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Use cases of automatically harvested data in energy system planning

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Name of the report: Use cases of automatically harvested data in energy system planning

Key words: data harvesting, use cases, energy system planning

Summary

Flexible energy system is a system that requires intelligent data processing so that the system can be controlled and the energy supply can be secured efficiently. The flexibility in the system provides an opportunity to connect for instance renewable energy production such as solar or wind power to energy system so that the system can be controlled and usual natural phenomenon do not collapse the system. To be able to minimize the risks the data are required for different analyses. Thus, a key role in the development energy systems in the future is played by data harvesting and use of the data.

This report presents different data sources, which can be used to provide important information for the energy system planning. The report contains examples of utilisation of environmental data, measured data from energy systems, measured data from other infrastructures and weather data.

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1 Introduction

This report is a part of the national research project called Flexible Energy Systems (Flexe). The purpose of the Flexe-program is to create abilities for the Finnish operators to plan, build, manage and use the future smart and flexible energy system. This program is funded by Tekes – the Finnish Funding Agency for Technology and Innovation.

This document describes the use cases of harvested data in energy system planning. The main responsible of the report has been Lappeenranta University of Technology and the co-operators in the study has been Elenia Oy and Empower TN Oy.

For instance, in FLEXe program, this study has a close relation with the study of Elenia “Power line monitoring using optical satellite data” (Häme et al., 2016), where the authors has studied more in-depth the opportunities of optical satellite data. Correspondingly, Empower TN has studied the role of service provider in information harvest and business opportunities of service providers in flexible energy systems. In addition, Empower TN has prepared a concept of the utilization of network condition measurement data in network planning activities that has a close linkage with this deliverable.

Flexible energy system is completely dependent on data processing. The flexibility is often achieved by a real-time monitoring of the system providing data, in which the information and communication technology (ICT) plays a key role (Pinomaa, 2016). The ICT is an essential part to provide a channel for the measured data or the statistics to the analyses where the data is processed. The importance of the data processing can be observed from Figure 1 that describes the objectives of FLEXe WP2 (Optimised and secured integration and operation of future energy networks), where this research involves. To be able to fulfill the goals of the WP2 new ways to collect, handle and process the data are required to be developed.

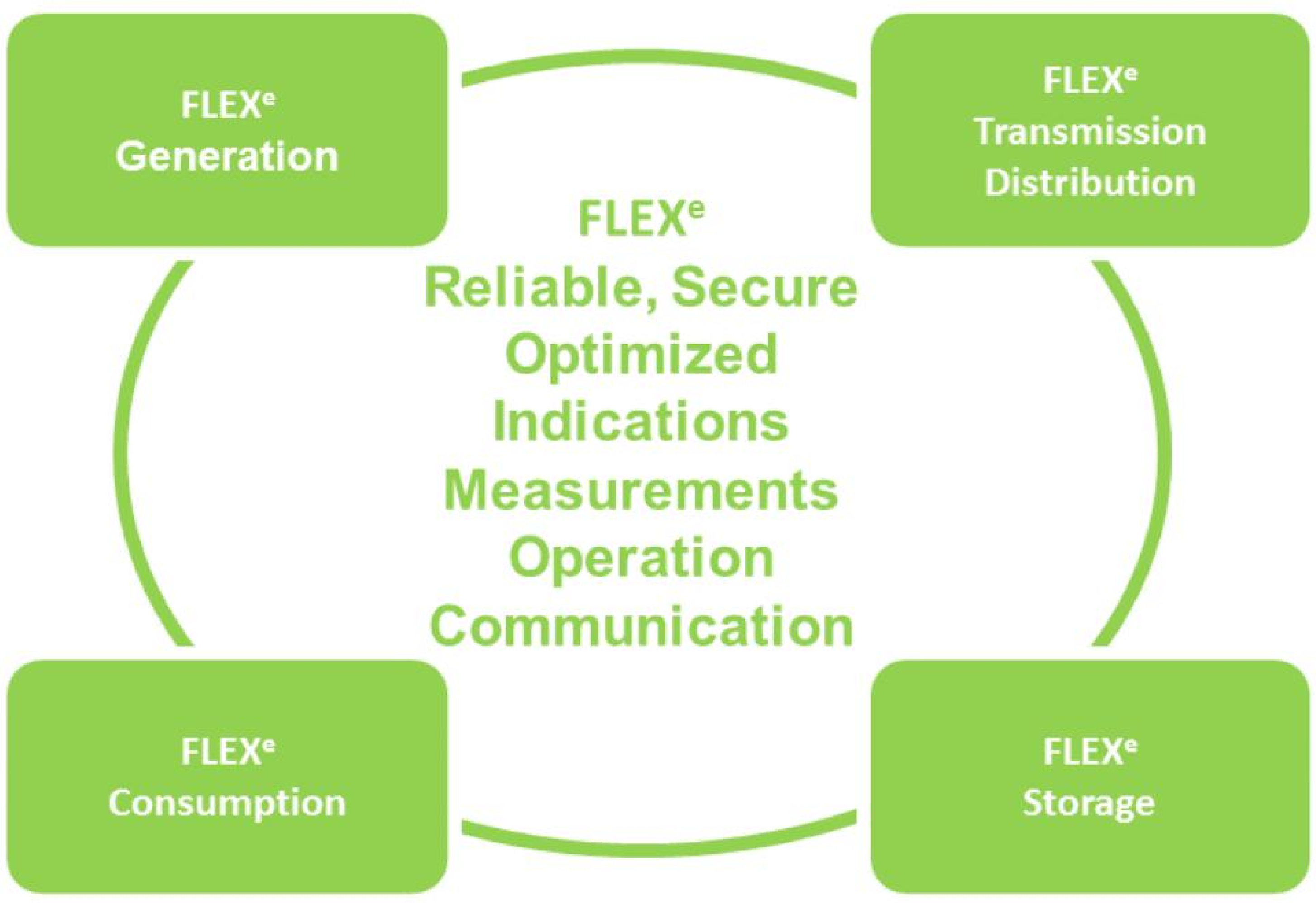

Figure 1. The objectives of WP2 in FLEXe (FLEXe, 2015).

At present several data sources are available to be utilized in energy system planning. The data can be used in both long-term planning (LP) and operational planning (OP). Long-term planning aims to determine proactively the optimal energy system structure for the lifetime of the system and operational planning aims to optimize the operation of the system.

The preconditions to use the data have been improved quickly. At the same time when the possibilities to gather the data have improved there has risen a need to

- develop energy system planning
- improve efficiency of system planning
- improve system stability.

This provides incentives to adopt new elements in the energy system planning process, which has already changed. For instance, many electricity distribution system operators (DSOs) already takes the benefits of aerial photography of the distribution lines or laser scanning of the lines in the annual tool box. This way they achieve, for instance, efficiency to line path inspections.

2 Determination of use cases

Opportunities to process data have been developed fast because of improved communication network and in general the digitalization. It makes possible to store and hence to use large amount of data and large databases, which contain huge amount of different kind of data. Also, new measurements have been developed, which create new data to databases. Often this is called big data. Different information sources that can be listed when considering the energy system planning are at least the environmental data, measurements from the energy networks, measurements from other infrastructure, fault and disturbance statistics and other type of data such as weather data. An example of data categorization is presented in Figure 2.

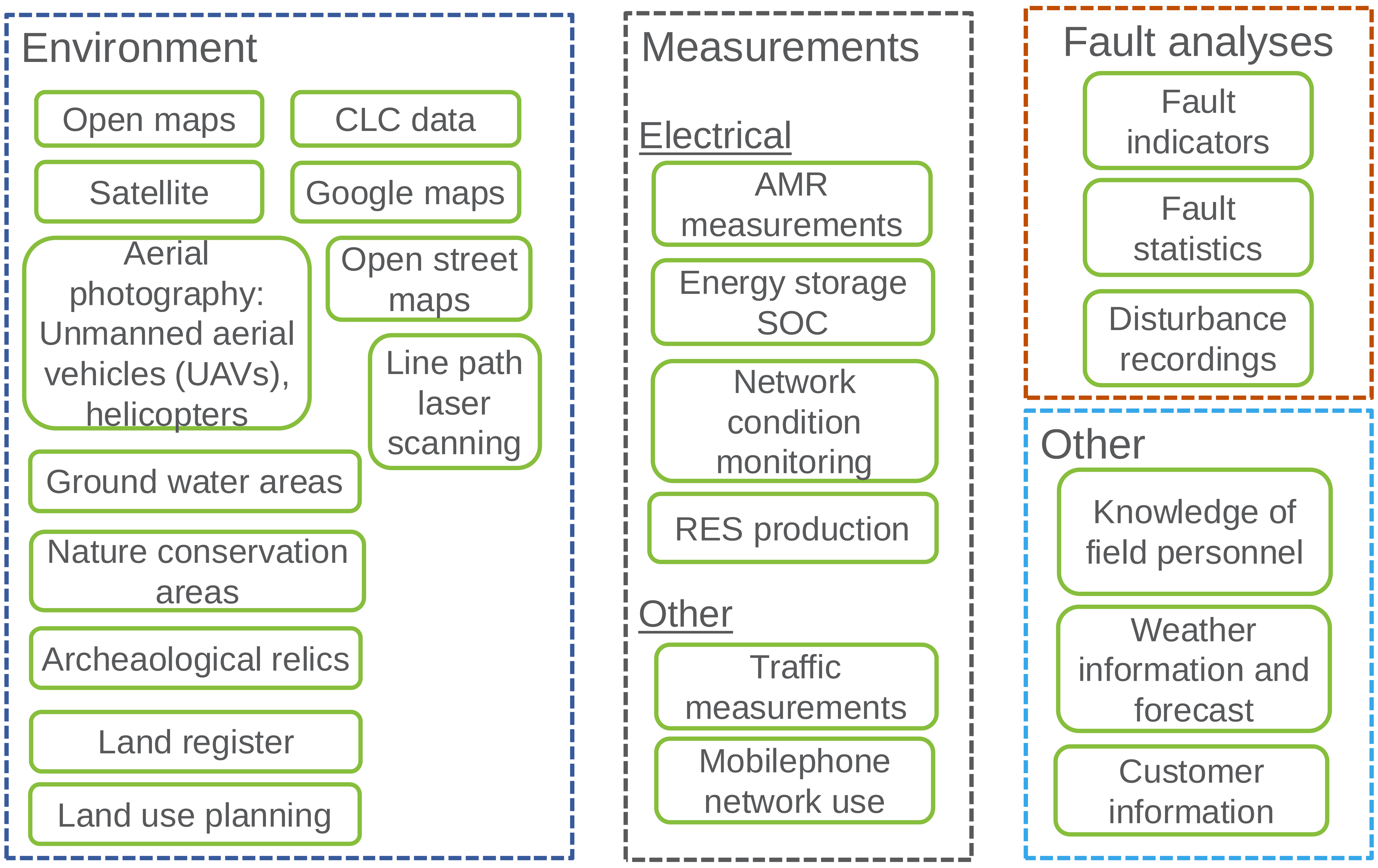

Figure 2. Categorisation of data sources.

2.1 Environmental data

At present a large amount of open data material is publicly available in Finland. For instance, a lot of different maps are freely distributed by National Land Survey of Finland (NLS) (Maanmittauslaitos in Finnish). The material contain both vector based material and raster pictures, which both can be used to analyze the geographical information in energy system planning. Environmental information is essential especially in long-term planning purposes because so that the line routes can be determined optimally, for instance, to minimize harm caused by supply interruptions. Table 1 presents different data sources providing environmental information and some example use cases where the data can be used.

Table 1. Data sources providing environmental information. LP = long-term planning, OP = operational planning.

Data sources	Use case example
Topographic database	LP: 1) Determination of households photovoltaic installation capacity, 2) notification of nature conservation areas in network planning, 3) notification of areas with flooding risk
Open maps, Open street maps, CLC data, Satellites	LP: 1) Determination of line path forest rates, 2) background information for investment planning (streets), 3) determination of trees for vegetation clearance planning
Aerial photography (helicopters and UAVs)	LP: 1) Scanning of important places forehand for investment planning, 2) line path laser scanning to detect risk places of energy system, 3) scanning of energy system forest rates OP: 4) determination of energy systems storm damages for disturbance management, 5) information to vegetation clearing
Land register	LP: 1) determination of the real estates and the contact information for the field planning, 2) determination of the real estates and the contact information for the line route renovation process or line route widening
Land use planning	LP: 1) Network planning and construction can be enhanced by sharing the knowledge of own construction plans and as well hearing of other infra operators plans, 2) information of planning zone has to be in every day planning to avoid situations where the surrounding infra is constructed but electricity network is still under planning

Use cases presented in Table 1 mostly relates with long-term planning, but especially the data provided by aerial photography can be essential to improve operation procedures such as major disturbance management and planning of vegetation clearing (VTT, 2014). Aerial photography is already used to observe the condition of the line paths in electricity distribution networks or to have a quick overview of the network in case of storm damages. Traditionally DSOs have used helicopters but the development of UAVs may turn the focus on these. If the cost-effectiveness of the UAVs develop well, the use can generalize rapidly.

An example of good infrastructure information source is Topographical database (NLS, 2015), which information can be useful for several processes in long-term planning. Topographical database is a collection of several information sources containing, for instance, information of buildings location and size, information of population centers. The building information can be used, for instance, used to define the potential of solar power.

At present a lot of different map services are publicly available such as basic maps and orthophoto maps. In Finland the maps are usually given by the NLS. Often the maps are integrated to network information system (NIS) of the DSO and thus they are used for instance in line route planning. However, the information of the maps can be used to determine background information of the network for the strategic decision-making in the long-term planning. In addition, satellites produce all the time information of the environment, which could be used in the energy system planning. An example of the exploitation of satellite data is power line monitoring studied by Finnish DSO Elenia (Häme et al., 2016).

Land register and land use planning is an important data source in network planning. However, often the co-operation between the DSOs and land use planning could be developed.

2.2 Measurements from the energy networks

Measurements from the energy networks are becoming common (Puurtinen, 2014). There are several reasons such as developing technology in measurement devices, improving data communication and decreasing prices of the used technology. Incentives for better measurements are the saving potential in energy system planning, construction and maintenance together with the requirements of improved energy system reliability and stability. The measurements are beneficial typically for operational planning but they can also be used in long-term planning purposes. Table 2 presents examples of use cases from the perspective of energy system planning.

Table 2. Data sources providing information from energy networks. LP = long-term planning, OP = operational planning.

Data sources	Use case example
AMR measurements	LP: 1) Load forecasting, creation of new load profiles → component dimensioning OP: 2) notification of LV network faults
RES production	LP: 1) estimation of network loads → dimensioning of components OP: 2) power balancing between production and loads
Monitoring of network components	OP: 1) critical component behavior can be monitored real-time, 2) estimation of component lifetime
Energy storage	LP: 1) estimation of network loads → dimensioning of network can be more efficient OP: 2) Measurements to keep power balance in the energy system

Real-time network measurements can be a good improvement to operational planning. For instance, the AMR measurements provide information to find out faults locating in low-voltage networks and to indicate under and over voltage issues in the network. More advanced measurements such as condition monitoring can be used, for instance, to indicate coming faults proactively that may be also an important information for operations and further in long-term planning. Accurate measurements from the network may offer us information of load variation in an hour that can be used in the dimensioning of the network.

2.3 Measurements of other infrastructures

Measurements from the other infrastructures can be used to provide additional information for the support of energy network planning. For instance, traffic measurements provides data to analyze the network effects of the coming electric vehicles as Tikka et al. present (2011). An example of traffic measurements is illustrated in Figure 3. Using traffic measurements, the new network loads can be estimated proactively, which is important in network planning and asset management. In addition, the use of mobile phone network can provide a reasonable information for energy network operation and planning.

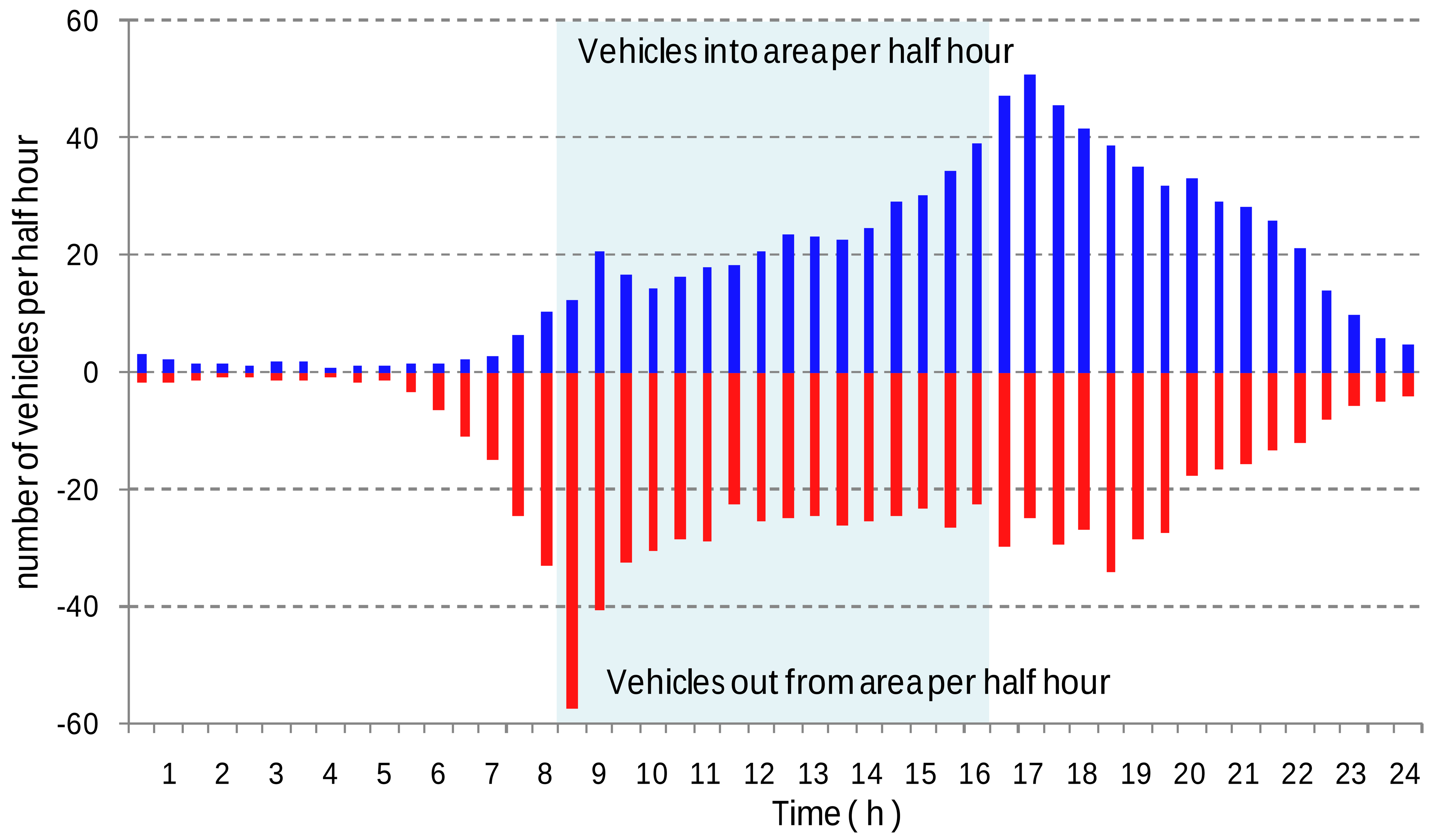

Figure 3. An example of traffic measurements containing numbers of average workday traffic flow.

2.4 Fault information indication

Compiling of fault statistics has traditionally been an important part of network long-term planning. However, the statistics can be relative rough for the analyses, which indicates that the compilation of statistics can be improved. Modern information systems provide opportunities to record fault occurrences case-specificly (Lehtonen et al., 2001). In addition, the new technology provides an opportunity to record information of the system behavior during larger disturbances, which can be important for the evaluation of network resiliency against new major disturbances. Another data source in the energy networks can be fault indicators, which provide real-time information of the network. In the best case, the fault indicators can fasten fault location sequence and thus the electricity restoration considerably.

Table 3. Data sources providing fault information. LP = long-term planning, OP = operational planning.

Data sources	Use case example
Fault statistics	LP: 1) estimation of future fault numbers and durations to provide good basis for long-term planning
Fault indicators	OP: 1) quick estimation of fault location based on measured electrical variable or other physical variable such as vibration of the electricity system wire, LP: 2) assessment of long-term effects of fault indication systems
Disturbance recordings	LP: 1) determination of supply security targets, which effects on DSOs strategy

2.5 Other data

Weather data play key role to assess operational part of energy system planning, especially in operational planning to keep the energy system balance. For instance, forecasting of irradiation or windiness can provide crucial information for the system to estimate production of photovoltaic panels and wind turbines. If there are expected rapid changes in power production the system should be prepared for changes in power balance.

In addition to the benefits of the weather information on the operation, the weather statistics are useful for the long-term planning. For instance, the temperature affect network loads, and thus it has to be taken into account in dimensioning of the network. Also, the irradiation determines the production potential of solar power, which should be considered with a generalization scenario of the photovoltaic panels to check a sufficient dimensioning for the network components. Different weather data having effects on energy system planning have been listed in Table 4. It presents an example of benefits of different weather data on energy system.

Table 4. Benefits of different weather data on stakeholders of electrical energy system.

	Temperature	Moisture	Precipitation, total rainfall	Lightning	Irradiation	Wind	Ground frost
DSO	Dimensioning of network	Snow load statistics	Statistics of ground softening: falling trees	Statistics: use of lightning conductors and surge arresters	Dimensioning of network components	Statistics: effects of direction of wind on trees	Estimation of construction costs
TSO	Power balance				Preparation of new balance control mechanisms	Preparation of new balance control mechanisms	
Producer	Profitability analyses		Hydro power planning		Profitability analyses	Profitability analyses	
Retailer	Balance → Forecasting of loads				Hedging	Hedging	
Service provider/ Constructor		Preparing to assignments	Preparing to assignments	Preparing to assignments		Preparing to assignments	Estimation of construction costs
Microgrid operator	Power balance				Power balance	Power balance	

Customer information is data source that is not a typical part in data harvesting. Often the DSOs and service providers get significant amount of data from the electricity end-users. However, typically a problem is that the information may not reach the database of DSO and thus the information might get lost. The customers' feedback contains often information related to fault locations such as fallen trees or problems in voltage quality issues, which could be exploited in the daily operation. This issue has been enlightened in the report of Empower TN "Report on network condition monitoring and network planning in practice" (Varjola & Leppäalho, 2016) published also in the FLEX^{e}.

3 Conclusion

Development of energy system flexibility requires new operation models, which need new type of data and analyses carried out with the data. Usually the data are provided by forecasts, statistics, measurements and databases. This report gives an overview of different use cases to take the benefits of data harvesting in energy system planning from both long-term and operational planning point of view.

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