Hydro Québec

Wind Diesel 2002 Workshop

Hotel Captain Cook, Anchorage, Alaska,

23-24 september 2002

Engineering of Wind-Diesel Systems using Matlab / PSB Tools*

**Power System Blockset*

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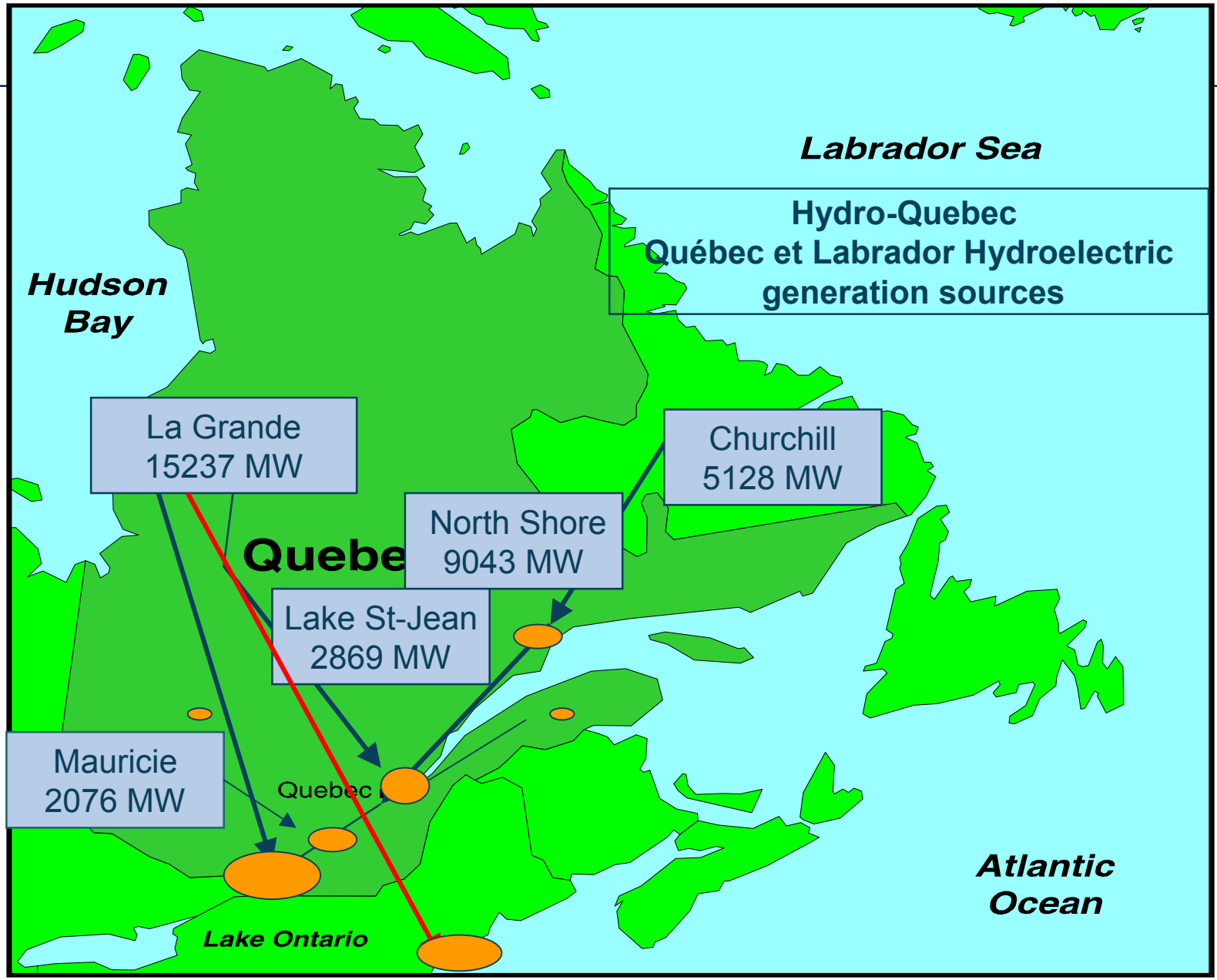
Overview

- **Background on wind diesel at HQ**
  - **Future WD projects in Northern Quebec?**
- **PSB Tools for analysis of wind integration in electrical power systems**
- **New ongoing project: Wind-Hydro coupling**
  - **Characterization of wind power into HQ system**


Labrador Sea
Hydro-Quebec
Québec et Labrador Hydroelectric
generation sources
Hudson
Bay
La Grande
15237 MW
Churchill
5128 MW
North Shore
9043 MW
Quebe
Lake St-Jean
2869 MW
Mauricie
2076 MW
Quebec
Atlantic
Ocean
Lake Ontario

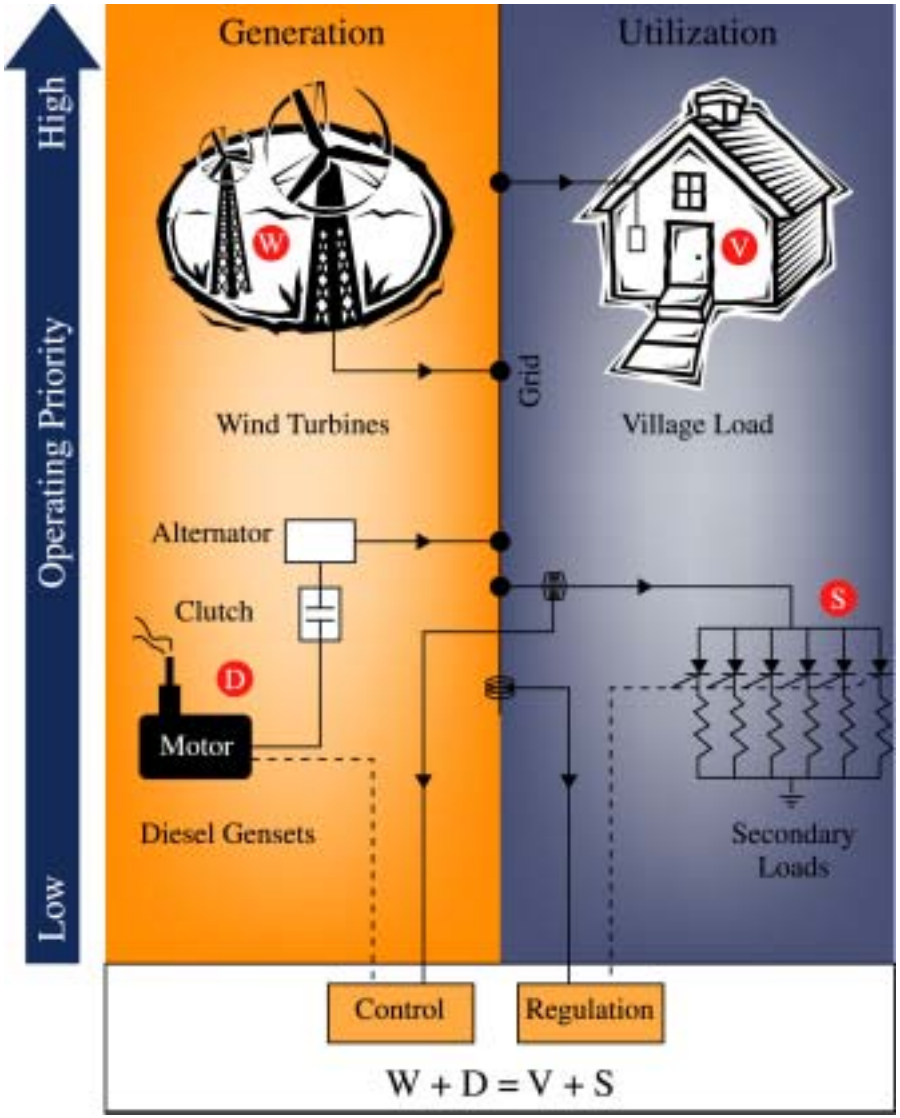
Background on wind diesel at HQ

- Quest for generating technologies capable of **reducing the annual operating deficit** of Hydro-Quebec in remote communities diesel-based electricity generation
  - Single electricity rates all-across Quebec
  - Operating cost > fuel cost > rates
  - **Avoided cost = ± fuel cost**
- Coastal sites have good winds
- **1975: Work on wind-diesel coupling starts**; Magdalen Islands (fuel savings)
- **1986**: Kuujjuaq 's Bonus 65kW wind turbine:
  - removed in summer 2002

Northern Quebec Power systems

- **Northern-Québec vs All Autonomous communities served by HQ**
  - **20 % of total installed diesel capacity**
  - **45,1% of total annual purchases of fuel**
  - **16,4 % of total electricity sales**
- **Fuel represents 53,8% of operating costs in Northern-Québec communities (8,6 M$ en 2000)**
- **Wind diesel technology represents a ~ 50% decrease of annual fuel purchases for HQ inuit communities (25% of total annual fuel purchases).**

The High Penetration No-Storage Wind Diesel Concept



- **Priority to Wind Energy Free Fuel**
  - Optimal Penetration Dictated by Economics: Cost of Fuel, Wind Resource
  - Diesels Are Shut When Wind Exceeds Demand
  - Energy Surplus Used in Secondary Loads (heating fuel savings)
- **No Power Quality Reduction**
- **A Regulator Maintains Balance Between Generation and Load**
- **A PLC Manages the Transitions Between the Operating Modes: All-Diesel, All-Wind and Wind-Diesel**
- **Savings**
  - Fuel: 50-70% Depending on Wind Resource
  - Increased Diesel Life
  - Diesel Maintenance
- **Electricity ->Energy planning**

HPNSWD project background…

- 1990:
  - Experimental proof of concept obtained at IREQ
- 1994:
  - HPNSWD technology demonstrated at AWTS, PEI
  - Working group constituted to assess the feasibility of using the technology in HQ Remote Networks (RN)
- 1995:
  - New study ordered to compare Hydro vs Wind options for 14 villages
- 1996
  - 8 out of 14 villages would benefit from the HPNSWD technology
  - Savings of ~ 2 M$ expected over retrofit program
  - Recommendation to start with a first project in Quaqtaq…

HPNSWD project background…

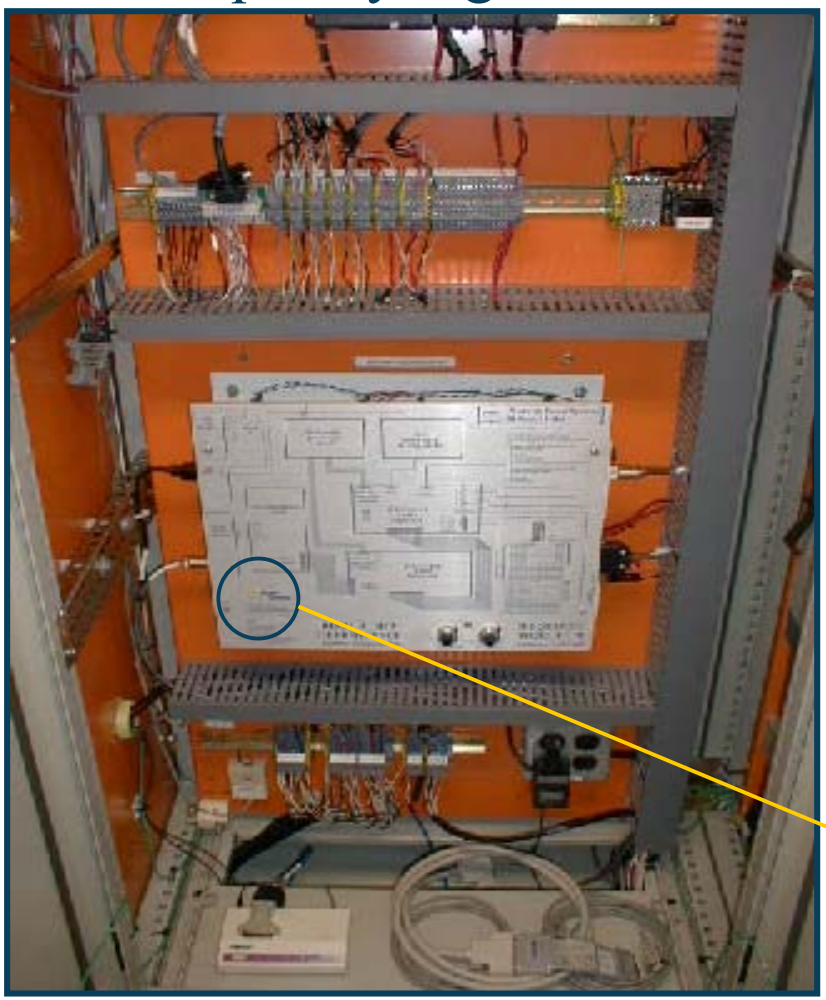
- 1996
  - Decision is upheld as HQ reevaluates its role in wind technology development
- 1997
  - HQ Wind Task Force is set up in 1997
  - The energy minister asks the Quebec Energy Board (QEB) an advice on the opportunities of wind technology for Québec;
- 1998
    - Hearings start in 1998
      - HQ positions itself as an eventual buyer of wind energy but not as a project developer
    - Favourable recommendation from the QEB
      - for wind energy set-aside (450-900 MW over 9 years)
      - W/D technology

HPNSWD project background…

- 1998
  - Quaqtaq HQ pre-project analysis is carried out
    - Costs are more than twice higher than 1996 study
    - decision to halt
  - NPS has a customer in St-Paul, Alaska (TDX Corp) interested in HPNSWD technology
    - IREQ-NPS sign a collaborative agreement to assist in the design of the system
- 1999
  - Regulator is delivered and installed in Alaska
  - System is commissioned march; operating since
- 2000
  - Based on NPS construction experience on the St-Paul project, a decision to undertake an update of the 1998 Quaqtaq study on a turnkey basis is made. NPS carries the economic study.

TDX system, St. Paul, Alaska

Frequency regulator



Secondary loads (excess energy)

A

Update needed for Northern Villages:

- **2001 NPS study on Quaqtaq, based on the St-Paul, Alaska project experience, confirms the cost estimates of 1996 by HQ WD working group.**

- **En 2002: better economics**
  - **Improvements in wind turbine productivity (lower ¢/kWh)**
  - **Lower cost of capital**
  - **Higher cost of fuel**

- **Success factors**
  - **Experienced integrators**
    - **Commercial projects (Northern Power Systems, Vt)**
    - **Demonstrated know-how and economics**

Recommendation made

- **Update 1996 economic study for the 14 Northern villages** using new data and expertise available
- Taking into account the current requirements and constraints, **recommend the most interesting village** for a first installation in Northern Quebec and a third party partner for a turnkey implementation
  - **Partners**:
    - **Autonomous grid planning**
    - **Local communities**
    - **Constructor and HQ Manager**
    - **IREQ**
- **Approved 16 september 2002**

New modelling tools

- Need of flexible tools
  - Stability Protection and Control issues
  - System Optimization
- Previous Simulations of the HPNSWD were carried out with EMTP (Electro-Magnetic Transient Program), EMTDC
- Other tools in Transient analysis…

+ Simulink

++ Power System Blockset

  - Comparison for Validation
  - User « friendly »
  - Control tools analysis

Power System Blockset

Power System

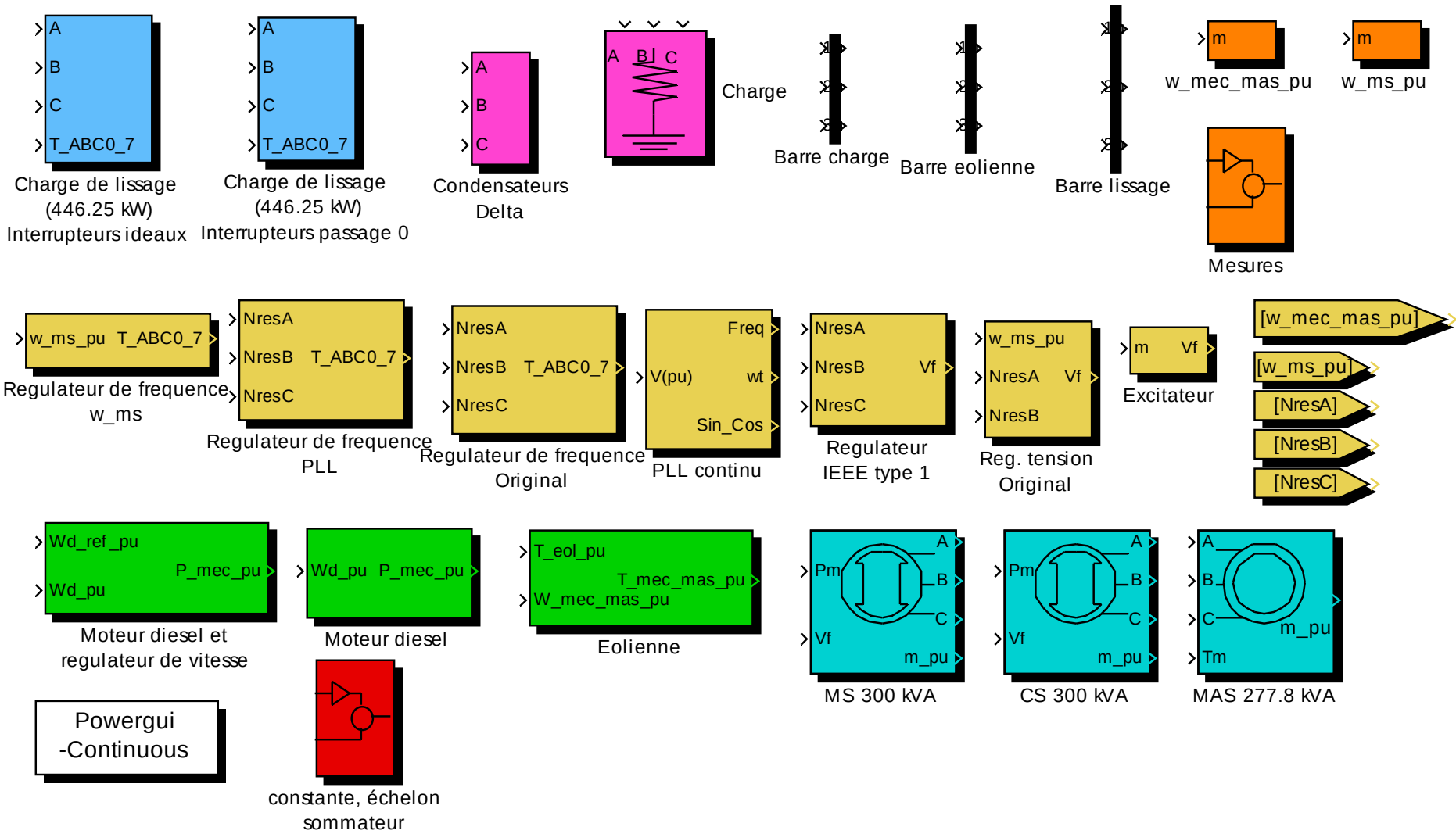
The Power System Blockset provides the ability to model and simulate electrical power systems and drives within the Simulink Environment. Applications of the Blockset include analysis and modeling of power utility distribution networks and self-contained power systems such as those for ships, aircraft and spacecraft. …And remote networks

The blockset covers the following areas:

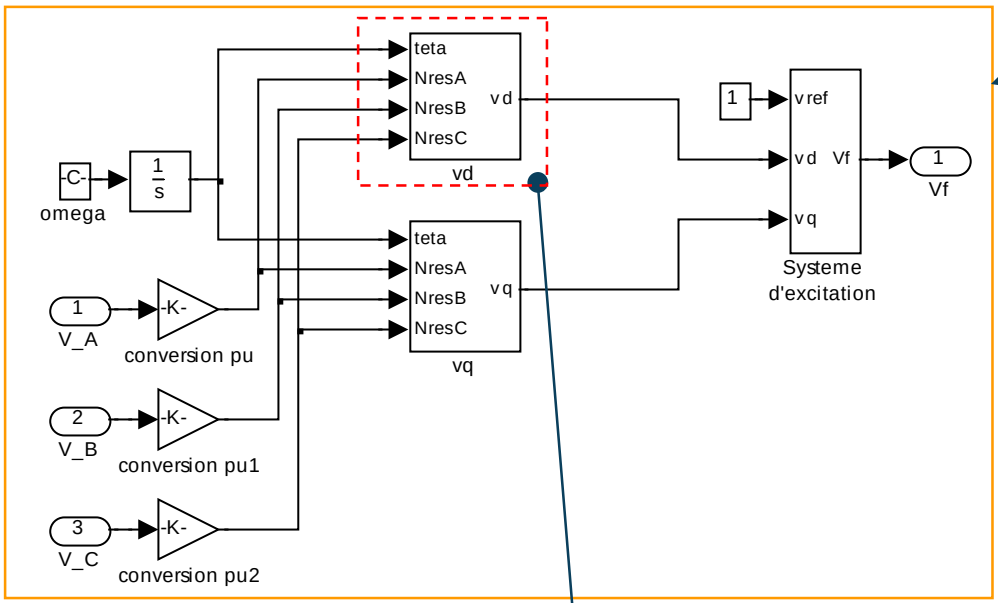
- Power system networks
- Electric machinery
- Power electronics
- Control and measurement
- Triphase library

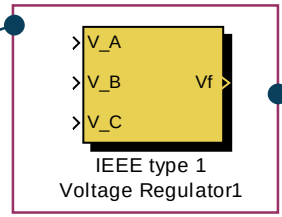
- **Power System Blockset**
  - developed at IREQ labs
  - Marketed and distributed by MathWorks
- **Simulink**
  - commercial product developed by Mathworks
  - requires MATLAB for its operation.
  - graphical block diagrams to simulate the mutually interactive components of a dynamical system.
  - used for system design optimisation.

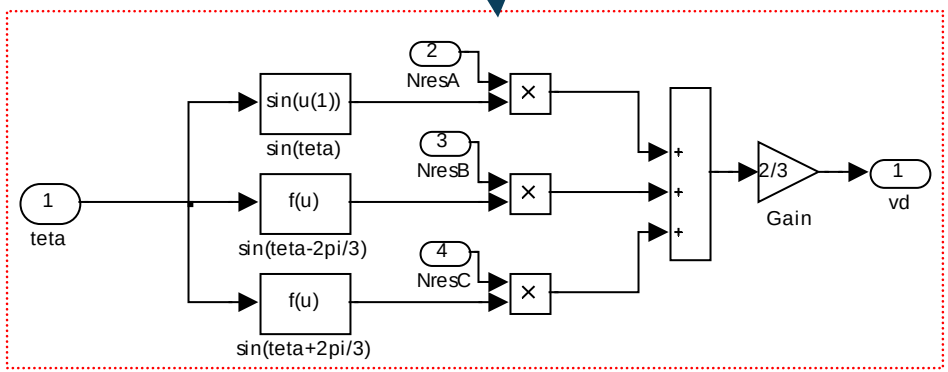
Library of objects for WD analyses



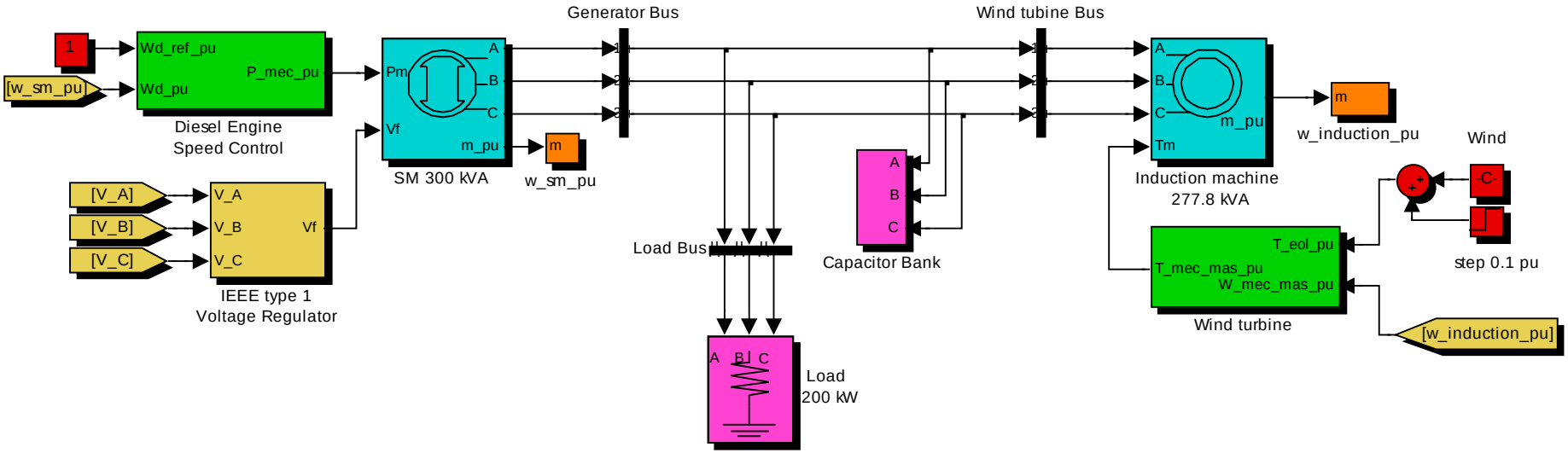
Object description and sub-models



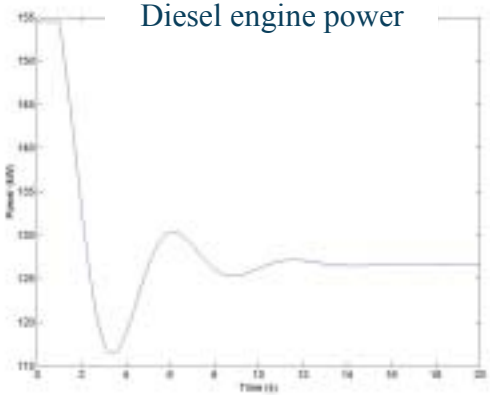


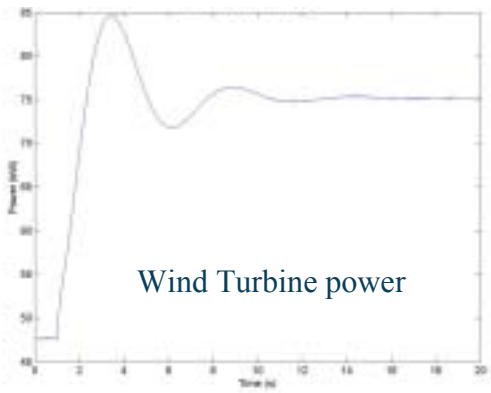


Wind Turbine And Diesel Generator



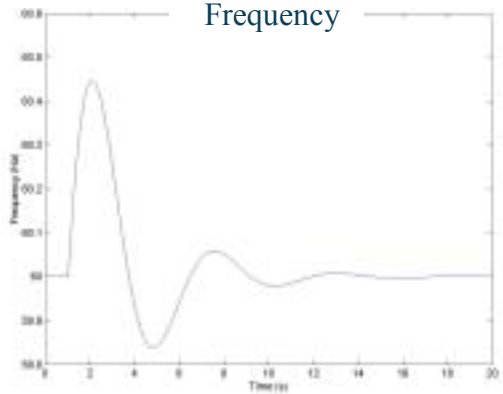
Diesel engine power



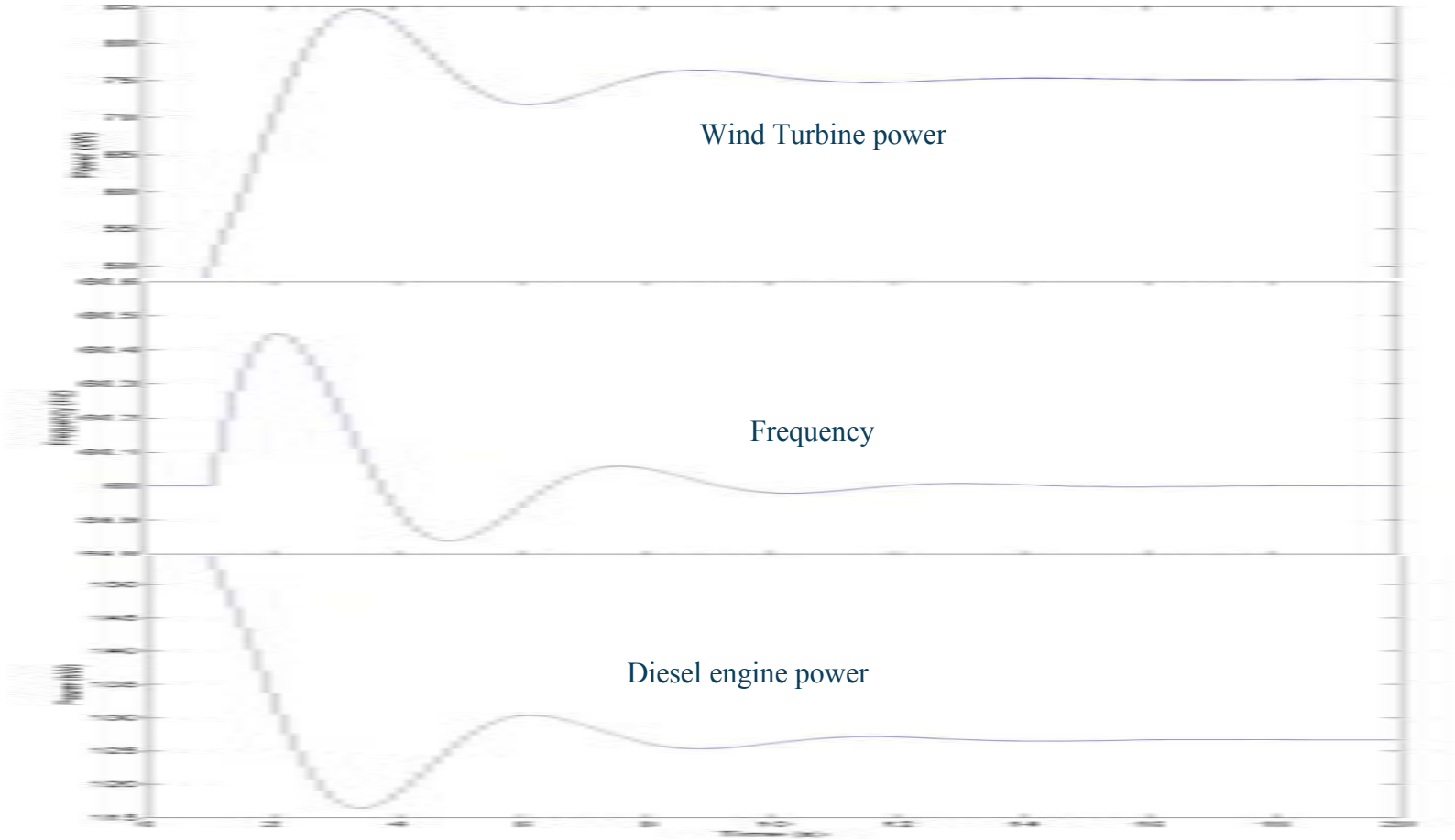


Wind Turbine power

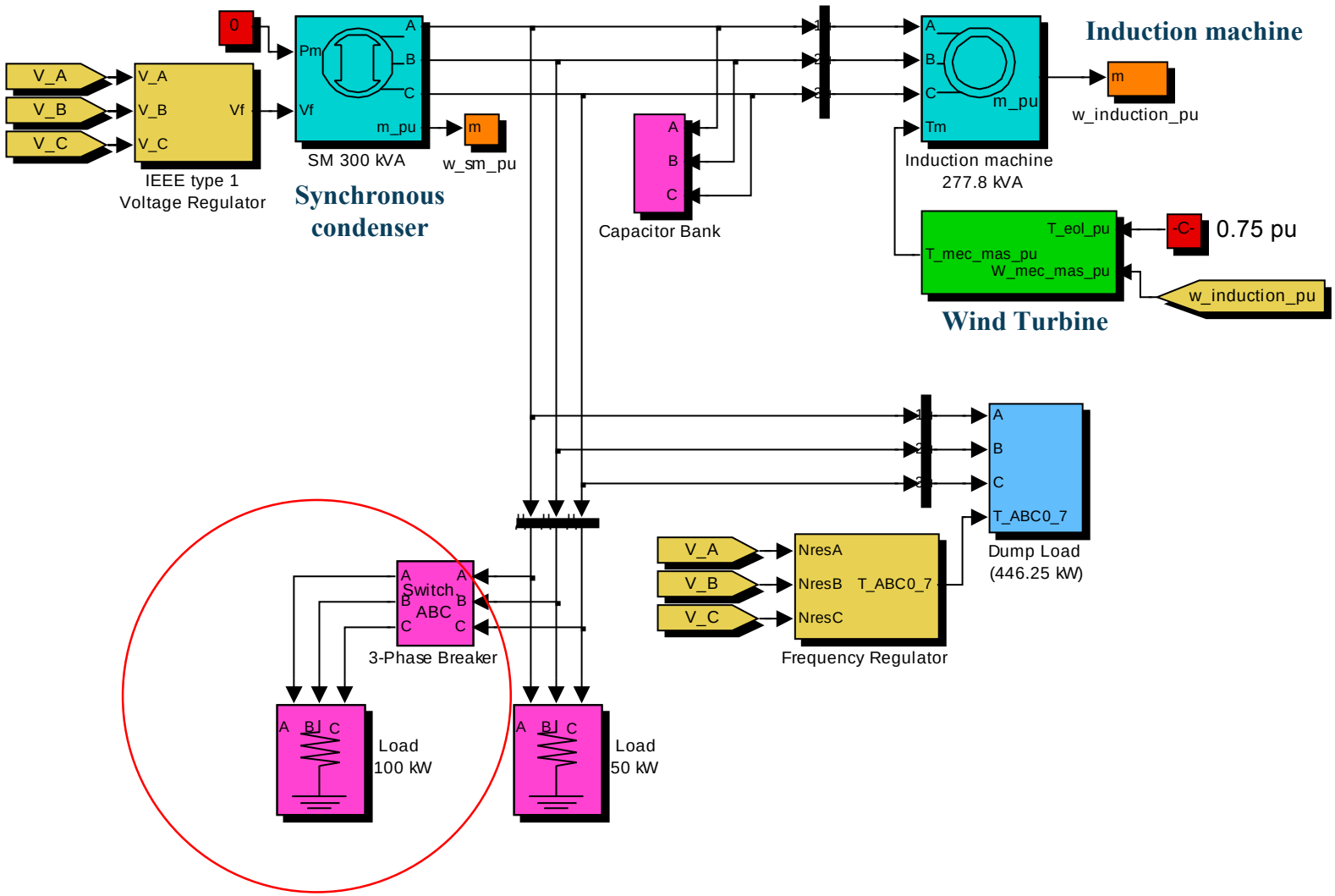
Frequency



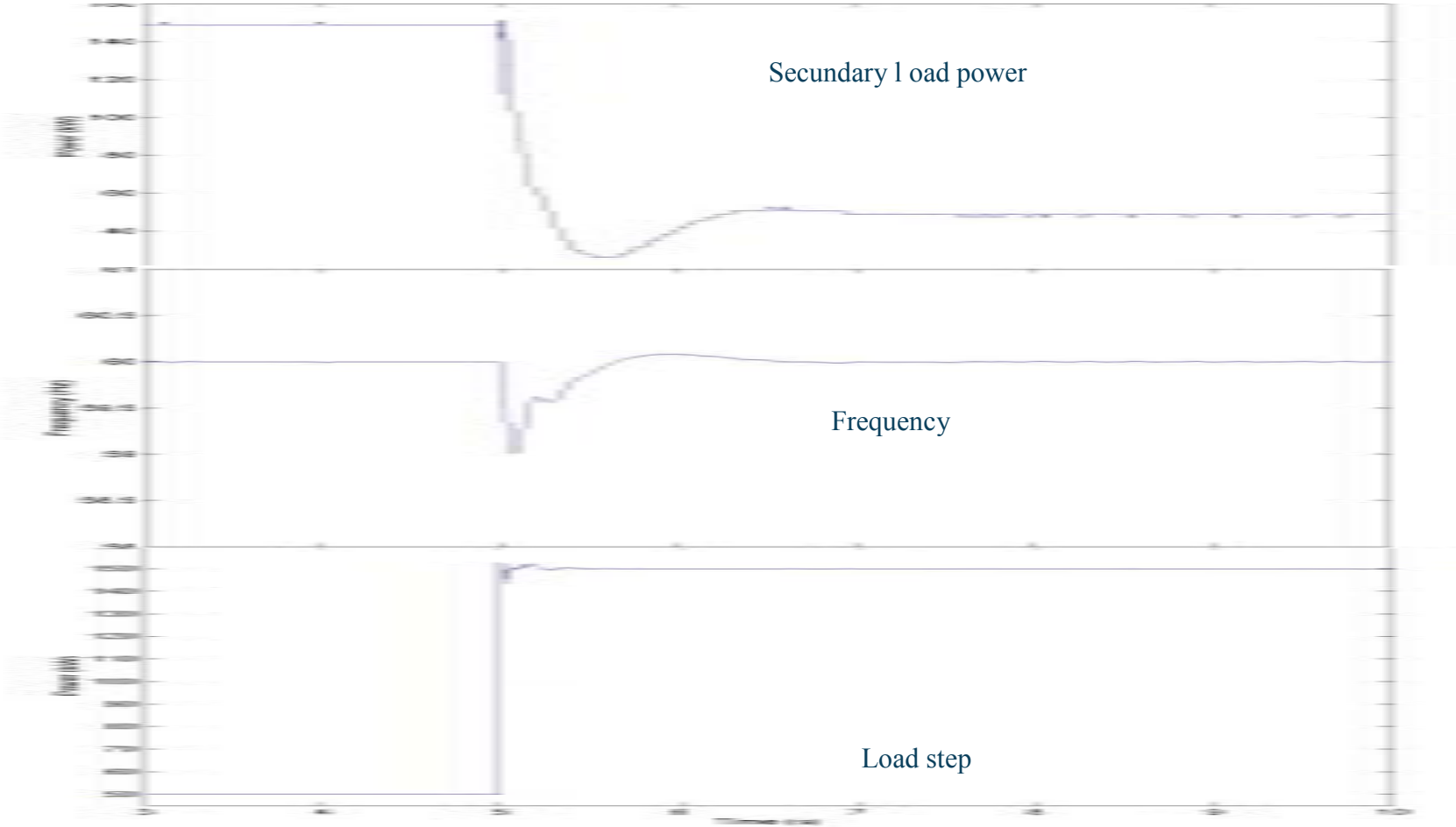
Diesel speed regulator response to a wind power increase

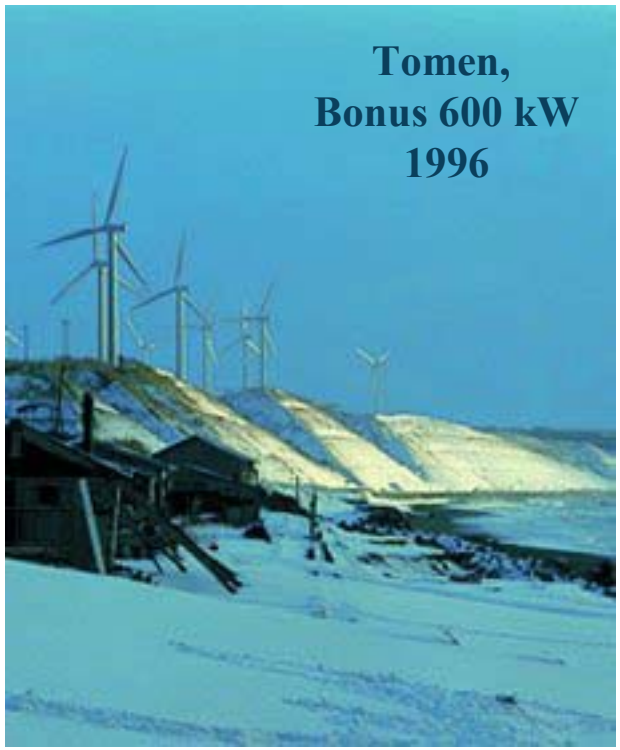


Secondary load regulator response in All-Wind mode (HPNSWD)



Secondary load regulator response in All-Wind mode (HPNSWD)





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