LEHRSTUHL FÜR REAKTORSICHERHEIT UND -TECHNIK
UNIV.-PROF. DR. RER. NAT. HANS-JOSEF ALLELEIN

Fonds National de la Recherche Luxembourg

SnT securityandtrust.lu

uni.lu UNIVERSITÉ DU LUXEMBOURG

RWTH AACHEN UNIVERSITY

Integration of Distributed Renewable Generators in the Luxembourgish Power System

PhD candidate: David Peter Benjamin NORTA
Supervision: Prof. Dr. Jürgen SACHAU (Université du Luxembourg / SnT)
Prof. Dr. rer. nat. Hans-Josef ALLELEIN (RWTH Aachen University)

Motivation

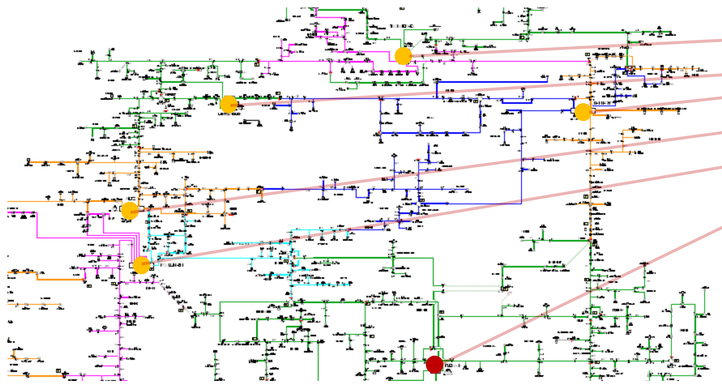
The amount of renewable generators increases worldwide. With the higher share of renewable resources in a system, simultaneously the alternating power generation increases. To understand the intermittent influence of the three main renewable technologies, namely windpower, solarpower and hydropower, energy balances of larger regions and the corresponding renewable, distributed generation has to be estimated to understand their generators' influence on a system. In the following Luxembourg is considered.

Model

In the study we consider the Northern Luxembourgish electricity grid. A simulation with the software PLEXOS is used to derive the system characteristics and corresponding prices for several scenarios for a future power system. The influence on the power supply as well as on the electricity price can be derived with the model.

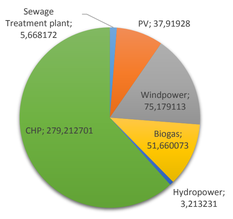
Currently the basic model specifications are:

- 5 nodes 220/65 kV (130 km), 44 nodes 65/20 kV (560 km) 49 buses.
- Renewable generation for solar PV and Windpower as well as hydropower are based on historic solar irradiation, windspeed and flow velocity data.
- The model is calculated for the real Northern network power balance in 15 min resolution for 2013.
- Villages are considered as individual loads and characteristic individual load curves scaling with the number of inhabitants were derived.

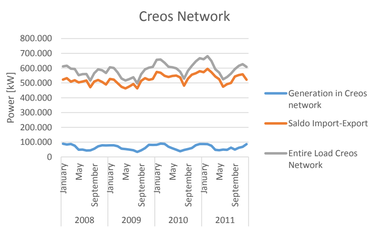


Part of the 20 kV network of Luxembourg [CREOS].

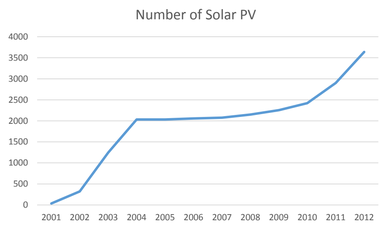
220 kV (red) and 65 kV (orange) network, including the 65/20nodes (orange).



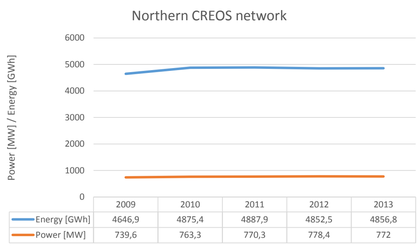
Generated energy in Luxembourg by technologies 2012 [ILR].



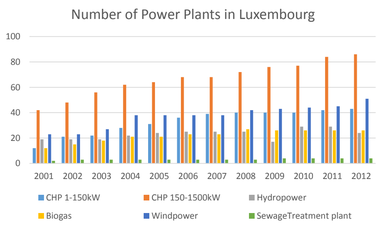
Monthly power values of the Northern network [ILR].



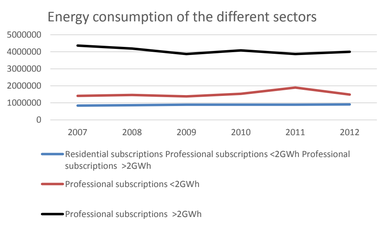
Development of the installed Solar PV plants 2001-2012 [ILR].



Annual values (peak power and energy) of the Northern network [CREOS].



Number of different power plant technologies in Luxembourg 2001-2012 [ILR].



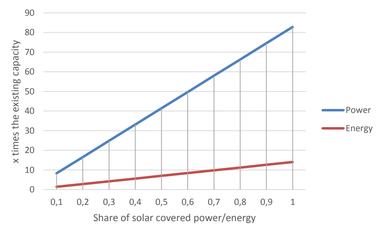
Energy consumption in Luxembourg of different consumer classes [ILR].

Findings

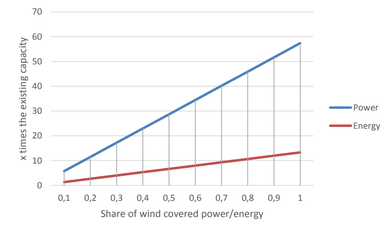
Luxembourg power supply is highly based on imports, about 80% of the electricity is imported. The number of residential consumers increases with less than 1% per year (180T in 2012), whereas the industrial consumer do not increase, or slightly decrease of less than 3% (3.5T 2012). The level of consumed energy is stable for the three groups of residential/professional <2GWh/a/ professional >2GWh/a.

Currently 51 windpower, 3638 solar PV and 24 larger Hydropower plants exist in the CREOS network. The largest generator is a hydropower plant of 5.5 MW in the Sauer river.

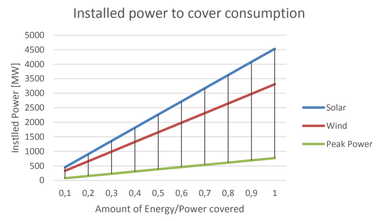
To supply smaller residential consumer a combination of renewable generators can be used, including an innovative hydrokinetic turbine. Considering a Luxembourgish average villages' consumption, we found out that the cheapest renewable supply is based on solar PV. Starting from the 100% renewable energy scenario for higher windspeeds windpower is beneficial. For this scenario up to 44 % of the annual power are covered and the excess power reduces compared to a pure solar supply.



Solar installation to cover power/energy balance.



Wind installation to cover power/energy balance.



Absolute wind/solar installation to cover balance power demand.

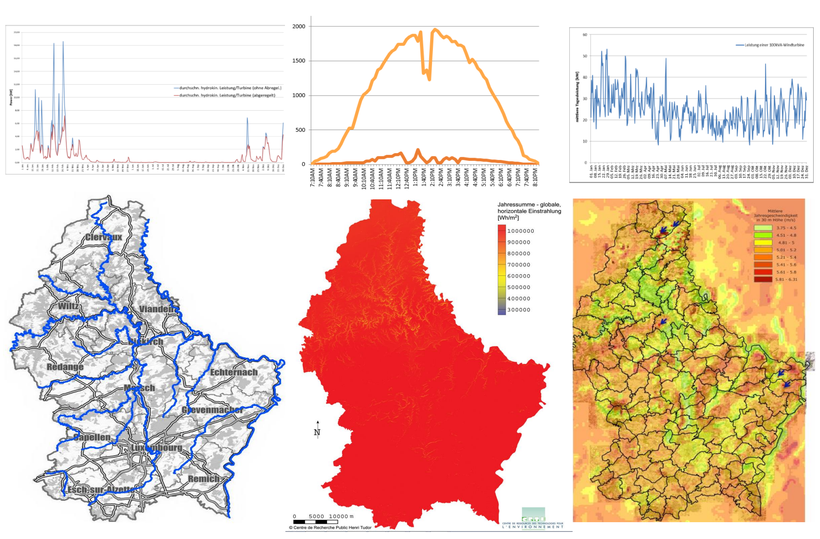
Next steps

Connect all the villages and their specific consumption depending on

- Number of Inhabitants
- Wind velocity
- Location at a river or not
- Industry located in the village
- Existing generators in the village

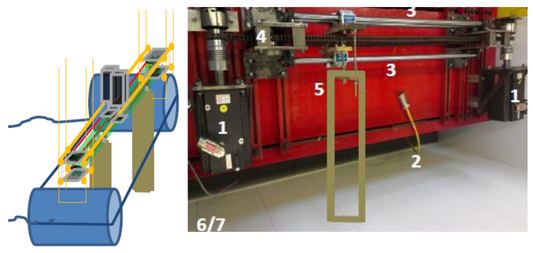
to the PLEXOS model and develop scenarios for a 100% renewable supplied Luxembourg. Include about 20 nodes per 65/20 kV node with 20/0.4 kV substations (village level) as lowest voltage level of the model. Choose ordinary power plants as backup. Afterwards, validate the system data. Derive prices for the Luxembourgish electricity cost for different scenarios.

Derive the influence of a developed innovative hydrokinetic turbine on the PLEXOS model. Describe the economic potential of the hydrokinetic turbine compared to the existing solar PV and windpower technologies.



Hydrokinetic specific annual generation and rivers, Arbitrary daily solar generation winter and summer day and national global irradiation, average windpower generation of a 100 kW converter and wind velocities of Luxembourg [Geoportail,solarinfo,energieagence].

Our river in Vianden, test location for the turbine.



Left: Hydrokinetic turbine concept (schematic); Right: 1 Generator, 2 cable,3 linear bearing, 4 bearing, 5 foil, 6/7 Control [own concept].

[ILR] Institut Luxembourgeois de Régulation / [CREOS] Luxembourgish Northern network operator

Contact: Dipl.-Ing. David Norta, david.norta@uni.lu / norta@lrst.rwth-aachen.de , +352 4666 44 5762, Université du Luxembourg / RWTH Aachen University