Proposal for Mongolian Power Station using Joint Operation System(JOS)

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MHI Control Systems Co.,Ltd.

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◆Contents

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What's JOS ?

JOS optimizes the plant status for a minimization of total energy.

How ?

- Each boiler, turbine and equipment has a high efficiency operation band.
- As a practical matter, all equipment can not be operated on the high efficiency area in the plant.

JOS can coordinate the operation point both the boiler and turbine. The operator can lead the plant to the minimization of total energy using JOS.

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◆Actual performance of JOS

Target of JOS ?

◆The plant has a number of boiler and turbine with common header.

◆Boiler uses some fuel for combustion.

◆Turbine has some extraction line for process steam.

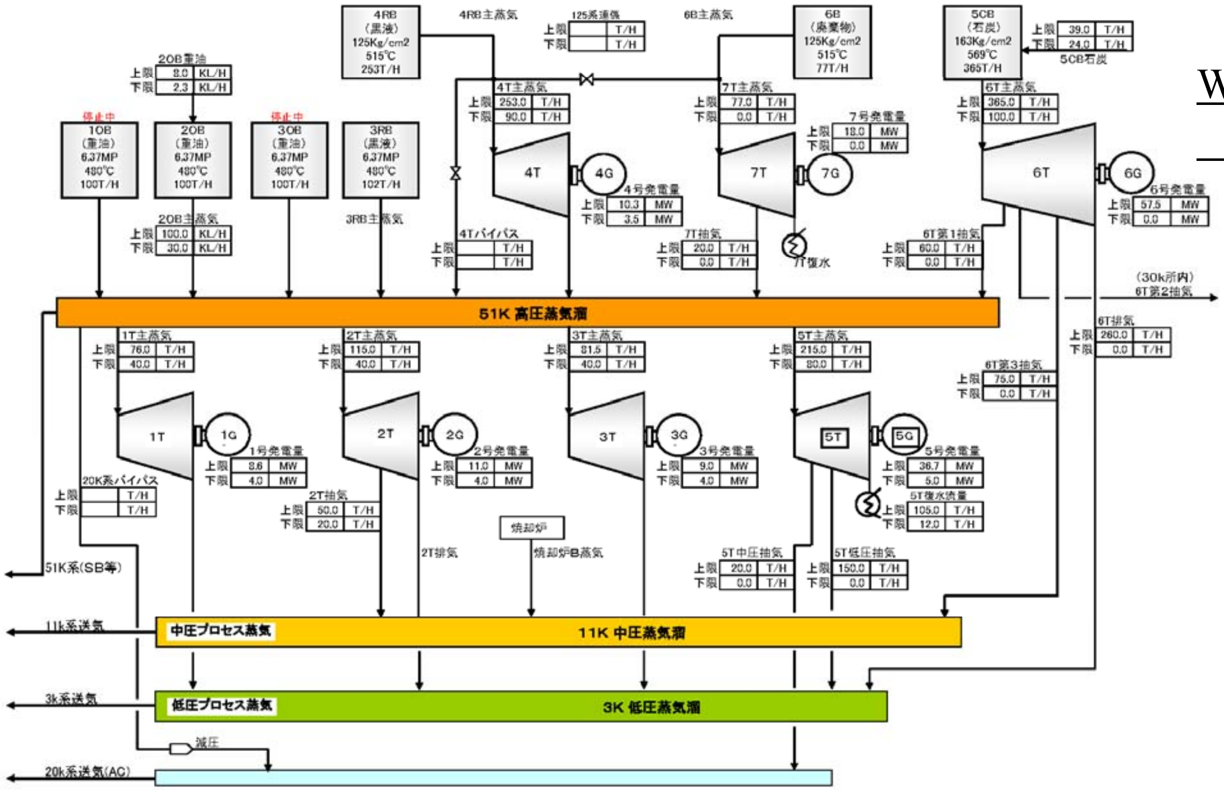

Figure 1. System diagram of paper manufacturing plant.

We have delivered JOS to the following plant,

- Paper manufacturing for 3 companies
  = 3Bx7T+16Bx9T, 3T, 6Bx7T
- Iron manufacturing for 2 companies
  = 3Bx4T, 5Bx5T
- Joint Thermal Power Plant for 1 company = 3Bx3T

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◆Functions and Features of JOS

Online real-time optimization

JOS calculates the optimal operation demand according to the mass balance of the steam and the power balance when the plant status changed.

Offline optimization

JOS can simulate the future plan to determine the running number of boilers and turbines.

Calculation of equipment operation characteristics model

JOS uses the model of boilers and turbines with the actual characteristics .

Economical operation demand

JOS calculates the total generating cost using nonlinear optimizing solver.

Automatic update the nonlinear model using identification

The model is corrected using the present plant condition.

Pattern setting of the utility power and its calendar

The operator can define when the utility power cost is decided and/or renewed by contract .

Estimation of the status

JOS estimates the actual value using mass balance because the flow sensor has an error under low flow status.

Demand control

JOS can selectively warn the operator operating the shutdown of auxiliary machine before the utility power reaches the limit of its contract at the end of a demand cycle.

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◆JOS for Paper manufacturing

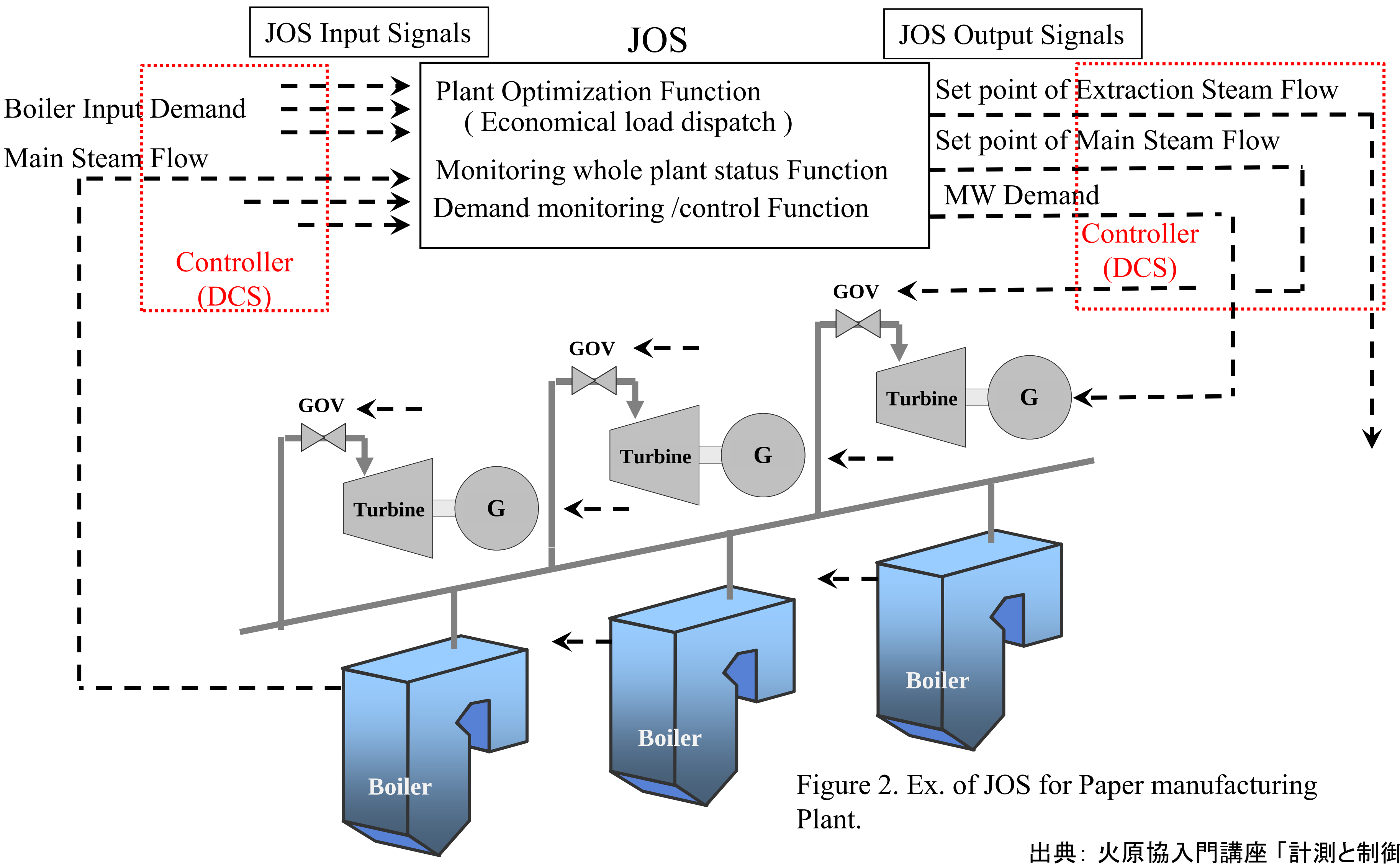

Figure 2. Ex. of JOS for Paper manufacturing Plant.

出典：火原協入門講座「計測と制御」

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◆System Configuration Example

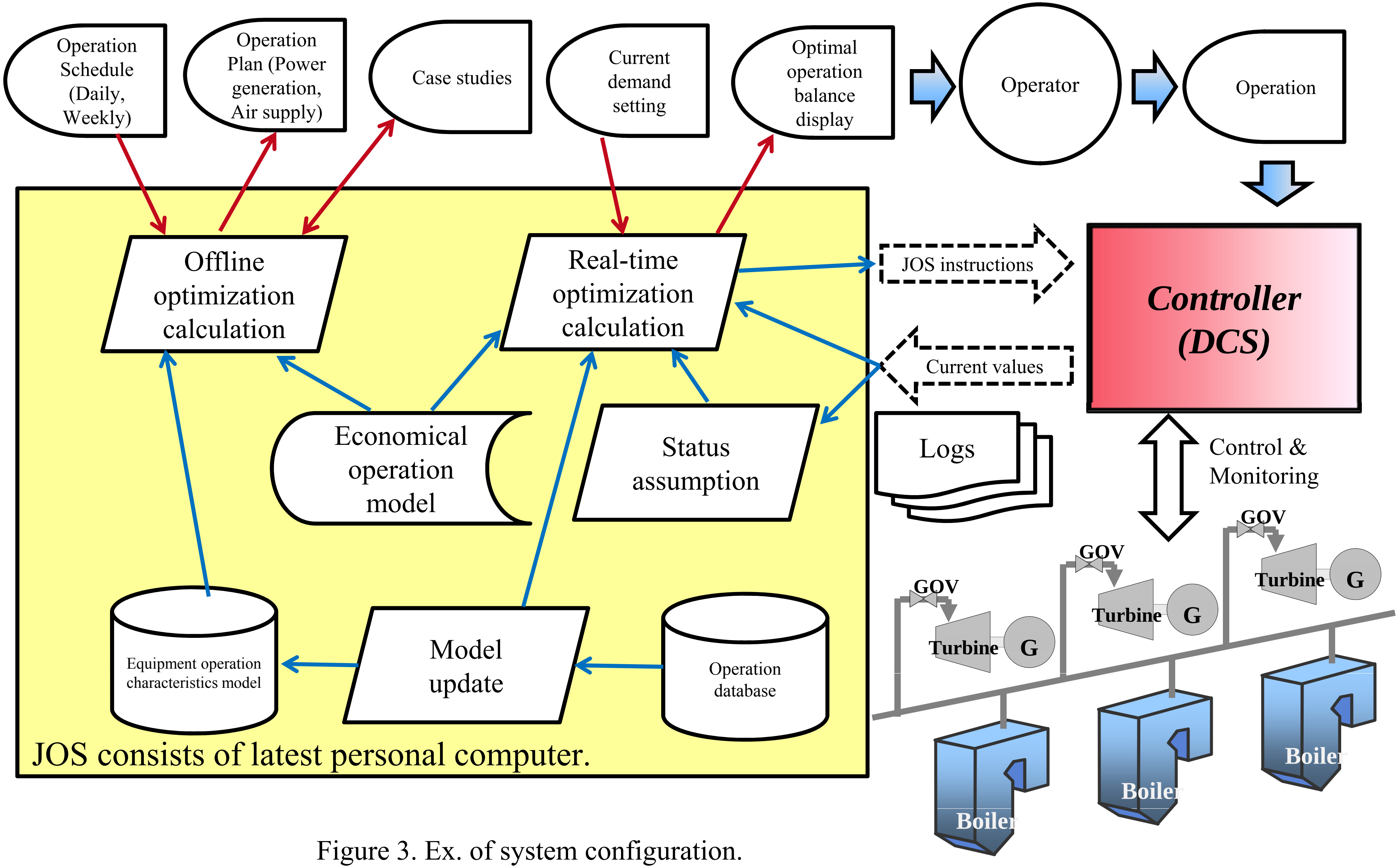

Figure 3. Ex. of system configuration.

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◆System Function Configuration

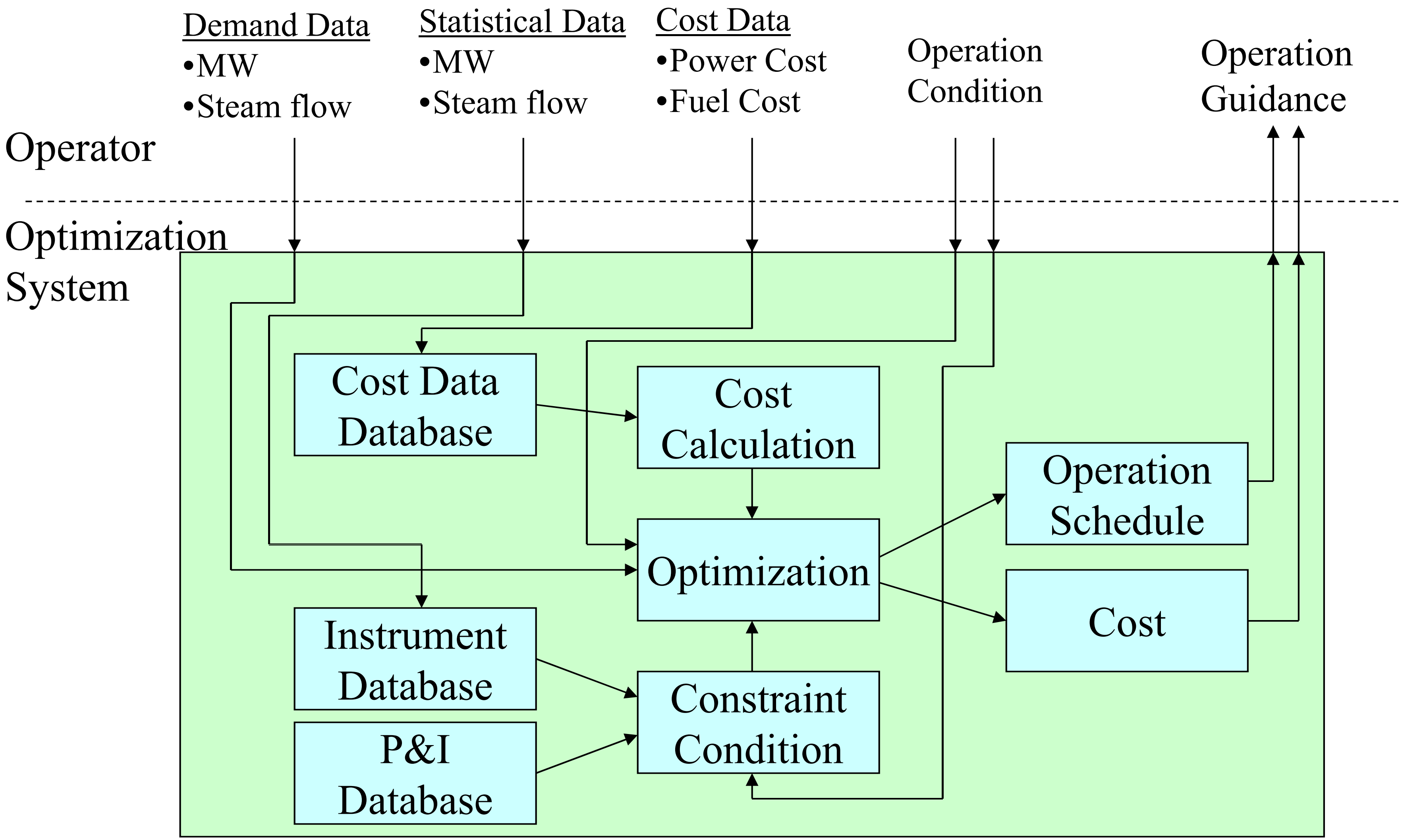

Figure 4. System function configuration.

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◆How to calculate optimization

Variables are defined for calculation

Variable ***X*** for JOS "Design Variable"	Steam flow of Turbine & ext. steam, oil & coal, etc.
Feed back from demand of JOS	MW, Steam flow of Boiler etc.
Condition for JOS	MW demand, Steam flow demand, etc.

Equations are made from these relationship using system diagram

Equality constraint	***H***	:Mass balance of turbine, Characteristics（Flow vs. MW） MW Demand＝ΣMW＋Utility power, Mass Balance around header, etc.
Inequality constraint	***G***	:MW of generator, Steam flow of boiler, etc.
Limitation of variable *X*		:Operation boundary of boiler and turbine, Utility power of contract
Object function of optimizing	***F***	:Total Fuel cost and Utility power cost

Optimization using nonlinear programming method

$\boldsymbol{H}=0, \boldsymbol{G}<0 \quad \& \quad \boldsymbol{F}\rightarrow \min$

Answer is ***X***

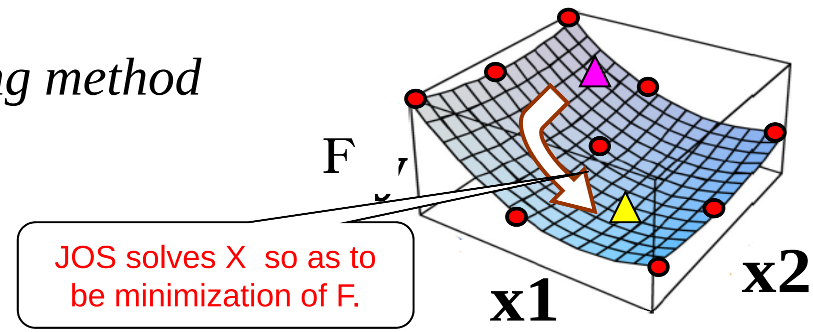

Figure 5. Solver image of JOS.

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◆ Calculation Example

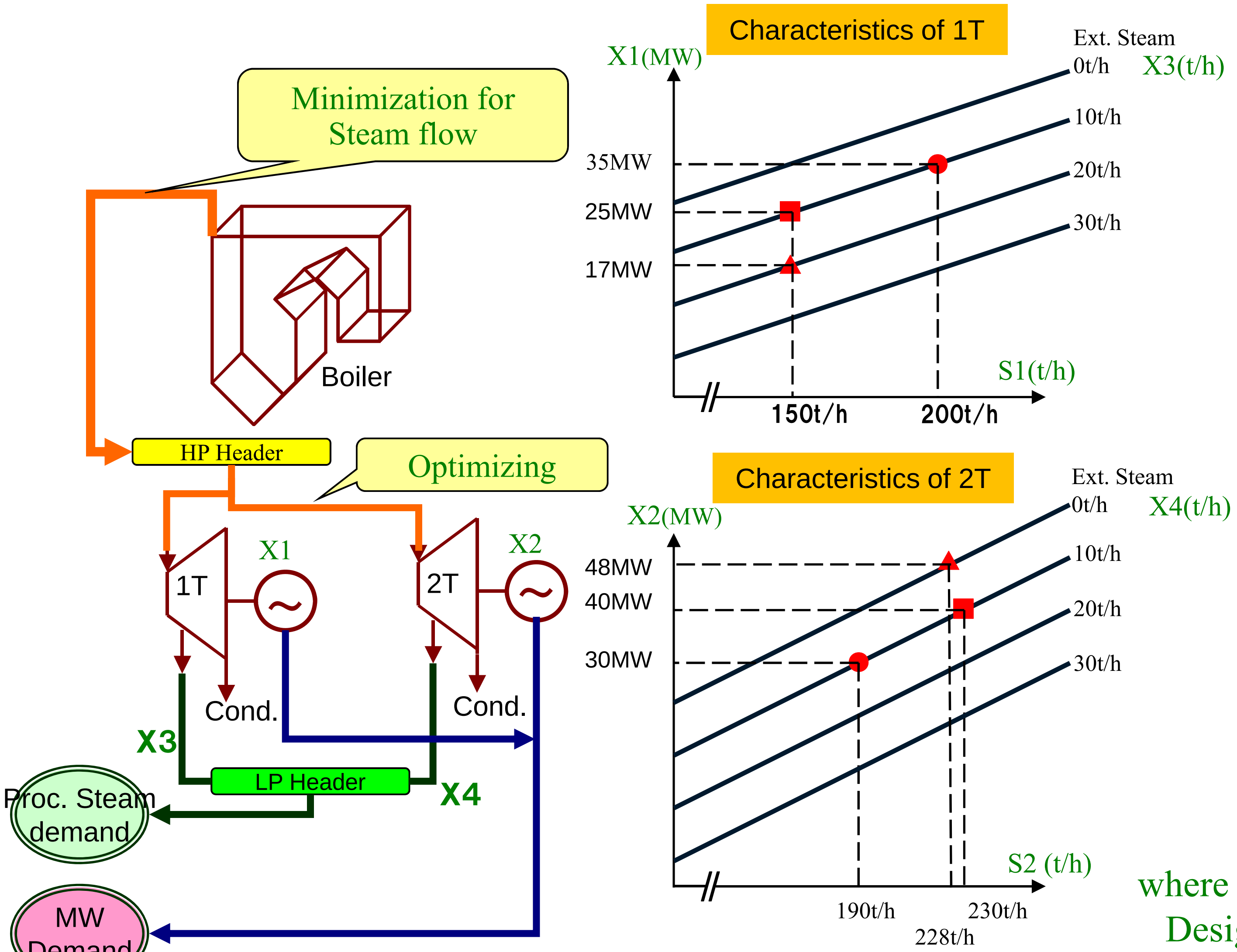

Figure 6. Calculation example of JOS.

Demand

MW = 65MW
Proc. Steam = 20t/h

Initial balance ●
Necessary Steam
= 390t/h

Optimizing

MW after optimizing ■
Necessary Steam
= 380t/h

Ext. steam aft. opt. ▲
Necessary Steam
= 378t/h

where
Design variable is X1～X4
Object function S1+S2

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(2) Proposal for Ulaanbaatar Power Station using JOS

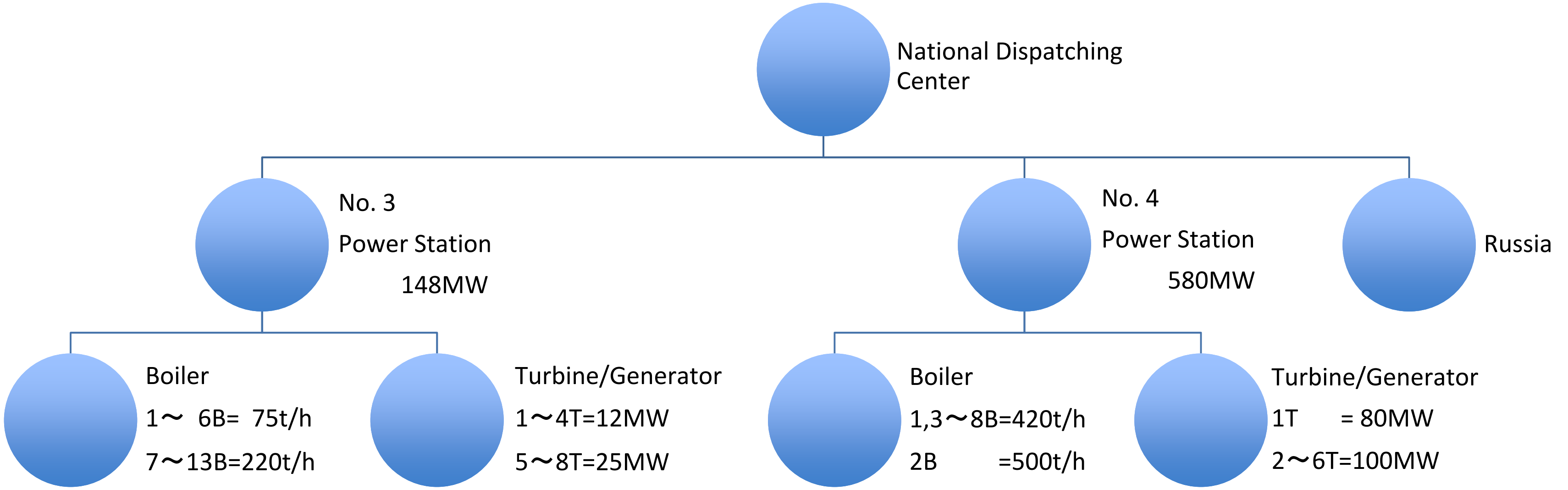

Figure 7. Ulaanbaatar power station.

- ***Problem***

  (1)The operation is manual for Turbine/generator. → The generating response is delay for the grid.

  (2)The boiler and turbine are not coordinated. → The plant is not stable by the mutual interference.

- ***Improvement***

  In order to stabilize steam pressure/temperature, improvement of boiler control itself should be required.

  (1)Stable and optimizing → (2)Reducing an over fuel → (3)Reducing the fuel cost and CO_2 emission

- ***Action***

  (1)The controller of Boilers and turbines should be improved using a proposed control method and a optimizing solver.

  (2)The power plant shall be optimized to minimization of total energy using JOS.

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◆Optimizing item

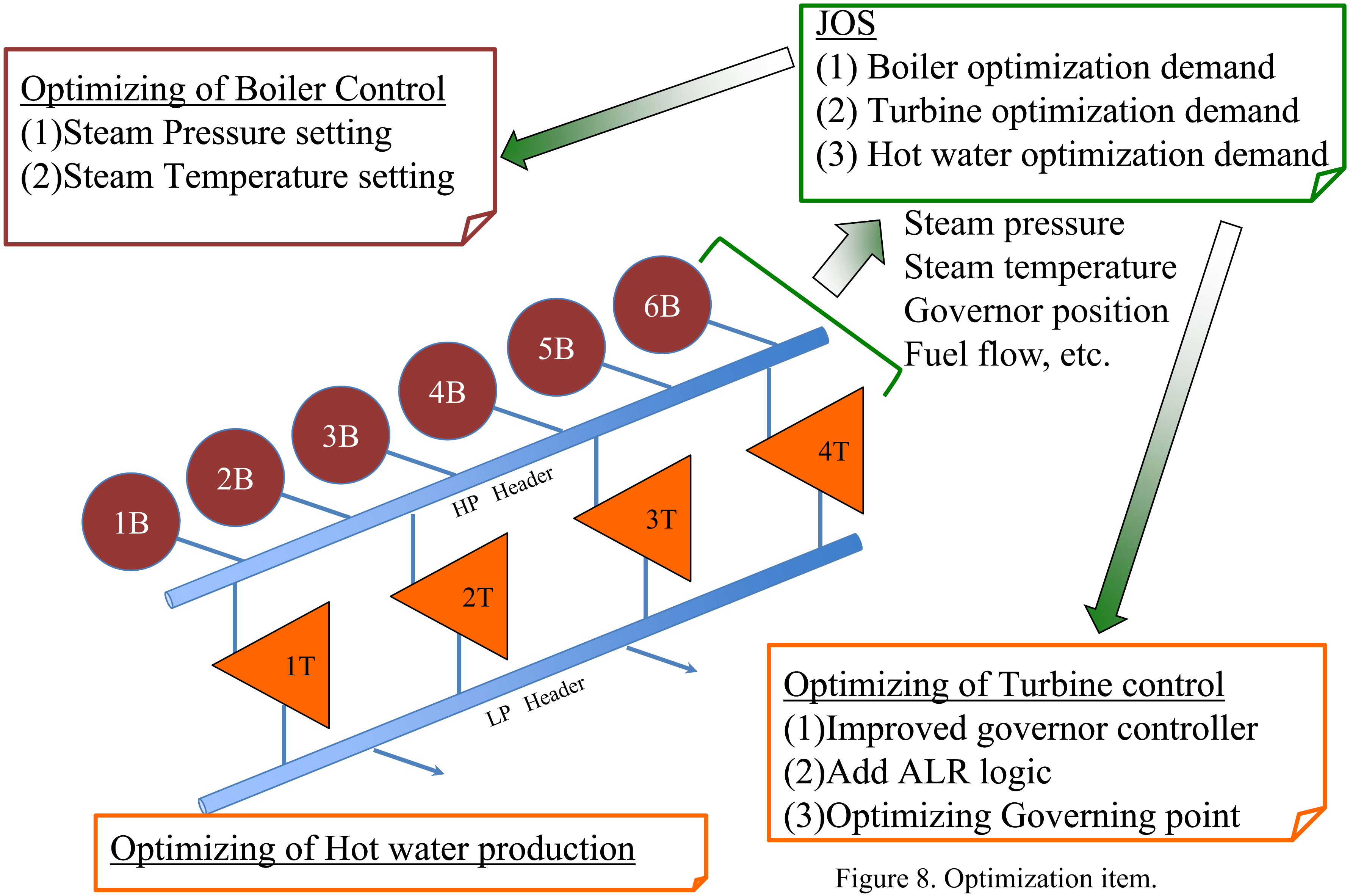

Figure 8. Optimization item.

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◆ALR & MW Optimizing

ALR operation using optimizing solver

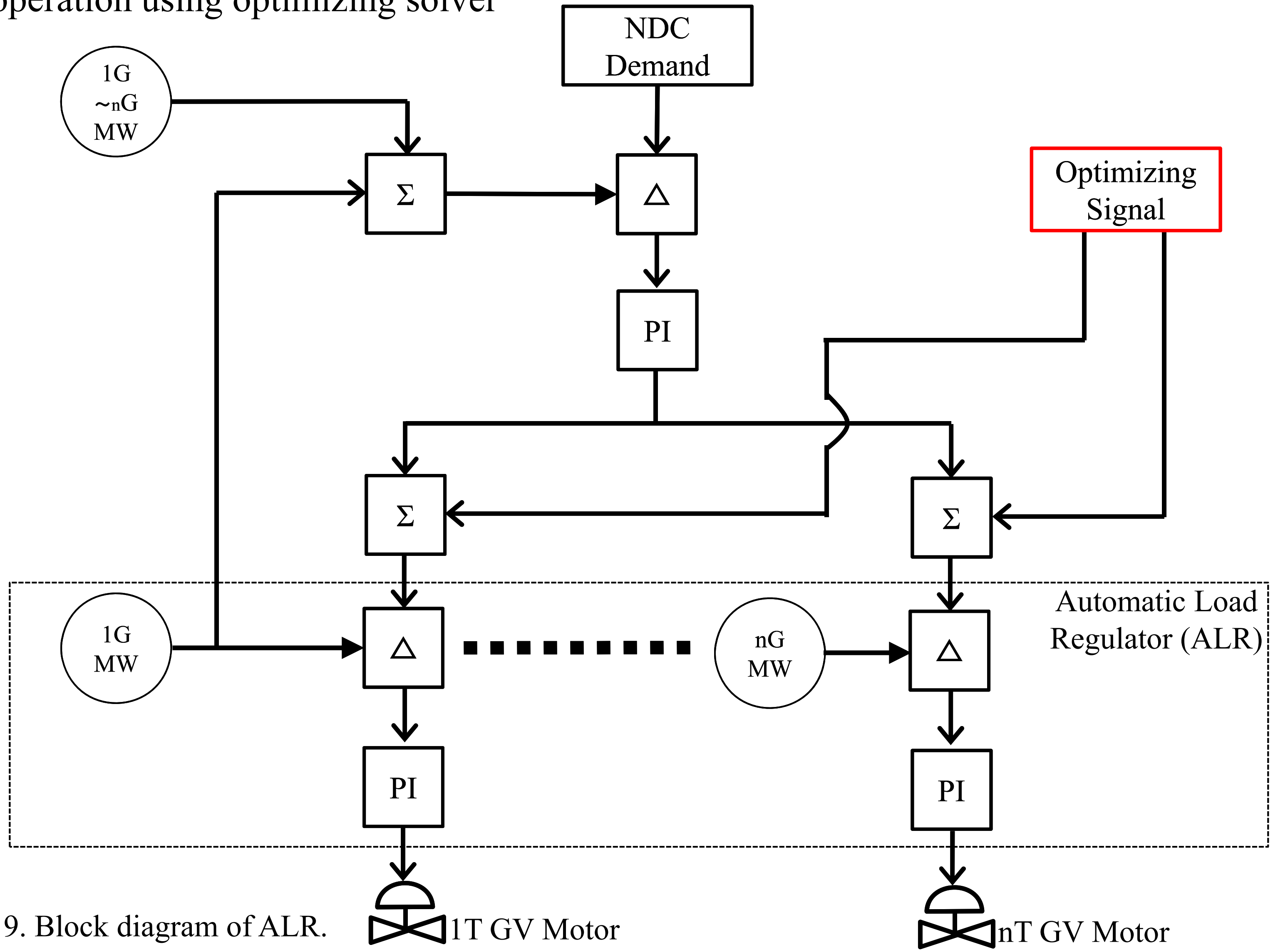

Figure 9. Block diagram of ALR.

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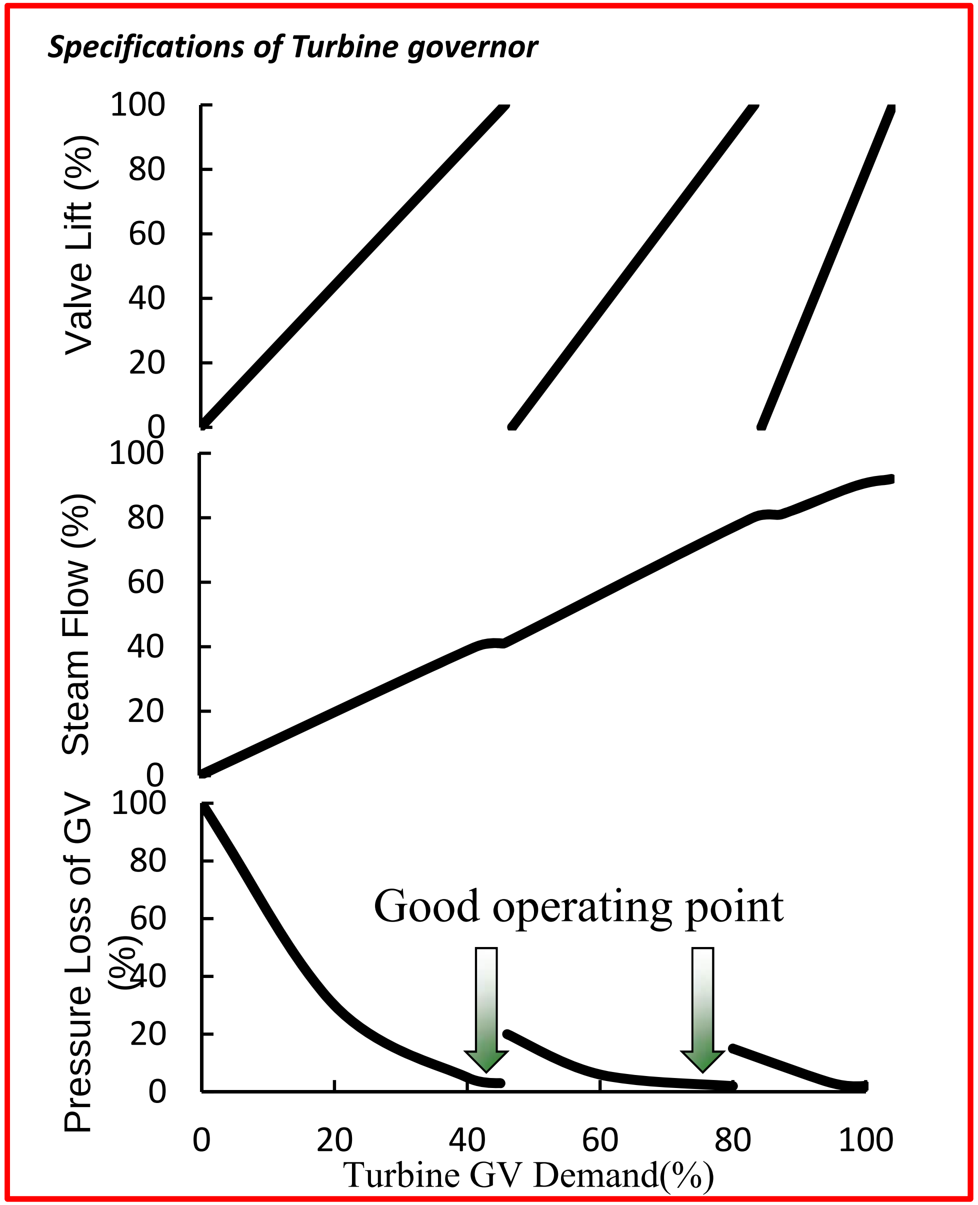
◆Turbine Optimizing(1/3)



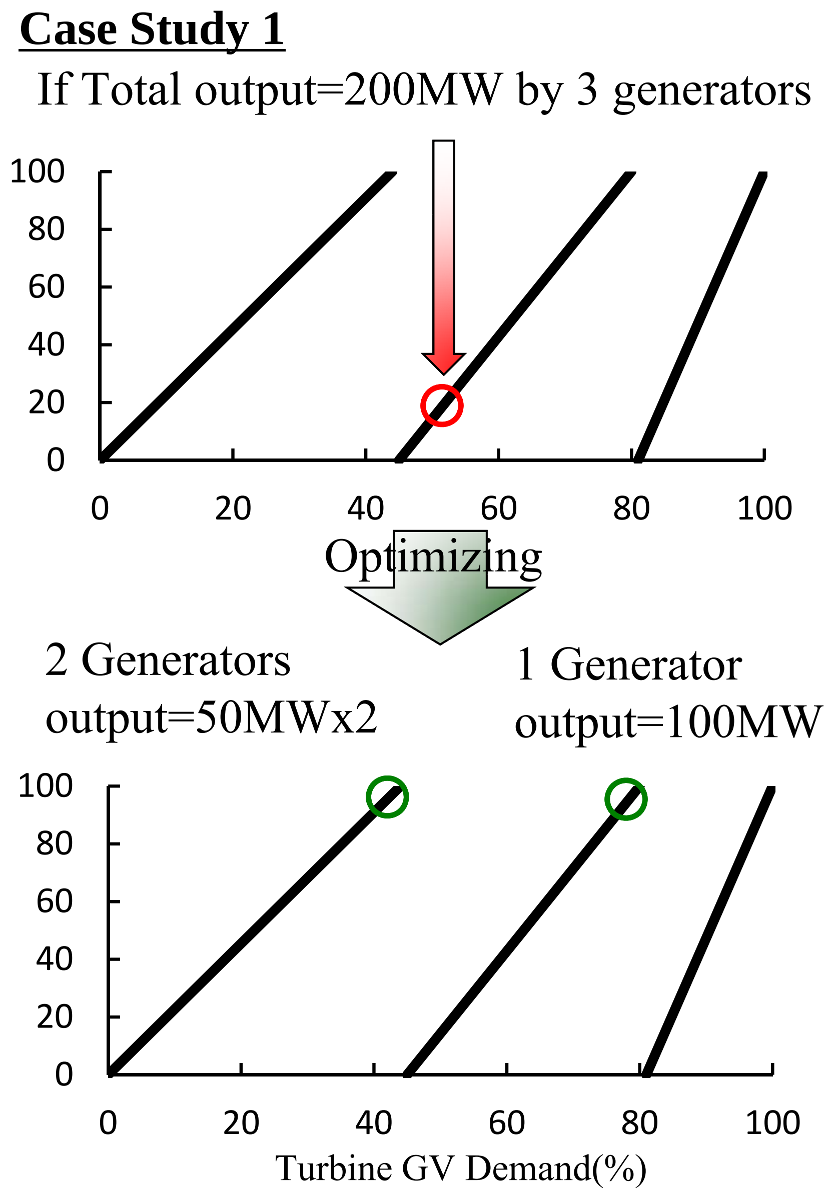


Figure 10. Turbine optimizing.

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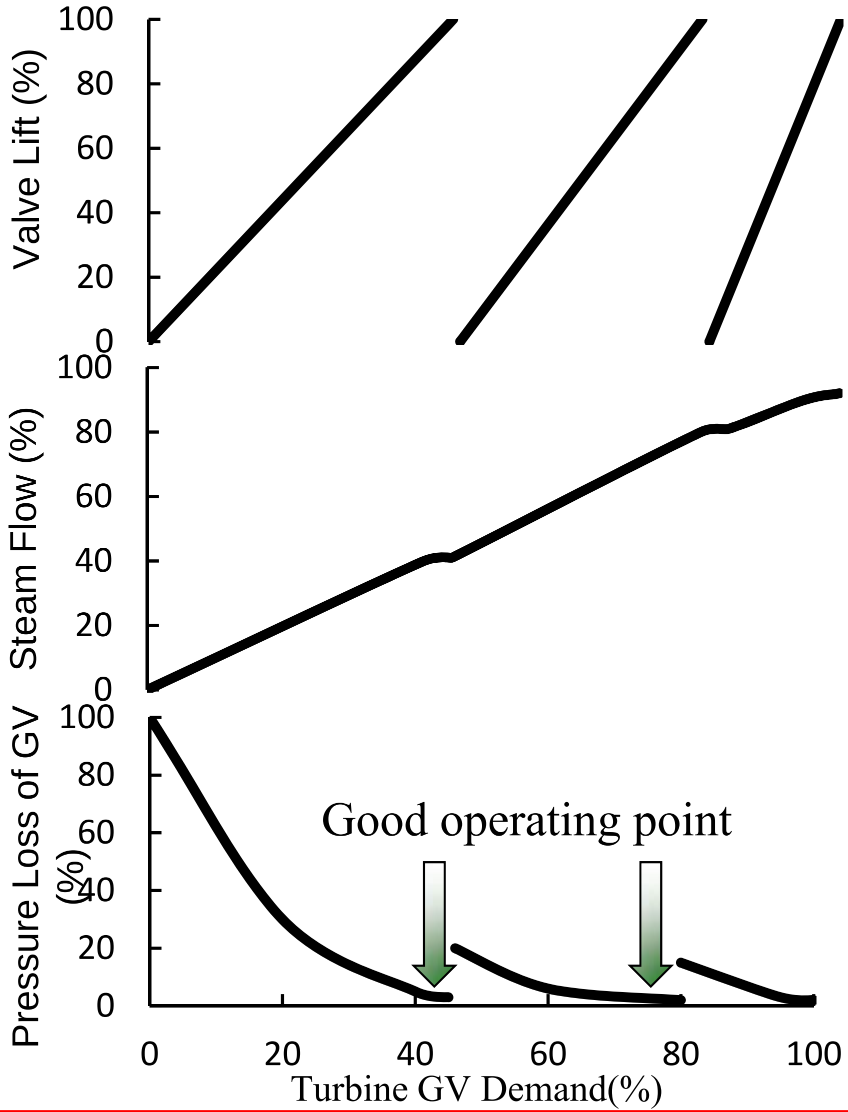
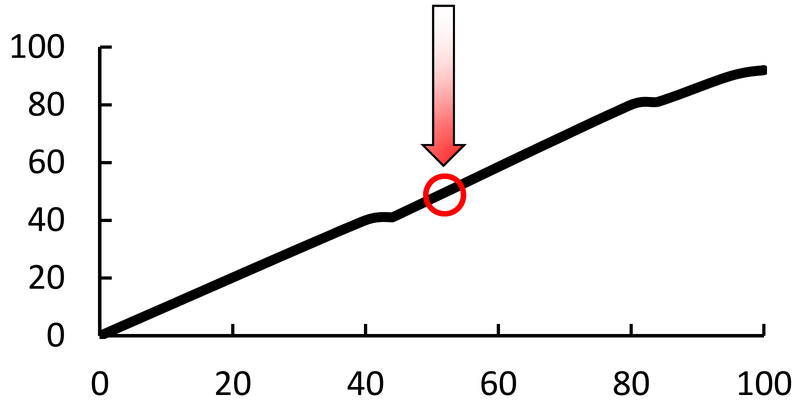
◆Turbine Optimizing(2/3)

Specifications of Turbine governor



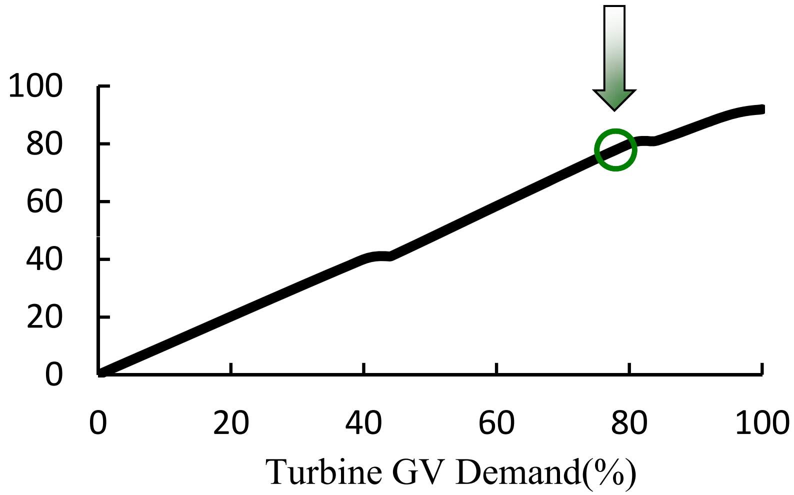
Case Study 2

If Total output=200MW by 3 generators



Optimizing

Reducing turbines inlet pressure set point



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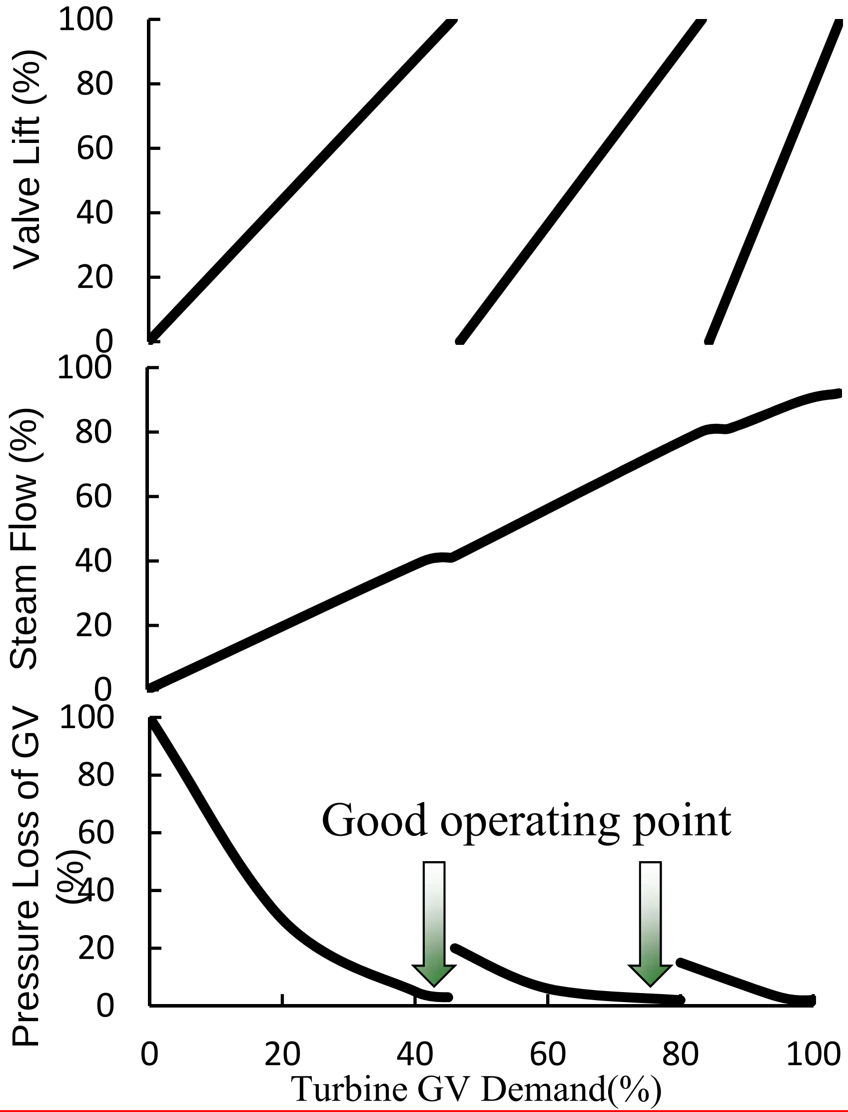
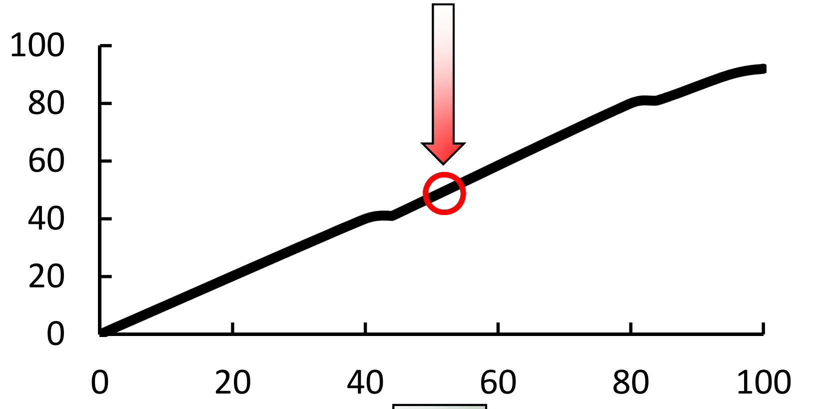
◆Turbine Optimizing(3/3)

Specifications of Turbine governor



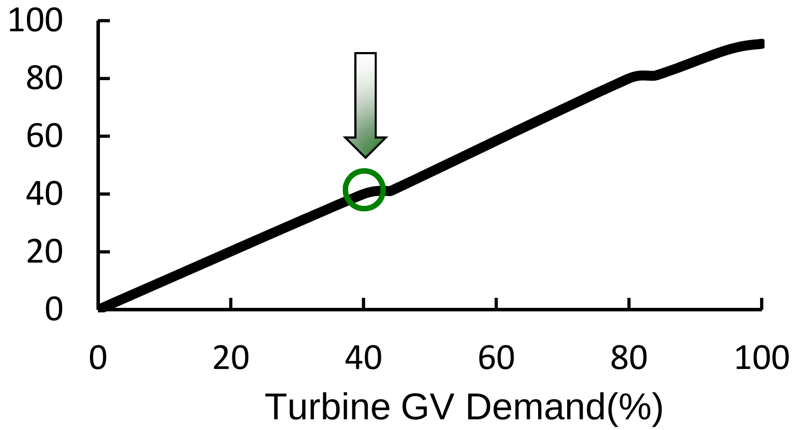
Case Study 3

If Total output=200MW by 3 generators



Optimizing

Increase turbines inlet temperature set point



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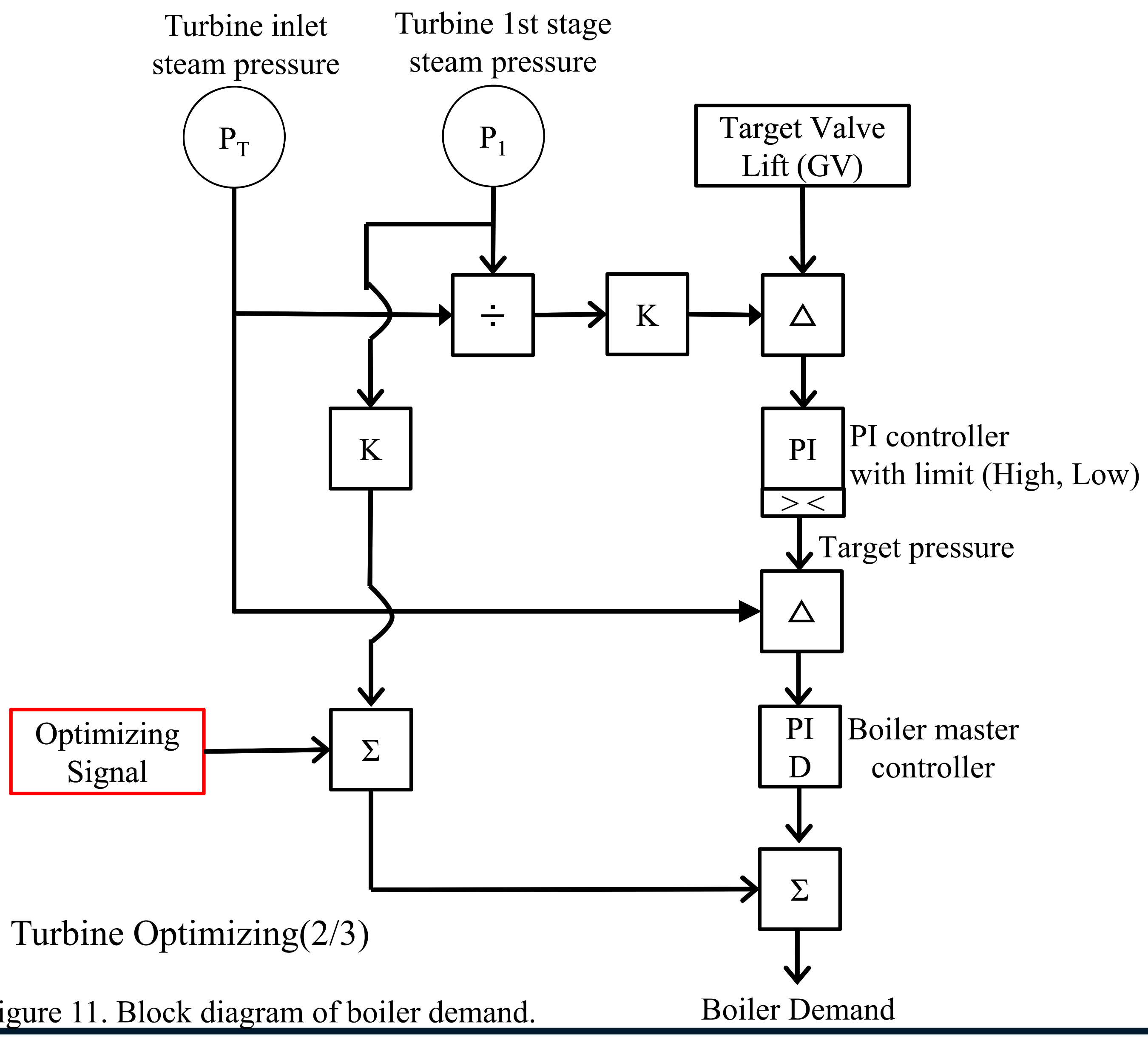
◆Boiler Demand & Optimizing



※Ex. Turbine Optimizing(2/3)

Figure 11. Block diagram of boiler demand.

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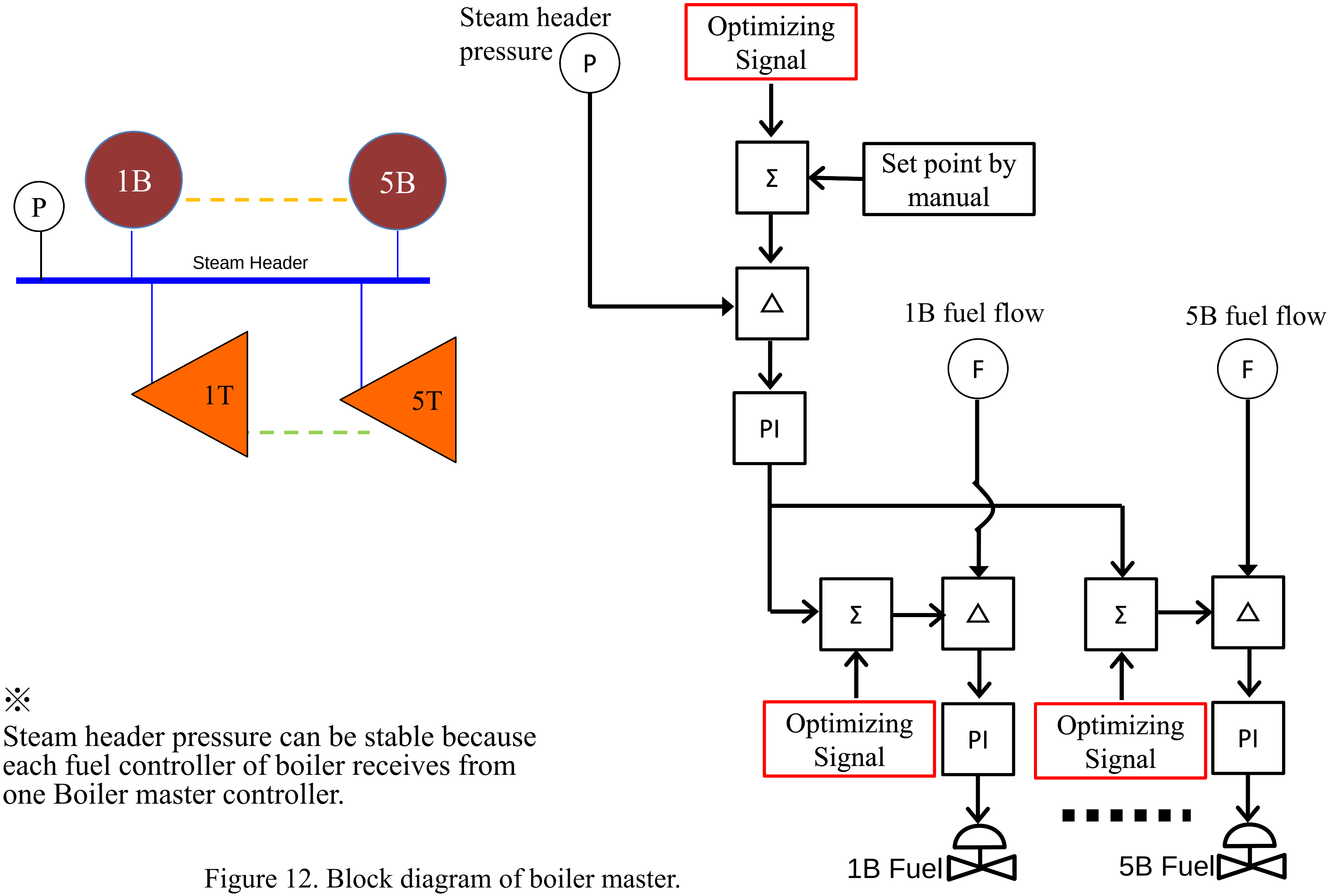
◆Boiler Master Controller & Optimizing



※
Steam header pressure can be stable because each fuel controller of boiler receives from one Boiler master controller.

Figure 12. Block diagram of boiler master.

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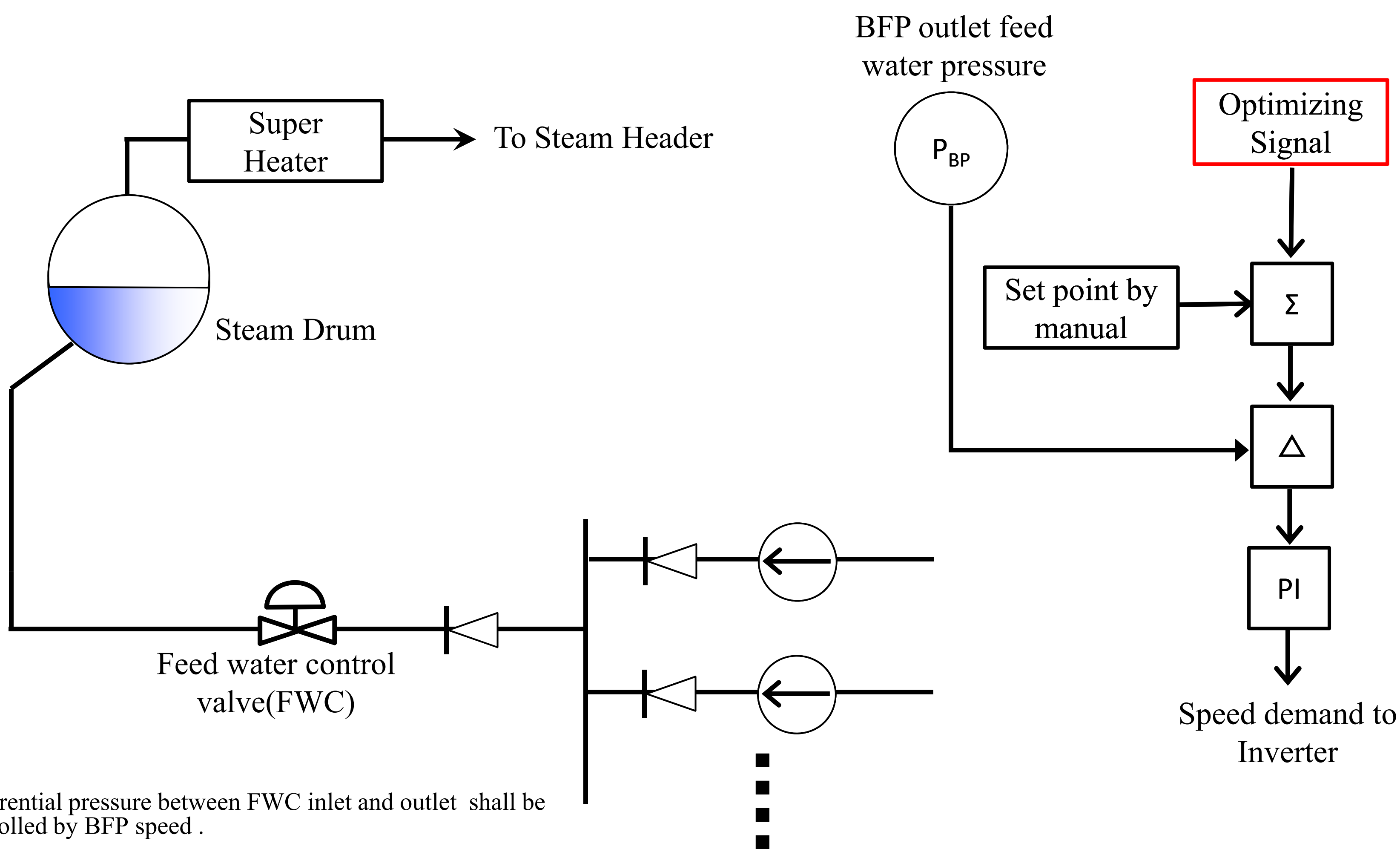
◆Boiler Feed Pump Inverter control & Optimizing



※
Differential pressure between FWC inlet and outlet shall be controlled by BFP speed .

FWC controls boiler drum level by using 1 element or 3elements signal .

Figure 13. Block diagram of BFP inverter control.

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◆Conclusions

The Plant shall be optimized to minimization of total energy using JOS.

- ◆ The manager can predict total cost using offline mode.
- ◆ The operator can get the most economical and safety operation using online mode.

Investigation of the following characteristics,

(1)Turbine mass/heat balance

(2)Characteristics of Turbine GV

(3)Boiler mass/heat balance

(4)Fuel consumptions and cost

(4)BFP Q−H characteristics

(5)FW CV, flow, diff. Press., position, etc.

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