Energy Technology ICT Project

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Date: 27/12/2020

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# Abstract

The report is intended to provide insight of the wind power system in Finland. More information about general technology and main technology used in Finland to produce energy will also be included.

# Introduction

In Finland, wind power construction began later than in many other European countries. However, from 2012 to 2013, wind power construction has gained momentum and national construction and production statistics have been broken year after year.

Wind power is a Finnish renewable energy source. Wind power generates no emissions to air, water or soil. The use of wind power increases Finland’s independence in energy production from imported fossil fuels and electricity.

# Research

## Electrical power system in Finland

Structure of electrical power system in Finland consists of power plants (especially in this report is wind farm), nation-wide transmission grid, regional networks, distribution networks and electricity consumers.

Diagram

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* Power generation level:
  + A wind farm consists of wind turbines, maintenance roads, a 20 kV network of underground cables connecting the turbines to the wind farm’s own electricity substation, a substation, and a 110 kV overhead line built for connecting the wind farm to the national electricity grid.
  + Protection in use: Generator Protection Relay. The circuit breaker connecting the two power sources can be closed when all these conditions are satisfied: Text

    Description automatically generated
    - REG670 Generator Protection Relay, AQ-G357 **generator** protection, ...
* Power transmission level: The power system in Finland is part of the inter-Nordic power system together with the systems in Sweden, Norway and Eastern Denmark. Moreover, there are direct current transmission links to Finland from Russia and Estonia for the connection of their systems, which work under different principles, to the Finnish power system. Similarly, the inter-Nordic system is connected to the system in Continental Europe by means of direct current transmission links.
  + Technology: Fingrid is responsible for the functioning of the Finnish electricity transmission grid. The transmission grid is the high-voltage trunk network which covers the entire Finland. Major power plants, industrial plants and regional electricity distribution networks are connected to the grid

Graphical user interface, text, application, email

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* + Protection in use: REX640 protection relays ABB, VAMP 50, Relion series of ABB or SIPROTEC series of Siemens, ...
* Power distribution level:
  + Technology: Smart grid, digitalization and automation system technology have been used within power distribution systems and the infrastructure to protect, control, measure and monitor these systems. Many companies in Finland develop their own technology to meet the need of certain urban or area. Like Helen, ABB, Caruna, ...
  + Protection in use: Relion series of ABB or SIPROTEC series of Siemens

Reference: Fingrid, Finnish Energy, Wiki, ABB, teacher’s docs ...

## Used and available energy resource in Finland

Electricity is produced in Finland in such various way, using different energy sources and production methods. Nuclear power, hydropower, coal, natural gas and wood fuels are the most important energy sources for electricity generation.

The share of wind power is still fairly small, but it has clearly grown in the past few years.

Chart, pie chart

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A picture containing telephone, cellphone

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Main technology to convert wind into electricity is PMG (**Permanent magnet generators**) wind turbine. At the end of 2019, there were 754 installed wind turbine generators, with a combined capacity of 2284 MW. They generated 7 % of Finland’s electricity consumption in 2019.

Diagram

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PM generators are synchronous machines with rotor windings replaced by permanent magnets. They need no separate excitation so rotor excitation losses – about 30% of total generator losses – are eliminated. This results in high power density and small size with the highest efficiency at all speeds, offering the maximum annual production of energy with the lowest lifetime cost.

## Smart Grid

### The origin of Smart Grid

Automatic meter reading devices introduced in the 1970s were the beginning of meters which provided information back to the utility, a basic requirement of any smart grid system.

And according to Wikipedia, *“A smart grid is an electrical grid which includes a variety of operation and energy measures including smart meters, smart appliances, renewable energy resources, and energy efficient resources.[1][2] Electronic power conditioning and control of the production and distribution of electricity are important aspects of the smart grid.”*

### Driving factor in the move toward Smart Grid

There are numerous of driving factors to move toward smart grid, here is few of them:

* Security of grid: Overhauls aging equipment in the grid, also tracking the problem happened in the grid.
* Distributed generation: Power generation connected to distribution grids.
* Renewable energy resources: Make create more small renewable energy producers.
* Opening of electricity markets, increasing the market of power producing => cost efficient power production.
* New market and business models: Customer can use and distribute their own electric energy.

### How to set up a Smart Grid

In order to set up a Smart Grid. We need a primary system which consists of:

* Conductor: Lines and cables
* Transformers
* Switching devices: circuit breaker, disconnectors
* Substations
  + Primary substation: From high voltage (HV) to medium voltage (MV)
  + Secondary substation (distribution substation): From MV to low voltage

the smart part:

* Operating system: Monitoring, control, protection
* Remote units in the grid:
  + Intelligent electronic devices (IED)
  + Remotely controllable switches
  + Sensors and meters
* Communication network
* Control center
  + Management of the whole system

And there are many parties involving into this grid: Transmission system operator, distribution system operator, energy retailer, aggregator, prosumer/customer, ...

Diagram

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## Smart electrical power substation and its operation

The smart electrical power substation, so called the digital substation starts with IEC 61850 "Communication networks and systems in substations".  This is the international standard governing communications, SCADA and automation systems within substations.  It is the backbone and framework around which a digital substation is built.

By taking the various elements required of a substation (circuit breakers, protection relays, CTs and VTs, etc.) and interconnecting these using **optical fibre**, the physical realisation of a substation becomes easier while at the same time, it's reliability and understandability increases.  Compared to the traditional substation where everything is connected together with hundreds of individual copper cables, the advantages become obvious.

Operation:

## Directions / anticipated future developments and their significance in the electrical energy system

## Description of the IEC 65180 standard

IEC 61850 is the international standard for Ethernet-based communication in substations. It enables integration of all protection, control, measurement and monitoring functions within a substation, and additionally provides the means for interlocking and inter-tripping.

# Conclusion