University of South-Eastern Norway

Analysing the stability of an islanded hydro-electric power system

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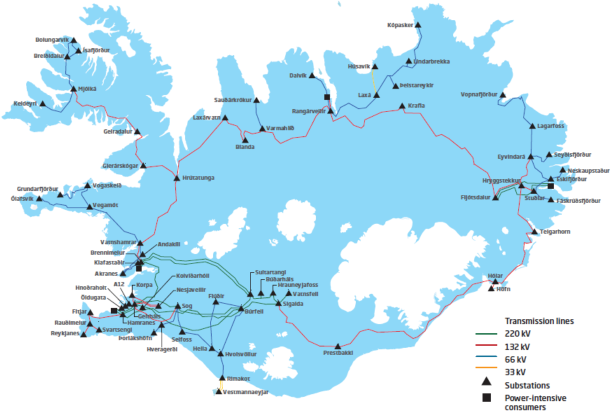
Introduction

Project background

The Westfjords

- Low reliability of power supply in this area
- Consumption is larger than area's local production
- If connection to central grid is lost loads need to be reduced

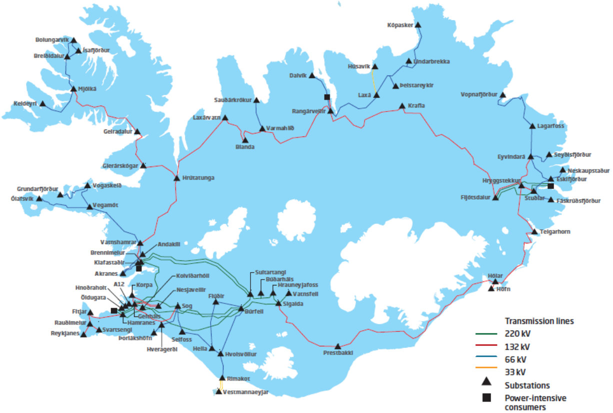


Introduction

Project objectives

Goal

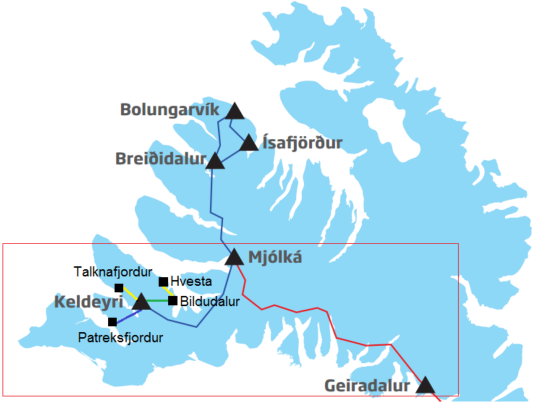
- Determine optimal disconnection sequence of loads
- Effect of additional production of Hvesta power station



Introduction

The transmission system

- 6 transmission lines
  - Operating at
    132 kV | 66 kV | 33 kV | 11 kV
- 3 load centres
  - Bíldudalur
  - Patreksfjörður
  - Tálknafjörður
- 4 generating units
  - Mjólká 1, 2 & 3
  - Hvesta



Introduction

The power stations

Mjólká

- Largest power station in the Westfjords
- Total capacity of $13.25\,\mathrm{MVA}$
- 3 Generating units
  - Mjólká 1 (Francis turbine, $3.4\,\mathrm{MVA}$)
  - Mjólká 2 (Pelton turbine, $8.5\,\mathrm{MVA}$)
  - Mjólká 3 (Francis turbine, $1.35\,\mathrm{MVA}$)

Hvesta

- Pelton turbine, $1.7\,\mathrm{MVA}$

Figure: Power house of Mjólká 1 and Mjólká 2

Modelling

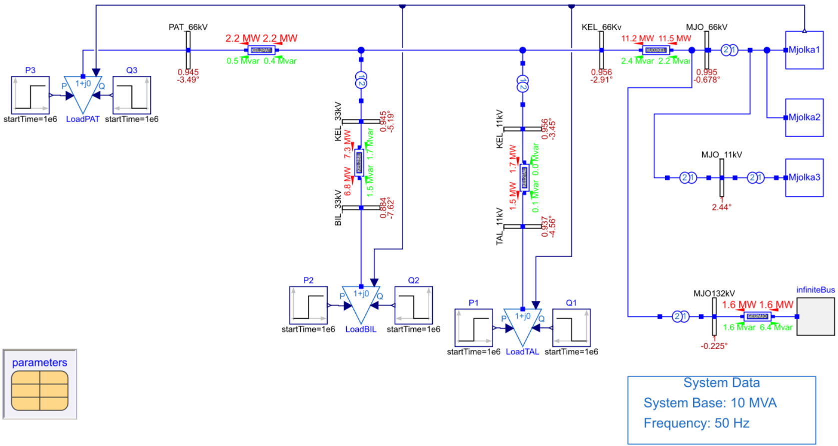
The Open Instance Power System Library

OpenIPSL

- open-source library for modelling of electrical power systems
- developed as an continuation of the iTesla project and is maintained by the ALSETLab research group
- components are based on and validated against models from the existing power system software such as “Power System Simulator for Engineering (PSS/E)” and “Power System Analysis Toolbox (PSAT)”

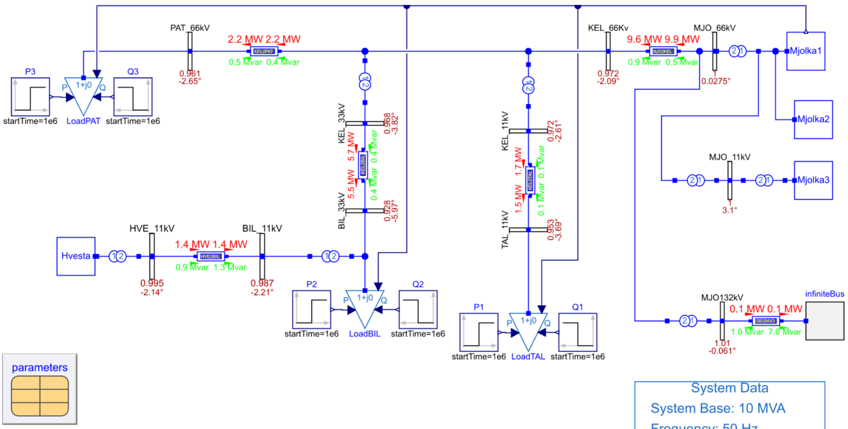
Modelling

Three-generator model



Modelling

Four-generator model



System Data
System Base: 10 MVA
Frequency: 50 Hz

Simulations

Scenario 1: Active and reactive loads

- Connection to the national grid is lost at 20 s
- Loads are partially disconnected if the frequency drops below a specified limit
- Loads remain disconnected
- Quality requirements:
  - Frequency
  - Voltage

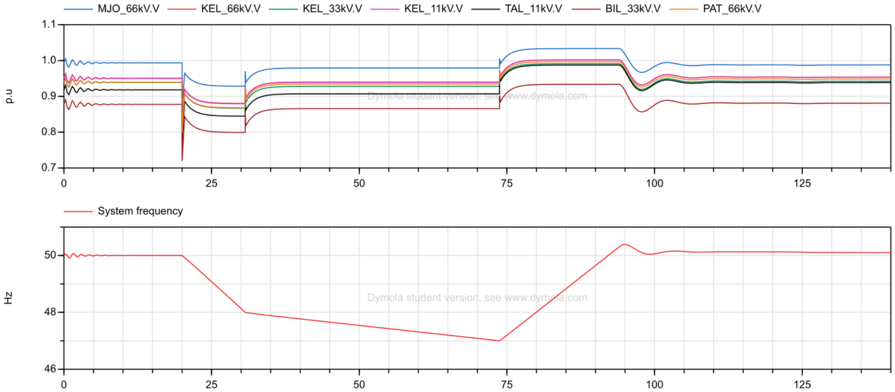
Initial loads

Load name	Active load [MW]	Reactive load [Mvar]
LoadTAL	2.5	0.1
LoadBIL	6.85	1.5
LoadPAT	2.16	0.54
Total loads	11.51	2.14

Simulations

Load Scenario 1.1: Disconnection of LoadPAT and LoadTAL

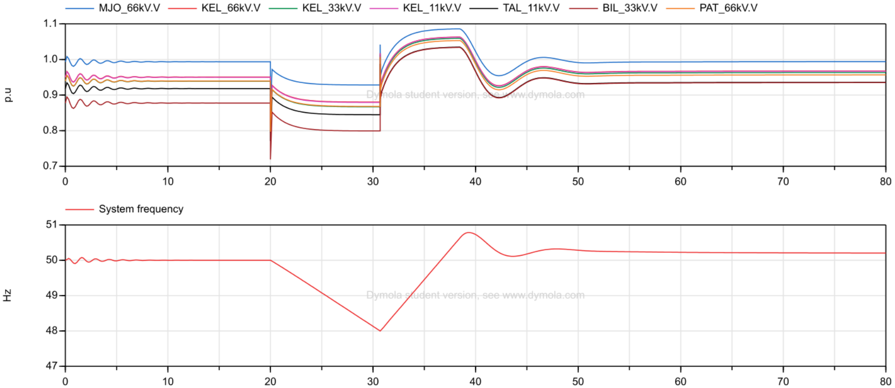
- 50% of LoadTAL and LoadPAT are disconnected
- System stabilises 85 s after the disconnection from the national grid



Simulations

Load Scenario 1.2: Disconnection of LoadBIL

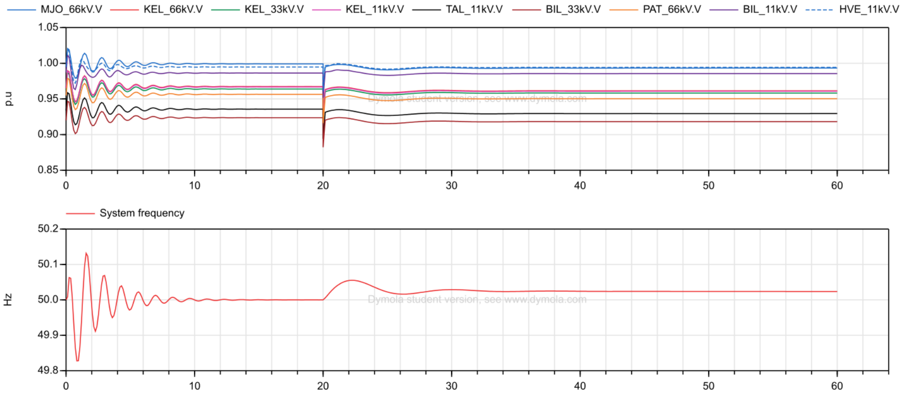
- 50% of LoadBIL is disconnected
- System stabilises 35 s after the disconnection from the national grid



Simulations

Load Scenario 1: Additional production, four-generator model

- The increased production of Hvesta stabilises the system
- System stabilises 8 s after the disconnection from the national grid



Simulations

Scenario 2: Active loads

- Connection to the national grid is lost at $20\,\mathrm{s}$
- Loads are partially disconnected if the frequency drops below a specified limit
- Loads remain disconnected
- Quality requirements:
  - Frequency
  - Voltage

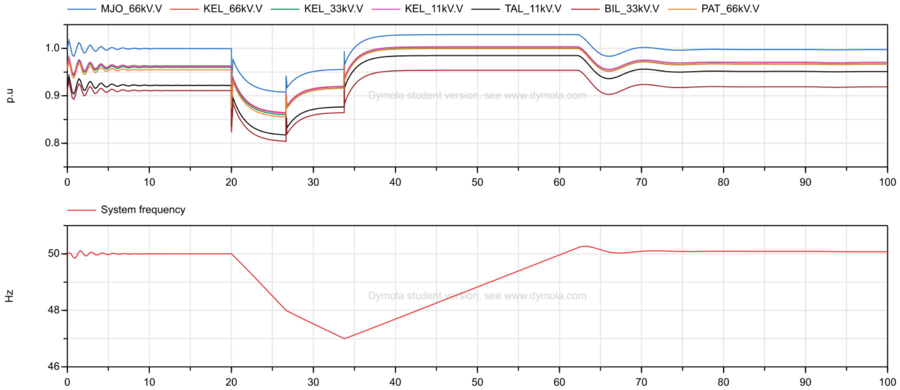
Initial loads

Load name	Active load [MW]
LoadTAL	3.3
LoadBIL	6.85
LoadPAT	2.16
Total loads	12.28

Simulations

Load Scenario 2.1 (3G): Disconnection of LoadPAT and LoadTAL (Three-generator)

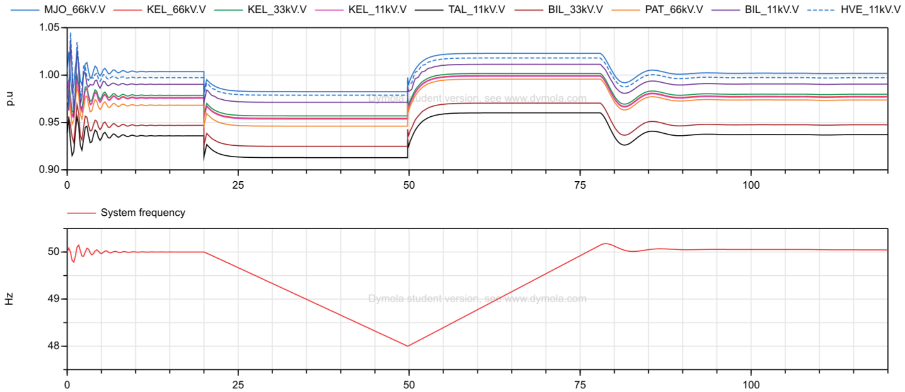
- 50% of LoadPAT and LoadTAL are disconnected
- System stabilises 55 s after the disconnection from the national grid



Simulations

Load Scenario 2.1 (4G): Disconnection of LoadPAT and LoadTAL (Four-generator)

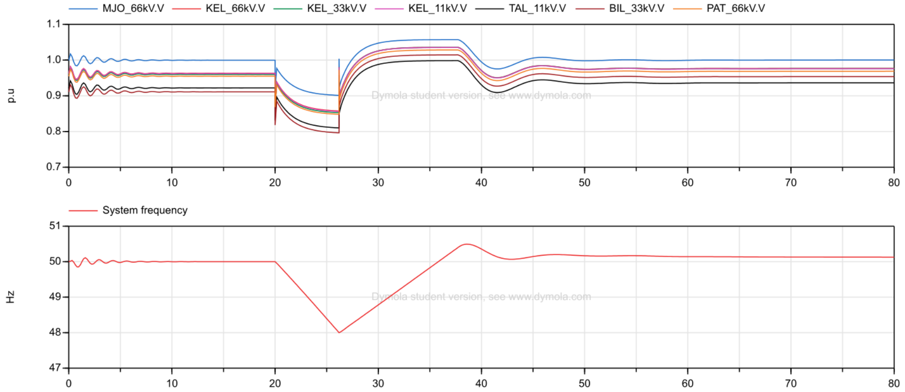
- 50% of LoadPAT is disconnected (LoadTAL stays connected)
- System stabilises 70 s after the disconnection from the national grid



Simulations

Load Scenario 2.2 (3G): Disconnection of LoadBIL (Three-generator)

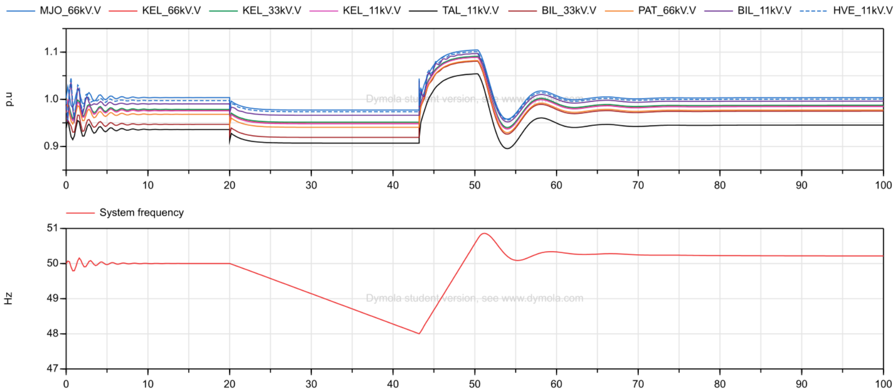
- 50% of LoadBIL is disconnected
- System stabilises 30 s after the disconnection from the national grid



Simulations

Load Scenario 2.2 (4G): Disconnection of LoadBIL (Four-generator)

- 50% of LoadBIL is disconnected
- System stabilises 50 s after the disconnection from the national grid



Conclusions

LoadBIL

- Disconnection of LoadBIL gives fastest stabilisation for both scenarios

Additional production from Hvesta

- Grid is not overloaded in scenario 1
- Gives better voltage stability at all buses
- System stabilises slower

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LoadBIL

- Disconnection of LoadBIL gives fastest stabilisation for both scenarios

Additional production from Hvesta

- Grid is not overloaded in scenario 1
- Gives better voltage stability at all buses
- System stabilises slower

Modelling Challenges

- For numerical reasons parameters had to be adjusted away from original PSS/E values
- Reduced load values $\rightarrow$ simulated voltage levels lower than in reality
- Sub-optimal turbine governor parameters lead to frequency offset

Thank you!

Acknowledgement and Contact

Acknowledgement

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