



Challenges of power management in single-family houses built in the 21st century

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Abstract [Full text available in Finnish, see: <https://el-tran.fi/analyysit/>]

Changes in electricity production and consumption, risk of electricity shortage and demand response issues are global topics. In Finland, too, forms of electricity production are changing and diversifying and uncertainty of production is increasing. Simultaneously, on the demand side, electric power peaks increase as heating systems change and become more electricity intensive, as cooling systems become more popular and electric cars enter the market. For the reasons mentioned, the design, control and monitoring of electric power behavior will play an increasingly important role in the future as a part of any functioning electric power system.

In Finland, single-family houses have a major role in the transformation of the electric power system. This publication addresses the problems associated with the design and management of power in single-family houses built in the 21st century. The role of single-family houses in the power profile of the entire electricity consumption of Finland is poorly understood. However, at the time of the Finnish electric system power peak in 2016 (about 15,000 MW), the effect of single-family houses on that power peak was estimated to be over a quarter. Electricity accounts

for 34% of the total energy consumption of residential buildings and over 80% of it is used for space heating and domestic hot water.

Among the smaller scale consumers, the purchase of electricity is based on the measurement of the total amount of energy (kWh) and possibly the size of the electricity connection, which is determined by the size of the main fuses. Among the larger scale consumers - in industry and commercial buildings - power grid service charges also include a power peak charge for both active and reactive power. Electricity cost models including power peak charges are also emerging among smaller consumers, which means that, in addition to the amount of energy consumed, there will one day also be a power-based component in the total electricity price.

The power measured by energy meters is significantly dependent on the length of the measurement period used. Billing for consumer electricity consumption is currently based on hourly energy metering. According to the Finnish Energy Agency, Finland will move to 15-minute balance periods in accordance with EU guidelines by December 18, 2020. After that date, 15-minute measurement periods will be used as the commercial unit for measuring and charging electricity. This will further emphasize the importance of power planning and management in the electric power system.

Research has shown that the energy consumption of single-family houses has decreased, but the variation in power consumption has increased because the nominal power of individual devices has increased and space and domestic hot water heating methods have changed. The popularity of direct electric heating systems and other heating systems has decreased and various types of heat pump-based heating systems have replaced them. The power management of heat pump systems is also included in "Programme of Prime Minister Antti Rinne's Government 2019". To conclude, it is important to note that the low energy consumption and power behavior of single-family houses are typically not comparable with each other: a house with low annual energy consumption may actually cause higher power peaks than a house consuming more energy on an annual basis - especially if the heating is based

on a single heating unit (e.g., heat pump) instead of many smaller heating units (e.g. electric radiators).

The main problems in managing the power of single-family houses include:

- lack of responsibilities and tasks of building services designers at the regulatory level
- preference for high-power consumer devices (e.g., bigger sauna facilities have led to bigger electric sauna heaters)
- device and system choices made based on erroneous information or inadequate knowledge
- lack of demand-response systems in the buildings

The power management in single-family houses in the future requires that energy efficiency planning should be replaced by resource efficiency planning taking account not only of the total energy consumption, but also of the power demand and power efficiency of the building. The energy efficiency legislation should therefore be reformed to take into account the technical equipment and installations of the entire property and their electrical power usage, as well as the controllability of the property's electrical system. The requirements for the building services designers and system planning of buildings should also be harmonized in the legislation. In addition, the skills, practices and capacity of building inspectors to enforce the requirements should be strengthened. Also, unified design and measurement guidelines should be established to support the design of the technical systems of buildings.