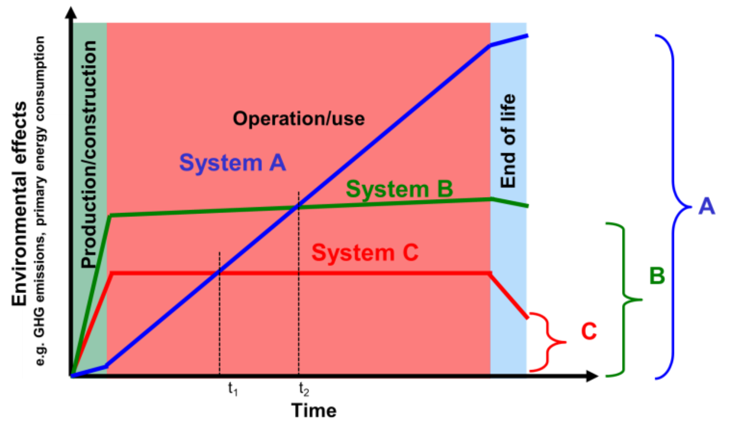

Figure 1: Timing of cumulated environmental effects of three systems with the same lifetime

Results

To illustrate the timing of the environmental effects in a dynamic LCA perspective the Austrian of Austria of increasing the renewable electricity generation up to 100% in 2030 is described. The additional renewable electricity generation in Austria increases between 0.2 up to 4 TWh per year from 2005 up to 2030. The annual GHG emissions due to the installation of new renewable electricity generation plants in Austria are between 100 up to 1,000 kt CO_2-eq. The combination of the annual GHG emissions and the additional electricity generation gives the specific GHG emissions of renewable electricity generation in Austria (Figure 2), on one hand the GHG emissions of the additional installed renewable electricity generation and on the other hand of the total renewable electricity mix in Austria.

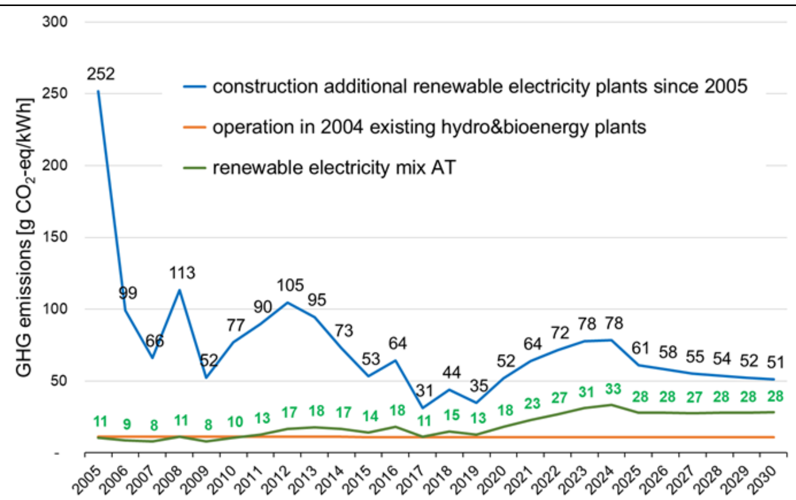

Figure 2: GHG emissions of renewable electricity generation in Austria

The introduction of BEV in Austria started in 2010 and the BEV fleet increased up to about 45,000 BEVs in 2020. Assuming an electricity demand of about 0.22 kWh/km (incl. heating, cooling and auxiliaries) and 10% grid and charging losses the additional renewable electricity demand for the operation of the BEV fleet increased up to 142 GWh in 2020. Considering the increased renewable electricity generation in Austria since 2010 the demand to operate the BEV fleet is in a range of 0.1 to 1.1% of the additional renewable electricity generated since 2010. In Figure 3, the change of GHG emissions of the BEV fleet substituting an ICE fleet in Austria are shown. In 2020, the GHG emissions of the production of the newly registered 16,000 BEV are about 167 kt CO_2-eq and the GHG emissions of the BEV fleet operation of about 45,000 vehicles with renewable electricity are about 3 kt CO_2-eq. Assuming each BEV substitutes for an ICE, about 16,000 newly registered conventional ICE vehicle were substituted in 2020 avoiding GHG emissions from their production of about 96 kt CO_2-eq and avoiding GHG emissions of about 94 kt CO_2-eq in the ICE fleet operation of about 45,000 conventional ICE vehicles. Therefore, in 2020 the BEV fleet in Austria emitted about 170 kt CO_2-eq and avoided about 190 kt CO_2-eq from substituting conventional ICE vehicles, which results in an overall GHG saving in 2020 of about 20 kt CO_2-eq.

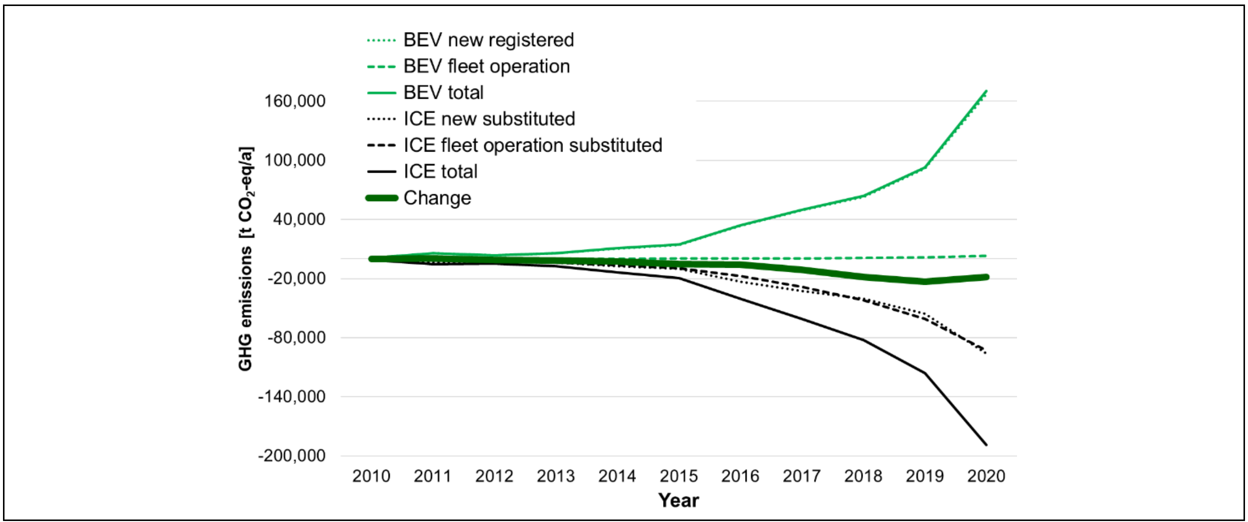

Figure 3: Change of GHG emissions of BEV fleet substituting ICE fleets in Austria

Conclusions

Timing of environmental effects in LCA of EVs production-operation-end-of-life phases becomes relevant in the transition time of

- strong BEV introduction in combination with a
- strong increase of additional renewable electricity generation and
- improvement of battery production technologies.

Within the framework of LCA a methodology is developed and applied to the annual environmental effects of an increasing BEV fleet and substitution of ICE vehicles by considering the annual environmental effects of

- New vehicle production
- Supply of renewable electricity from existing and new power plant
- Substituted operation of ICE vehicles and
- End of life of old vehicles.

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