Nordic Council of Ministers

Nordic Energy Research

Norconsult

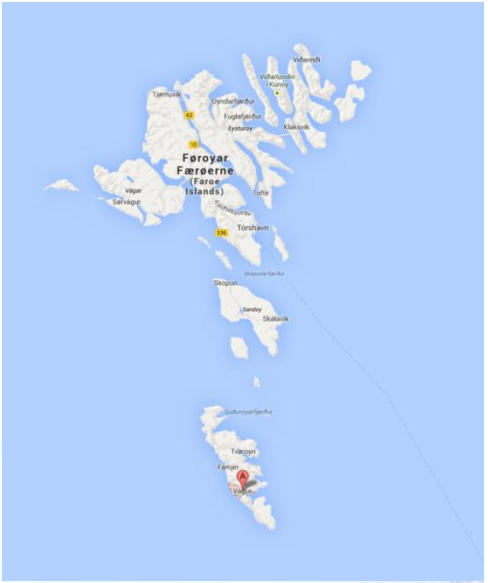
Wind power based pumped storage on Suðuroy

Franziska Ludescher-Huber, Norconsult

Background

Suðuroy on the Faroe islands:

5000 inhabitants.



Background

Power consumption has increased due to a fish processing factory.

Power consumption earlier: 3 MW

Power consumption expected: 8 MW

Power production today

Botní hydropower plant (1,1 MW + 2,2 MW)

Vágur power plant (heavy fuel oil; 2,7 MW + 2,7 MW + 4,15 MW)

Picture: SEV

Hydro Power

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Main questions to be answered:

- Cost of investment for a new pumped storage power plant?
- How much more renewable energy can be produced with a pumped storage plant?

Presumption:

A 10 MW wind farm is going to be installed on Suðuroy.

Hydro Power

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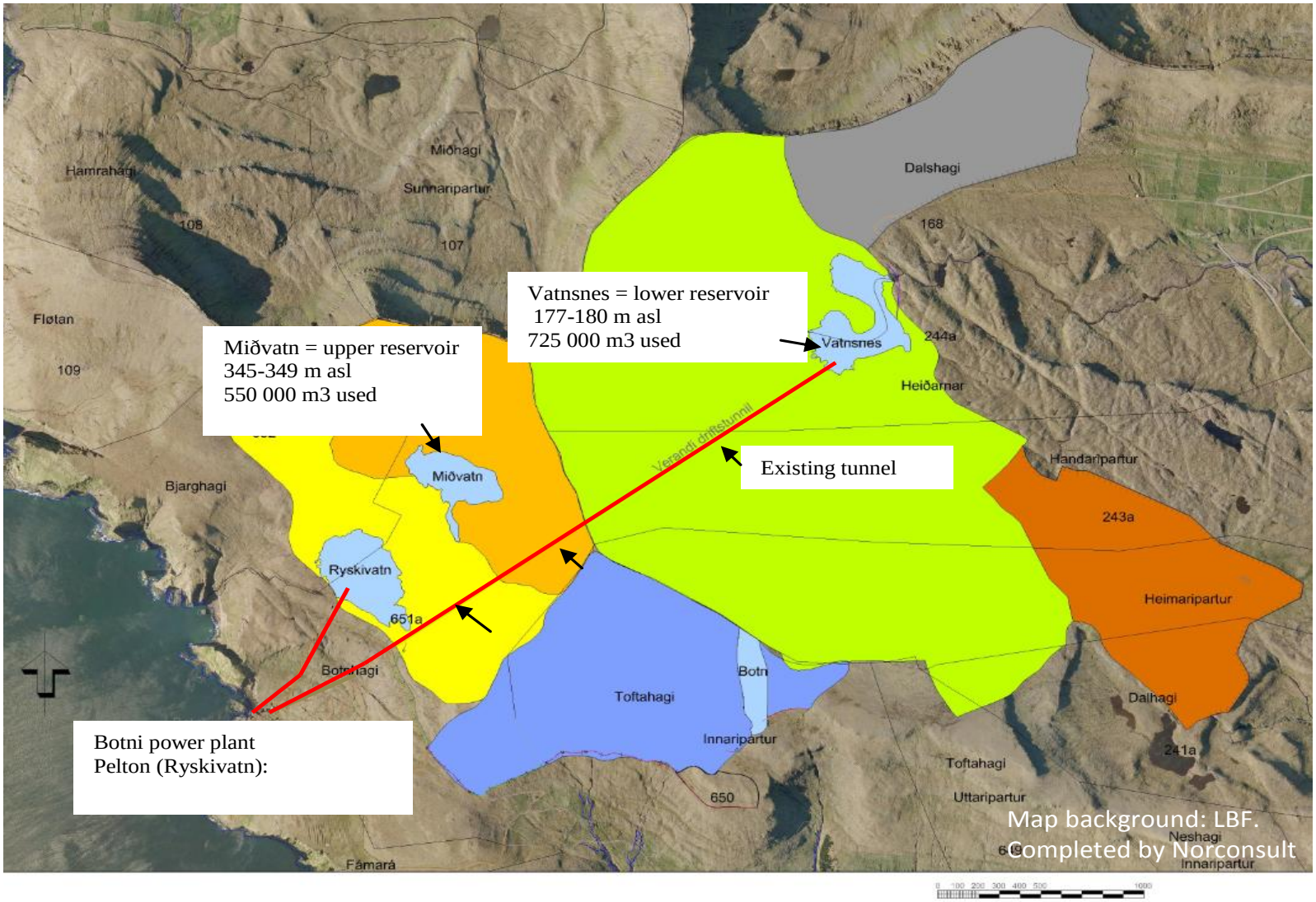
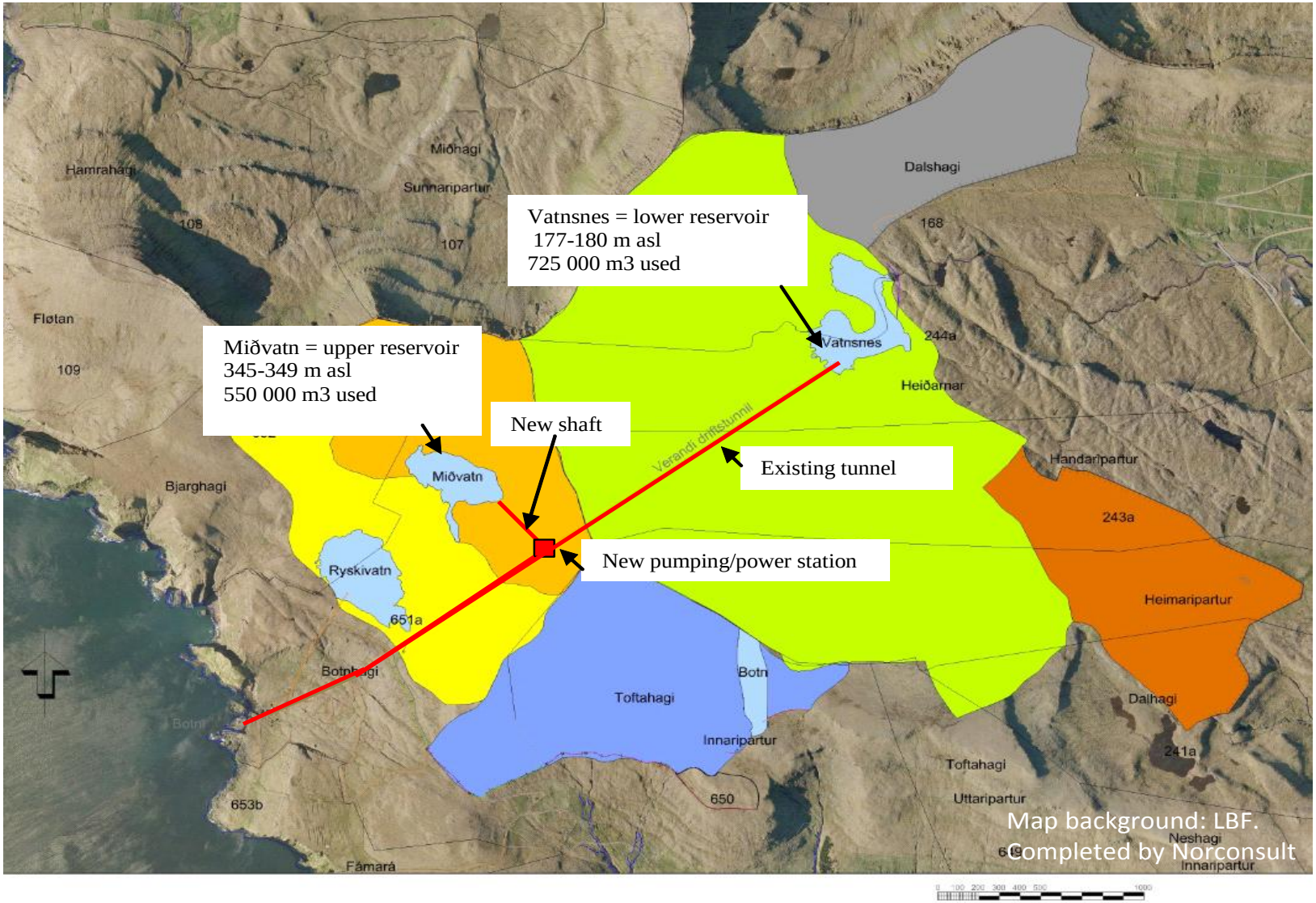
Source: unknown

Status quo


Miðvatn = upper reservoir
345-349 m asl
550 000 m3 used
Vatnsnes = lower reservoir
177-180 m asl
725 000 m3 used
Existing tunnel
Botni power plant
Pelton (Ryskivatn):
Miðhagi
Hamrahagi
Sunnaripartur
Dalshagi
168
108
107
Fløtan
109
Vatnsnes
244a
Heiðarnar
Veiandi driftstunnil
Miðvatn
Bjarghagi
Handaripartur
243a
Ryskivatn
651a
Heimaripartur
Botnhagi
Botn
Toftahagi
Innaripartur
Dalhagi
241a
Toftahagi
650
Uttaripartur
Neshagi
Innaripartur
Fámará
Map background: LBF.
Completed by Norconsult

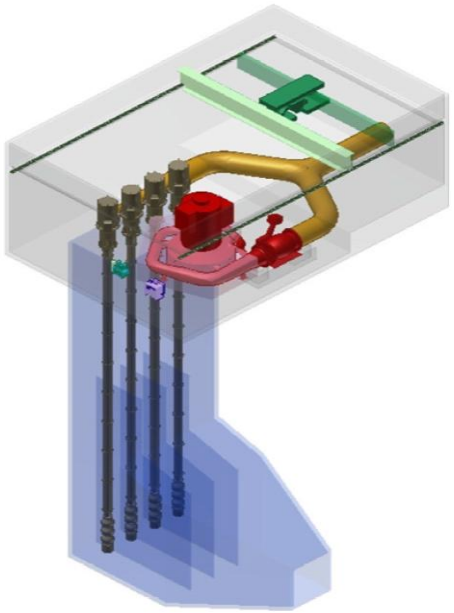
Pumped storage power plant



Costs of investment

Pumped storage plant : 105 mill. NOK

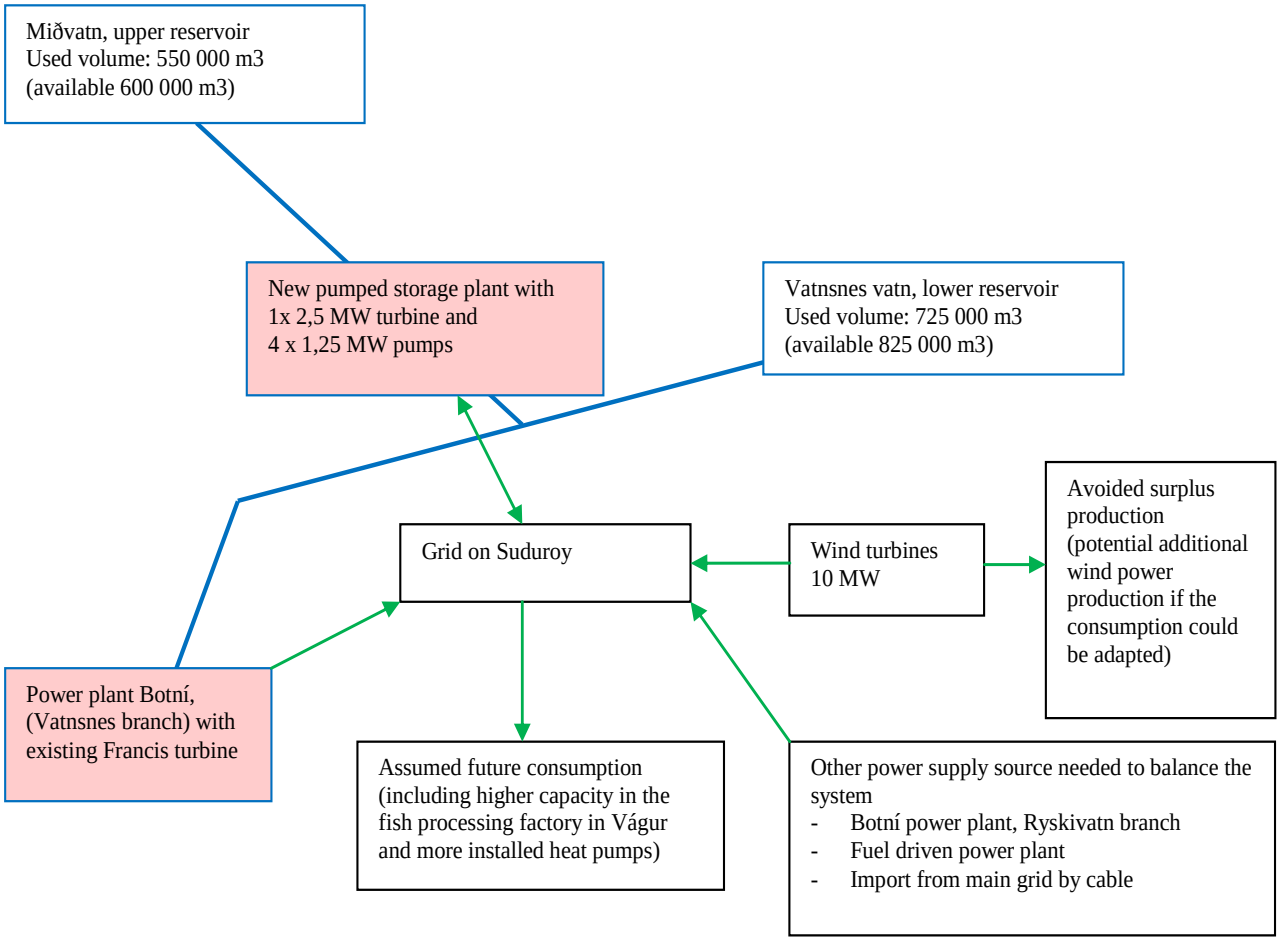
(2,5 MW turbine and 4 x 1,25 MW pumps)



10 MW wind turbines

80 mill. NOK

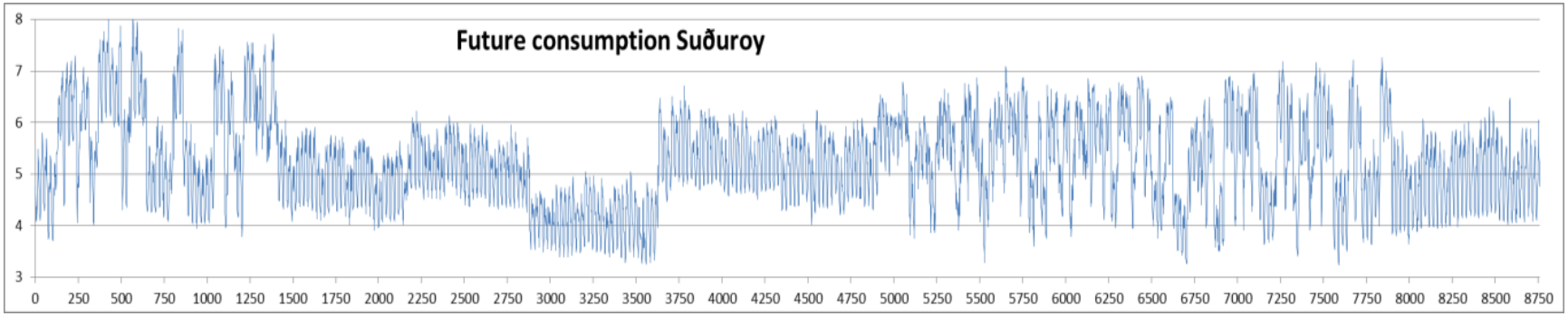
Production simulation



Simulation input - consumption

Power consumption (hourly data for one modell future year)

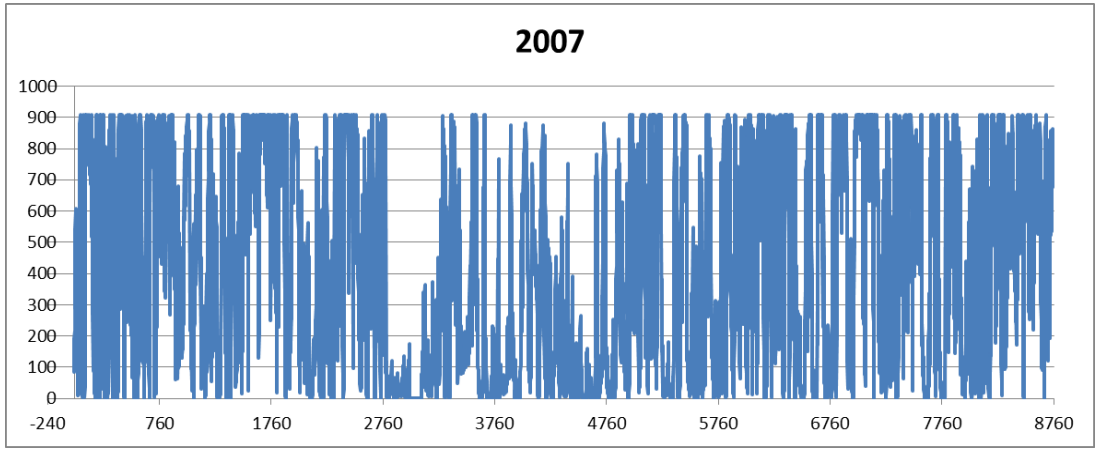
Strong variations
- daytime variation
- fish processing factory

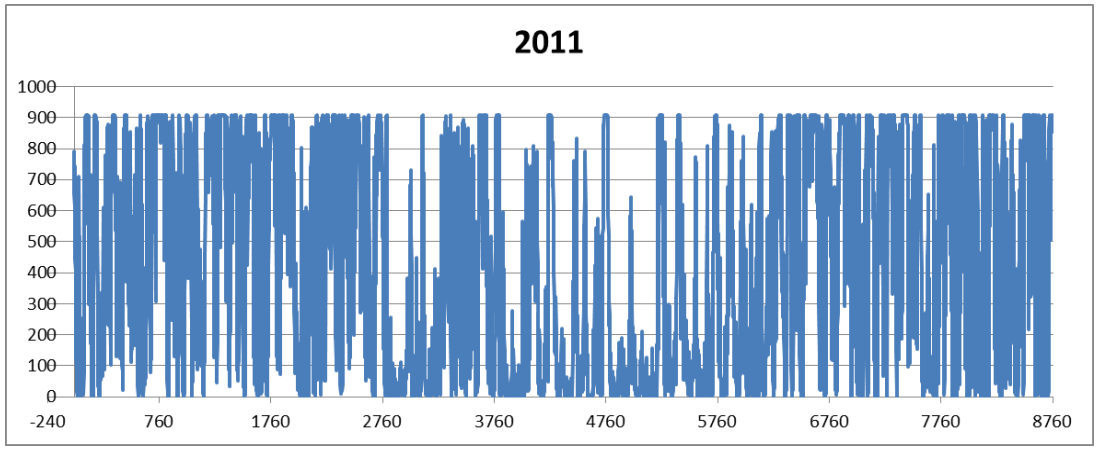


As the fish processing factory just had started producing, it was not possible to use empirical values. Jarðfeingi constructed a modell year based on different sources, which was used for the simulations.

Simulation input - wind data

6 years of wind data for Suðuroy (2007-2012) were made available and were used to calculate the power output of the wind turbines.





Simulation input - wind data

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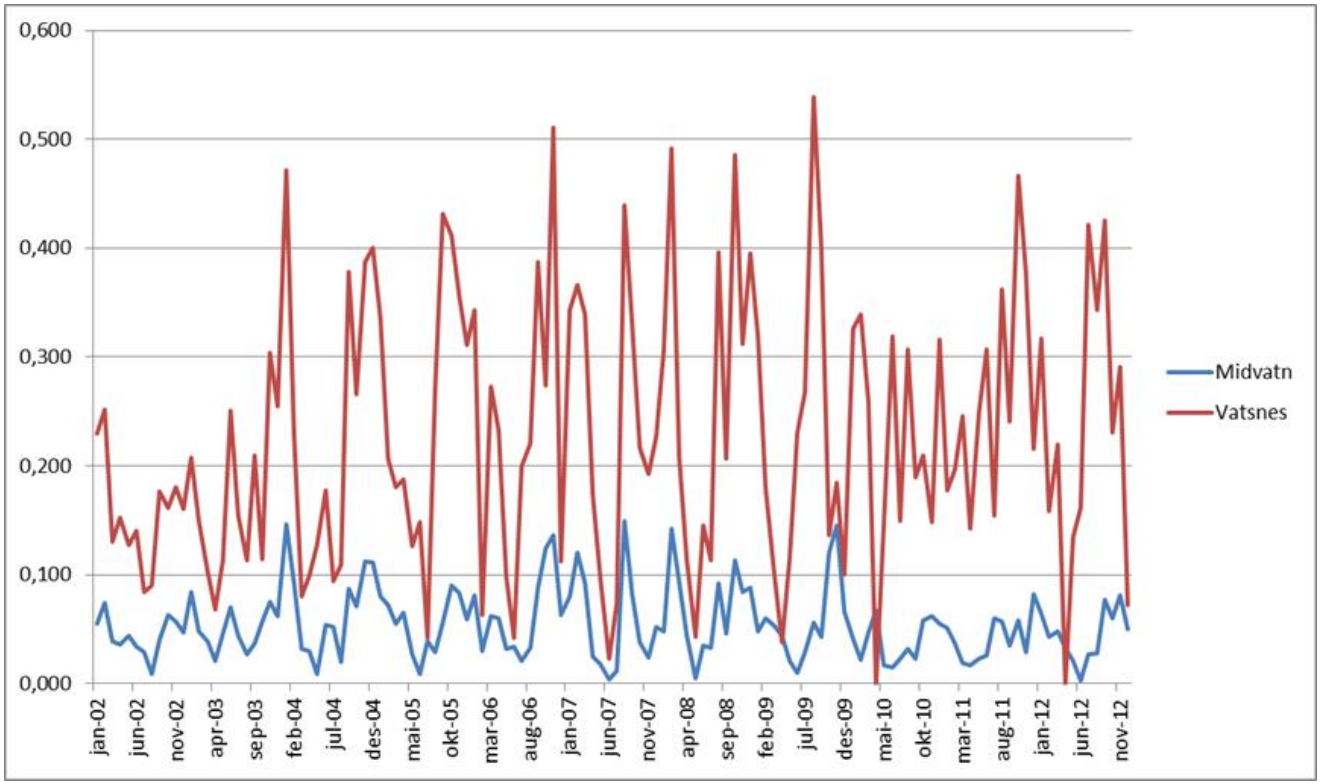
Inflow data for the reservoirs Miðvatn and Vatnsnes:

Daily inflow over a 11 year period (2002-2012). Basic data provided by SEV, adapted by Norconsult.



Simulation

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Simulation period: each hour from 1.1.2002 - 31.12.2012

Simulation rules:

- Wind power that meets the consumption is used directly
- "Excess wind power" is used for pumping (if the upper reservoir is not full).
- If there is too little wind power -> the turbine of the pumped storage plant starts.
- The program optimizes the operation of the pumped storage plant and the hydropower production in Botní.
- optimization for reservoir levels/volumes in order to maximize total production of renewable energy
- In situations where demand exceeds the production from wind and hydropower the model assumes additional supply from another source of power.

Results

With 10 MW of wind power installed on Suðuroy and with a new pumped storage plant, the island can be supplied with more than 80% renewable energy:
65 % wind power (meeting the demand directly)
18,5 % hydro power (including from pumped storage)
16,5 % must be imported from the main grid or be produced by other means.

Production	**Base case**	**+ 25% turbine capacity**	**+ 25% turbine capacity and larger upper reservoir**
	GWh	GWh	GWh
Wind power production (used for general consumption and pumping)	**34,3**	**34,6**	**34,9**
Hydropower production (pumped storage and Vatnsnes branch in Botni)	8,6	8,8	9,0
Hydropower production (Ryskivatn branch in Botni)	1,2	1,2	1,2
Total hydropower	**9,8**	**10,0**	**10,2**
Wind-and hydropower available	44,1	44,6	45,1
Fuel based power production or import from main grid	**8,8**	**8,6**	**8,4**
Total power production	**52,9**	**53,2**	**53,5**
Consumption			
	GWh	GWh	GWh
General consumption	45,8	45,8	45,8
Pumping energy	7,1	7,4	7,7
General consumption and pumping	**52,9**	**53,2**	**53,5**
Surplus wind power production (no demand on Suðuroy)	*5,0*	*4,7*	*4,4*

Results

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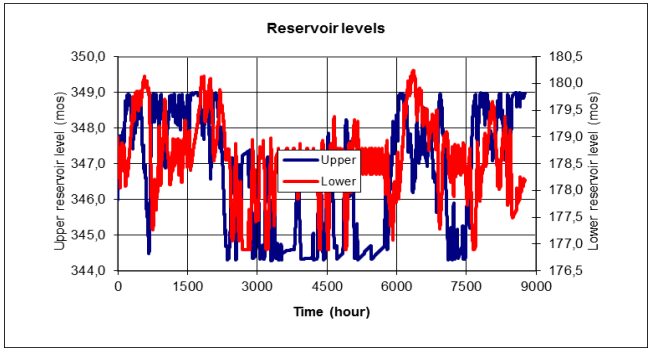
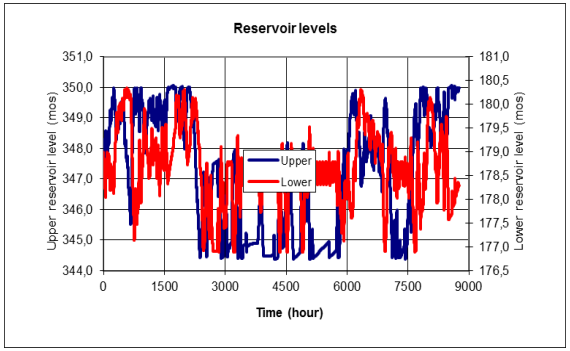




Miðvatn, upper reservoir
Used volume: 550 000 m3

New pumped storage plant with
1x 2,5 MW peltonturbine producing 5,3 GWh
4 x 1,25 MW pumps using 7,1 GWh

Vatnsnes vatn, lower reservoir
Used volume: 725 000 m3

Wind power production.
Potential: 39,3 GWh.
34,3 can be used. Direct use for general consumption. 27,2 GWh.
Used for pumping when consumption is low:
7,1 GWh.

Surplus production (no demand on Suðuroy at that time)
5 GWh

Grid on Suduroy

Power plant Botní, (Vatnsnes branch)
3,4 GWh

Assumed future consumption

45,8 GWh

Other power supply source needed to balance the system (total average need: 9,9 GWh)
- Botní power plant, Ryskivatn branch 1,2 GWh
- Fuel driven power plant
- Import from main grid by cable

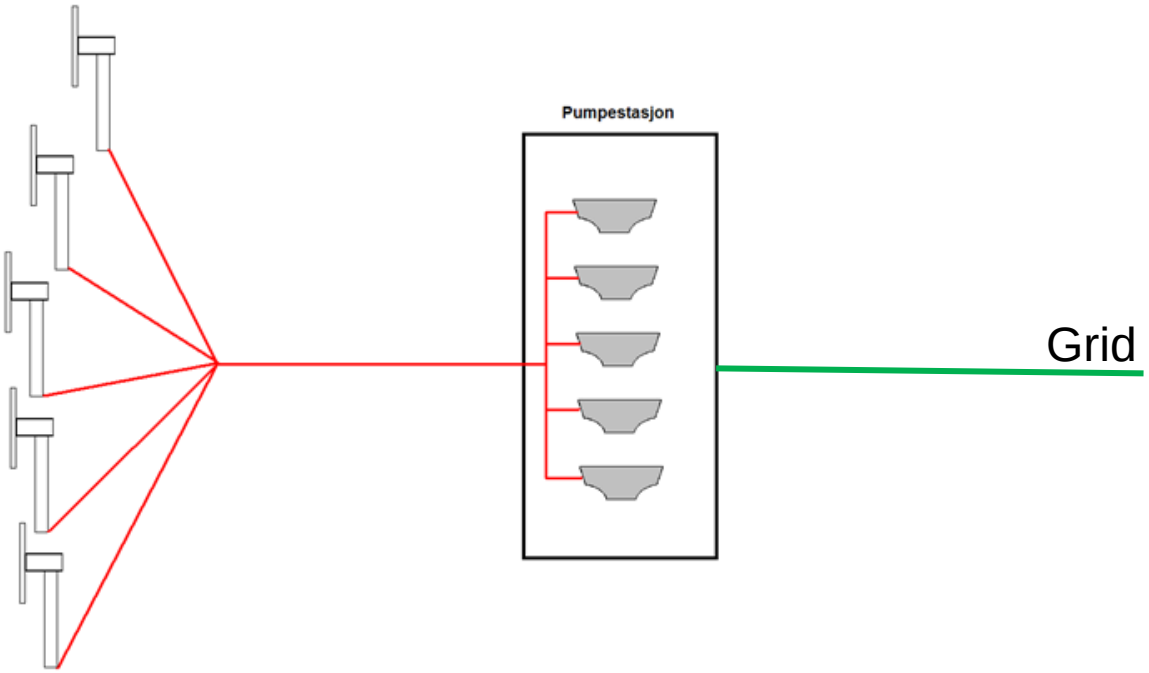
Economical issues

Production method	Price DKK/kW el	Comment
Heavy fuel oil based power	0,87	excl. O&M
Wind power	0,28	incl. O&M
Pumped storage (net hydropower)	1,07	incl. O&M
Wind power + pumped storage	0,4	incl. O&M

Source: Jarðfeingi, Ea Energy Analysis based on Norconsults report and information from SEV

Conclusion: price for production with pumped storage+wind is comparable to heavy fuel based power!

Alternatives?



Connecting the wind turbines only to the pumped storage plant, which again is connected to the grid is theoretically possible.

In order to get the same net energy (due to the loss of energy though pumping), it would be necessary to install more wind turbines (14 MW). In addition, a larger pumped storage plant would be needed (14 MW pumps and 10 MW turbine). This possibility has not been studied.

Other issues: Cable to the main grid?

Cable: it is not certain that a cable to the main grid is needed.

➡ Check before taking for given!

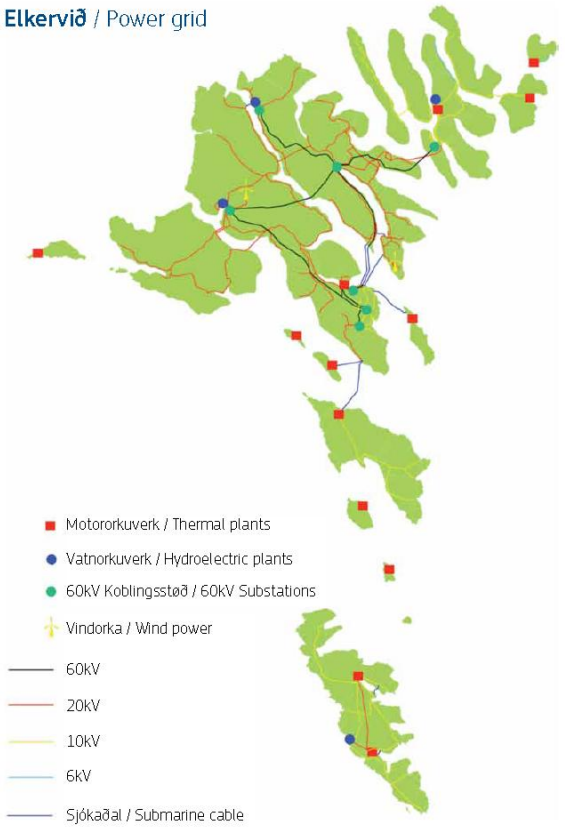


Figure: SEV

Other issues: Adapt consumption?

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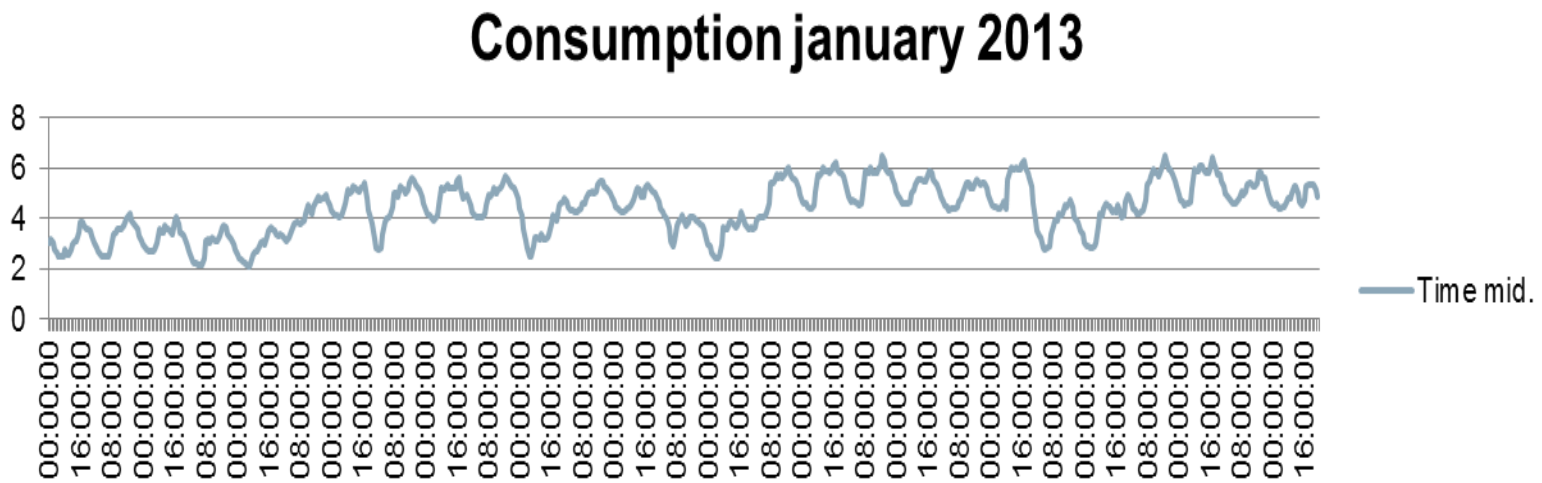
Adapt consumption?

➡ Possibilities to reduce consumption in short periods should be studied (smart grid approach).

➡ Useful in combination with wind power production.



Thank you for your attention!