ADVANCED PROCESS MODELLING FORUM
LONDON
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gPROMS Utilities

Online utility optimisation for chemical parks

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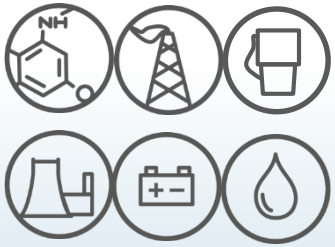
gPROMS product family

A family of advanced process modelling environments built on the gPROMS platform

"Vapour-liquid process world"



g|PROCESS gPROMS ProcessBuilder	Process gMLs, AMLs
g|WATER	Water MLs
g|UTILITIES	Utilities MLs
g|CCS	CCS MLs
g|POWER	Power MLs
g|OILFIELD	Oilfield MLs

"Formulated products world"

g|FORMULATE

gPROMS FormulatedProducts

Crystallization MLs	**g|CRYSTAL**
Solids MLs	**g|SOLIDS**
Oral absorption MLs	**g|COAS**
g|FLARE *	Flare & depressurisation MLs
g|FUELCELL	Fuel cell AMLs

General mathematical modelling

g|MODEL

gPROMS ModelBuilder provides essentially the full platform functionality

The gPROMS platform

Equation-oriented modelling & solution engine

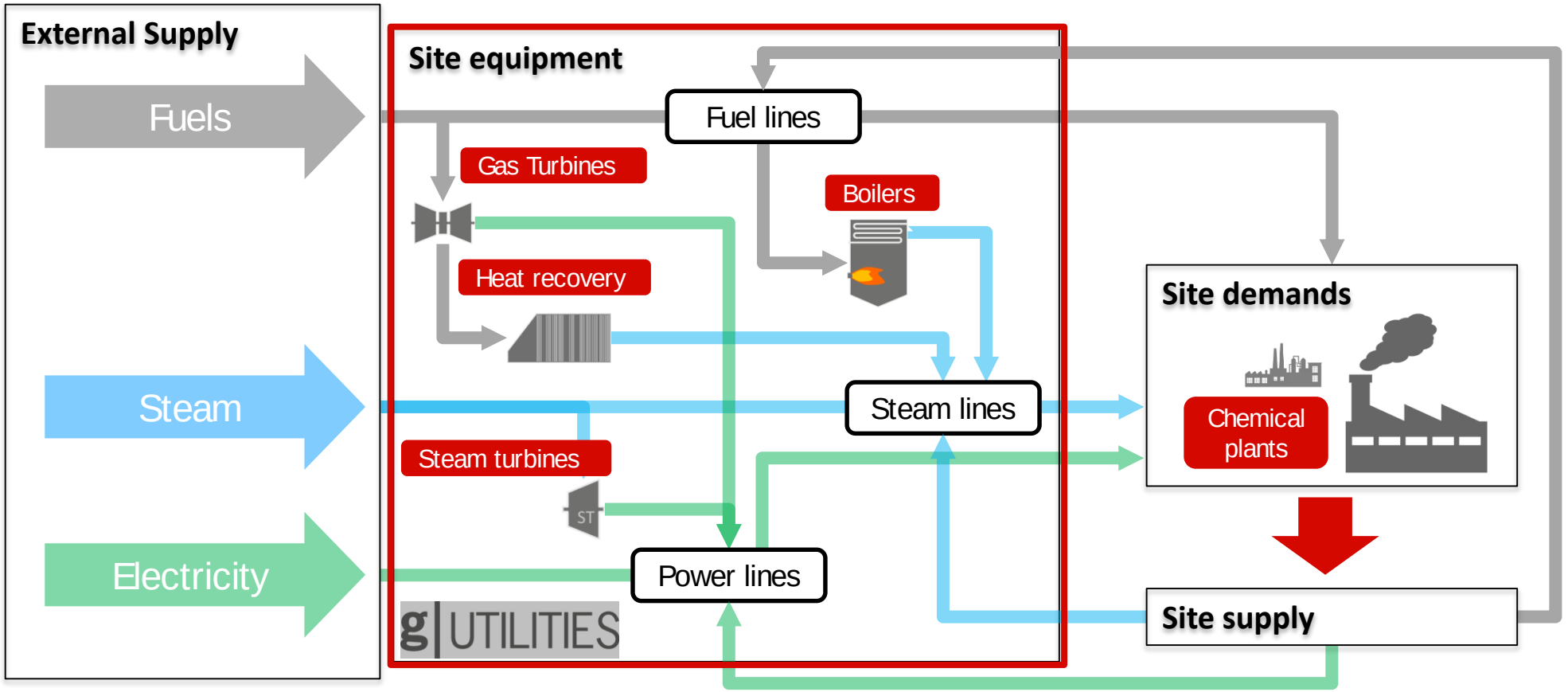
* Primarily used internally by PSE for delivery of services

Utility management

Aim

- Tens to hundreds of plants covering areas several km^2, each requiring fuel, steam at various pressures and / or electricity
- Utility management must ***predict and meet all demands simultaneously***, and deal with upsets.
- The objective is to ***minimise overall cost***

Options



- The key is how to manage the options available in the most cost effective way
- While meeting all constraints of the system

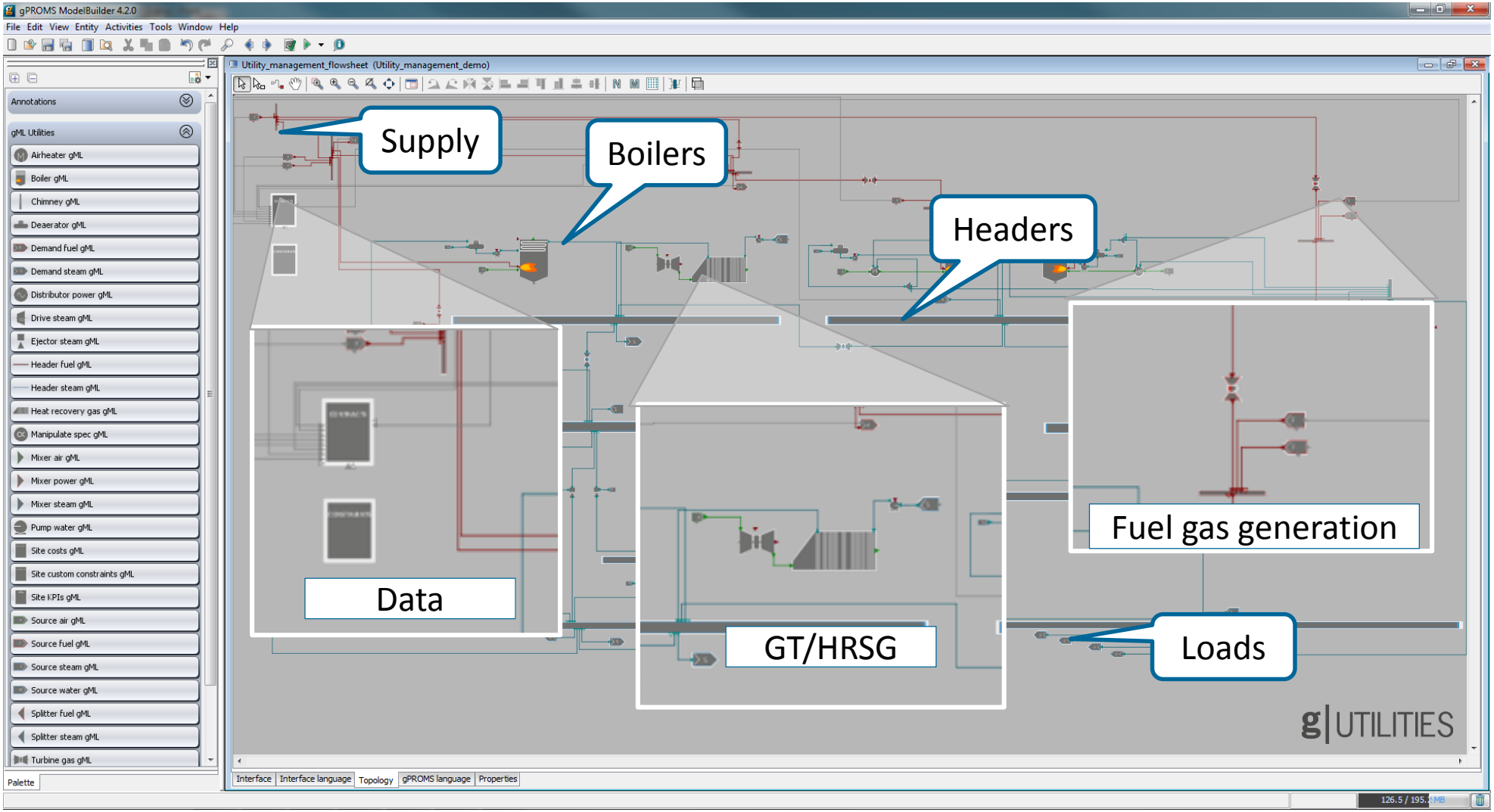
Constraints

- Location
  - Sites are very large
  - Logistical difficulties moving fuel & steam around
  - ***Fuel produced by plant X must be consumed in boiler Y***
- Losses
  - Some headers are very long with multiple inlets and outlets
  - Want to keep steam flowing in same direction to avoid issues w/ pressure & condensation
  - ***Unless header is isolated, ensure flows > F_{min}***
- Backup
  - Lots of plants on site: upsets happen!
  - Need to ensure a trip or surge at plant X does not cause interruption to plant Y
  - ***Maintain a minimum steam reserve***

Optimisation tools

Flowsheeting

Engineer view



Optimisation

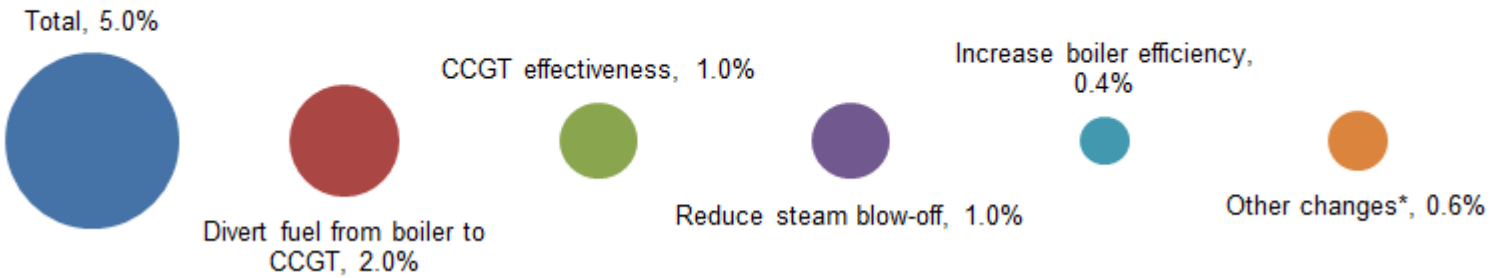
- Controls
  - Unit availability (on, off or available)
  - Unit operating range (between F_{min} and F_{max})
  - Expect 10-50 such units

- Constraints
  - Unit operating range (between F_{min} and F_{max})
  - Custom equations (spinning reserve, geographical constraints)
  - Expect 10-50 units + 0-10 custom equations

- Objective
  - Total cost = ∑ fuel cost + ∑ steam cost + ∑ electricity cost

Online advice

Read Tag values → *Run Optimisations* → *Display advice*



Boiler Management

	Current	Optimum
Boiler A	60	OFF
Boiler B	OFF	50
Boiler C	60	50
Boiler D	OFF	OFF

CCGT

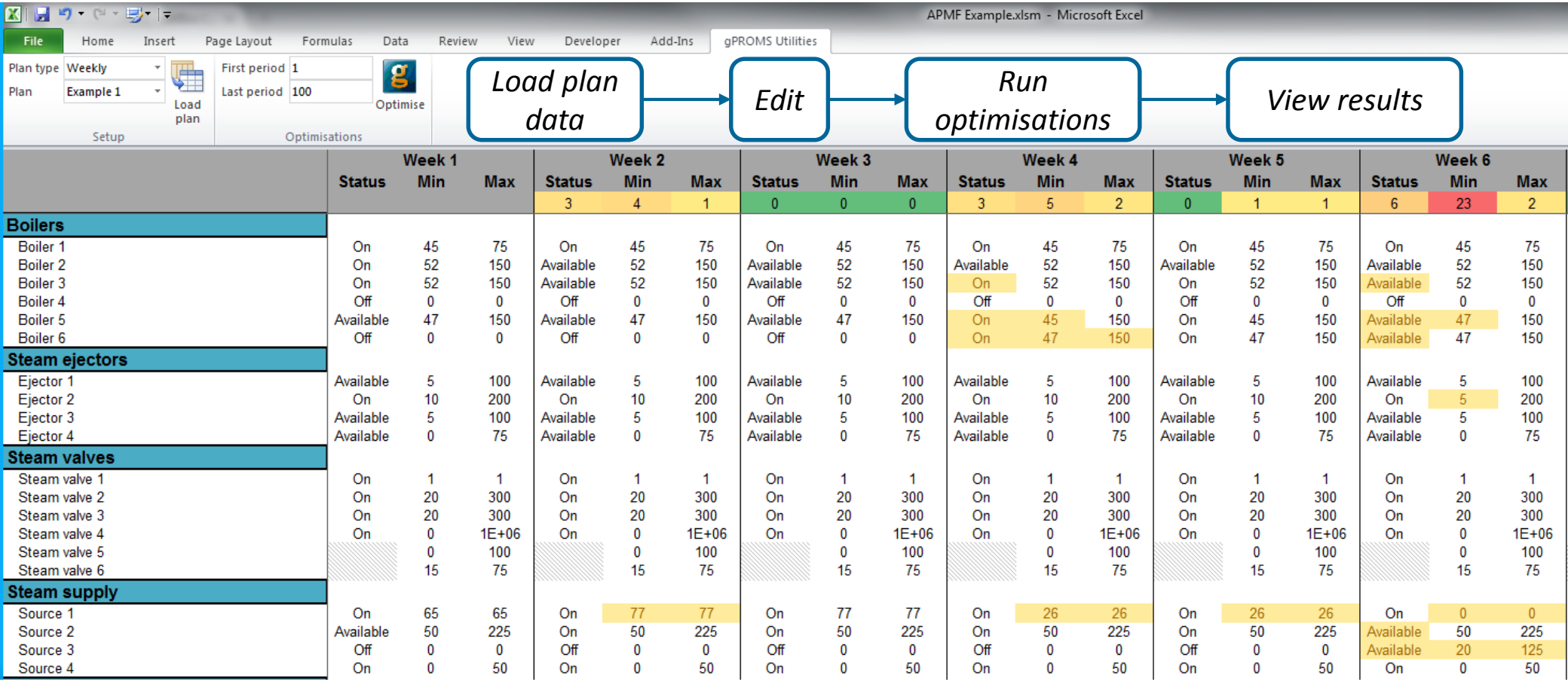
	Current	Optimum
GT Load	60	80
Duct firing	ON	ON
HP steam use	150	120
MP steam use	0	30
ST power	50	60

Hourly charges

	Current	Optimum
Fuel	£4,500	£4,600
Steam	£2,000	£1,750
Electricity	£500	£300
Total	£7,000	£6,650

- Display advice alongside current readings
- Prioritise: what makes the most difference to overall performance?

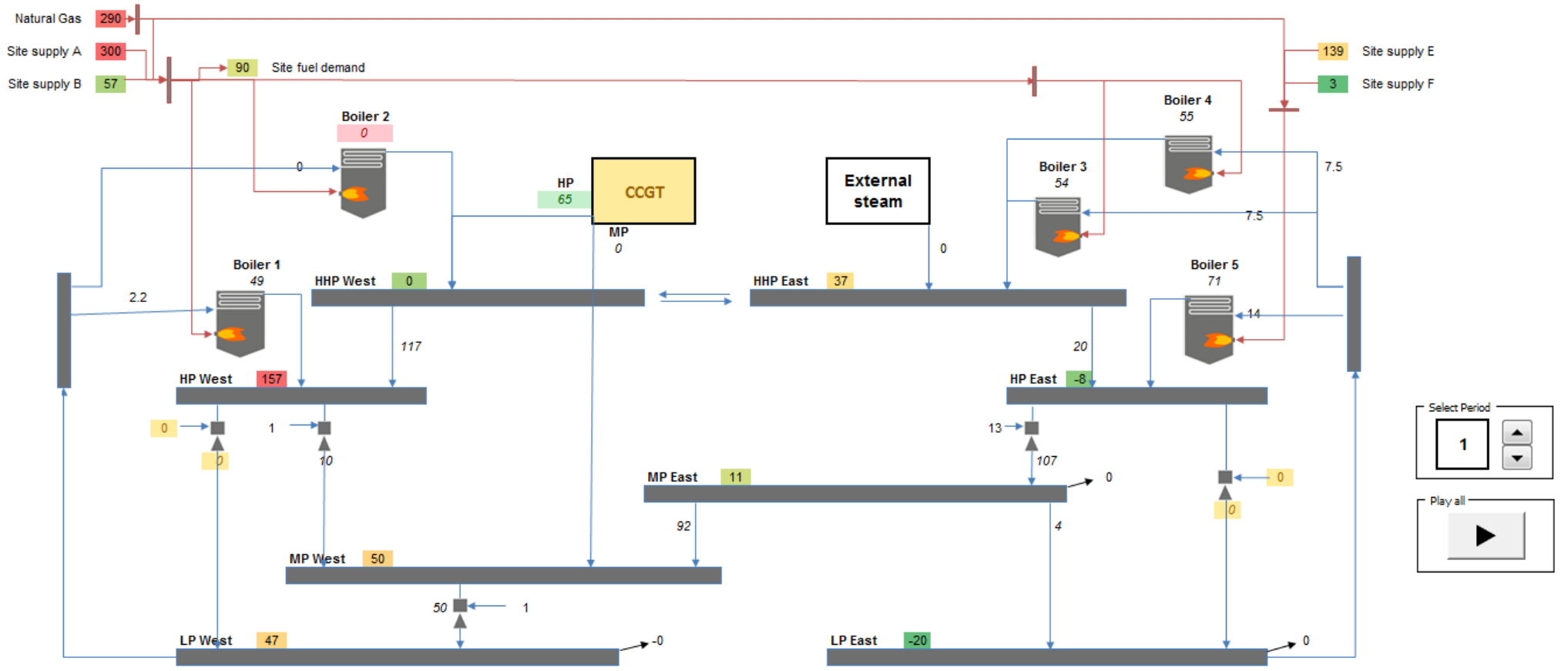
Scenario planning



	Week 1			Week 2			Week 3			Week 4			Week 5			Week 6		
	Status	Min	Max	Status	Min	Max	Status	Min	Max	Status	Min	Max	Status	Min	Max	Status	Min	Max
				3	4	1	0	0	0	3	5	2	0	1	1	6	23	2
Boilers																		
Boiler 1	On	45	75	On	45	75	On	45	75	On	45	75	On	45	75	On	45	75
Boiler 2	On	52	150	Available	52	150	Available	52	150	Available	52	150	Available	52	150	Available	52	150
Boiler 3	On	52	150	Available	52	150	Available	52	150	On	52	150	On	52	150	Available	52	150
Boiler 4	Off	0	0	Off	0	0	Off	0	0	Off	0	0	Off	0	0	Off	0	0
Boiler 5	Available	47	150	Available	47	150	Available	47	150	On	45	150	On	45	150	Available	47	150
Boiler 6	Off	0	0	Off	0	0	Off	0	0	On	47	150	On	47	150	Available	47	150
Steam ejectors																		
Ejector 1	Available	5	100	Available	5	100	Available	5	100	Available	5	100	Available	5	100	Available	5	100
Ejector 2	On	10	200	On	10	200	On	10	200	On	10	200	On	10	200	On	5	200
Ejector 3	Available	5	100	Available	5	100	Available	5	100	Available	5	100	Available	5	100	Available	5	100
Ejector 4	Available	0	75	Available	0	75	Available	0	75	Available	0	75	Available	0	75	Available	0	75
Steam valves																		
Steam valve 1	On	1	1	On	1	1	On	1	1	On	1	1	On	1	1	On	1	1
Steam valve 2	On	20	300	On	20	300	On	20	300	On	20	300	On	20	300	On	20	300
Steam valve 3	On	20	300	On	20	300	On	20	300	On	20	300	On	20	300	On	20	300
Steam valve 4	On	0	1E+06	On	0	1E+06	On	0	1E+06	On	0	1E+06	On	0	1E+06	On	0	1E+06
Steam valve 5		0	100		0	100		0	100		0	100		0	100		0	100
Steam valve 6		15	75		15	75		15	75		15	75		15	75		15	75
Steam supply																		
Source 1	On	65	65	On	77	77	On	77	77	On	26	26	On	26	26	On	0	0
Source 2	Available	50	225	On	50	225	On	50	225	On	50	225	On	50	225	Available	50	225
Source 3	Off	0	0	Off	0	0	Off	0	0	Off	0	0	Off	0	0	Available	20	125
Source 4	On	0	50	On	0	50	On	0	50	On	0	50	On	0	50	On	0	50

- Load information from SQL database (optional)
- Configure and run *n* periods

Scenario planning



- Execute *n* gPROMS MINLP optimisations (max 10s per case)
- Returns information to interface for viewing

Industrial use case

Experience

- DSM have over 10 years experience in developing and using models for Utility Optimisation

- Key criteria:

Site

- Options to chose which utility to use
- Options to convert utilities
- Complexity

Model

- Include all major “managed” equipment related to utility provision
- Solution easy to manage & deploy
- Fast, robust and reliable optimisation

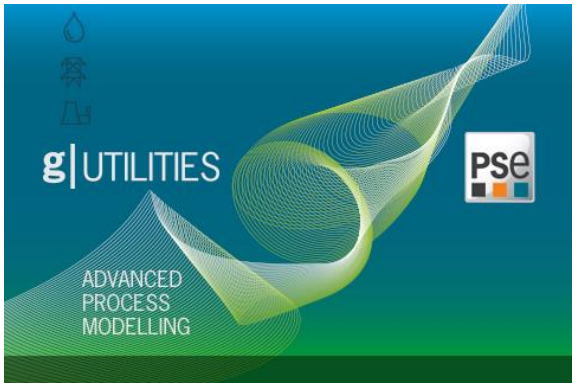
Practical uses

- Long-term strategic planning (years)
  - Budgeting
  - Contract evaluation/negotiation
  - Evaluation of future investments
- Short-term tactical planning (months)
  - meet contractual commitments
  - observe (equipment) maintenance schedules
- Actual operational optimization to reduce daily/weekly/quarterly costs
  - Benefits:
    - 2-3% energy consumption for well-managed plants (~3-4% operating costs)
    - Up to 10-15% reduction of energy consumption for plants in emerging markets and/or less know-how

Benefits

- **Operation**
  - Optimum equipment on/off decisions
  - Optimum equipment load allocation (exploit differences in efficiency)
  - Reduced off gas flaring/steam venting
  - Ability to establish optimum operation fast (also after changes in utility loads or plant upsets)

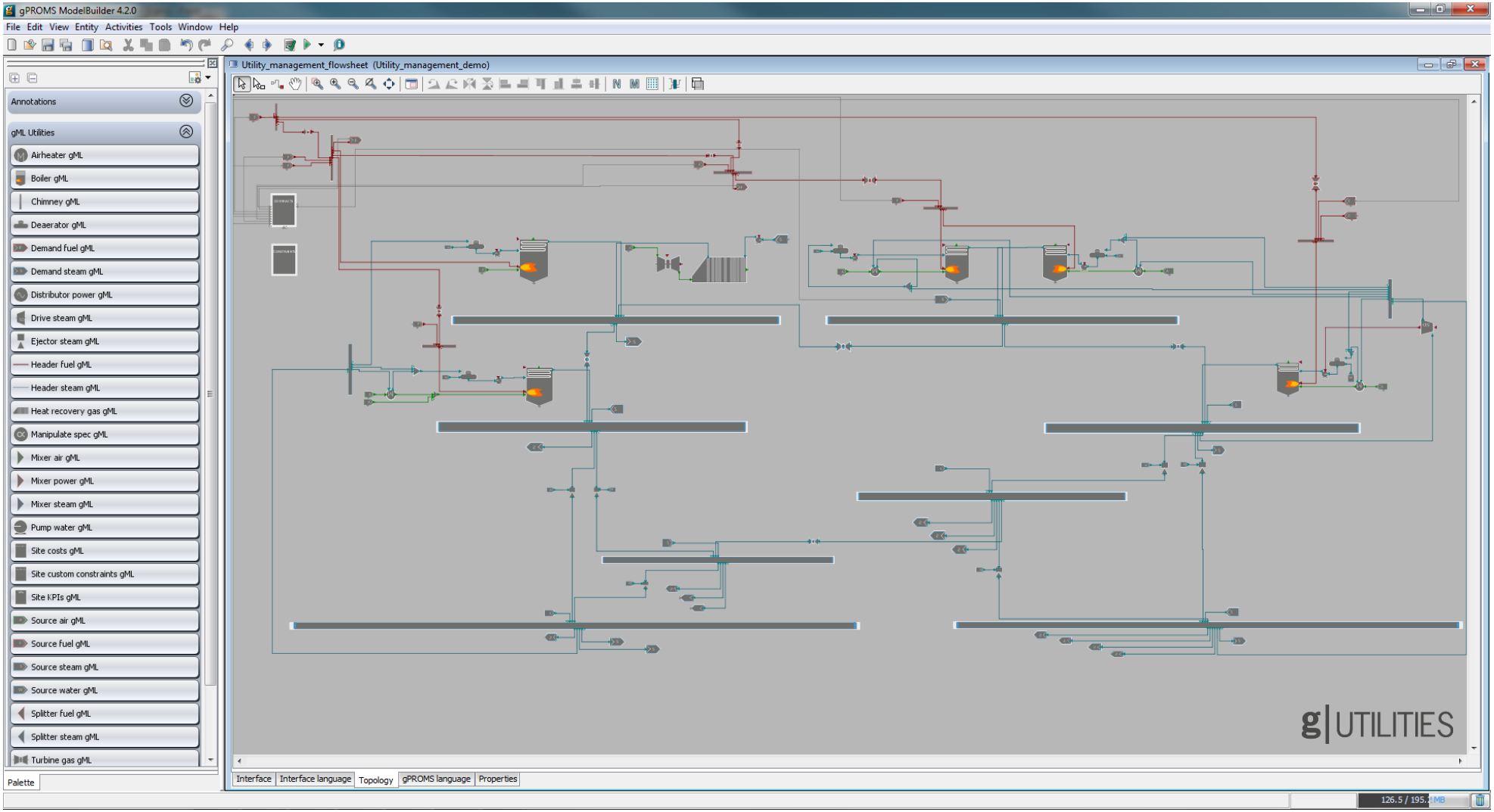
- **Management**
  - Utilities Contract Management
  - Maximize benefits from negotiating ‘special conditions’ for utility contracts
  - Effective equipment maintenance by improved performance monitoring



Thank you

Flowsheeting

Engineer view



Summary

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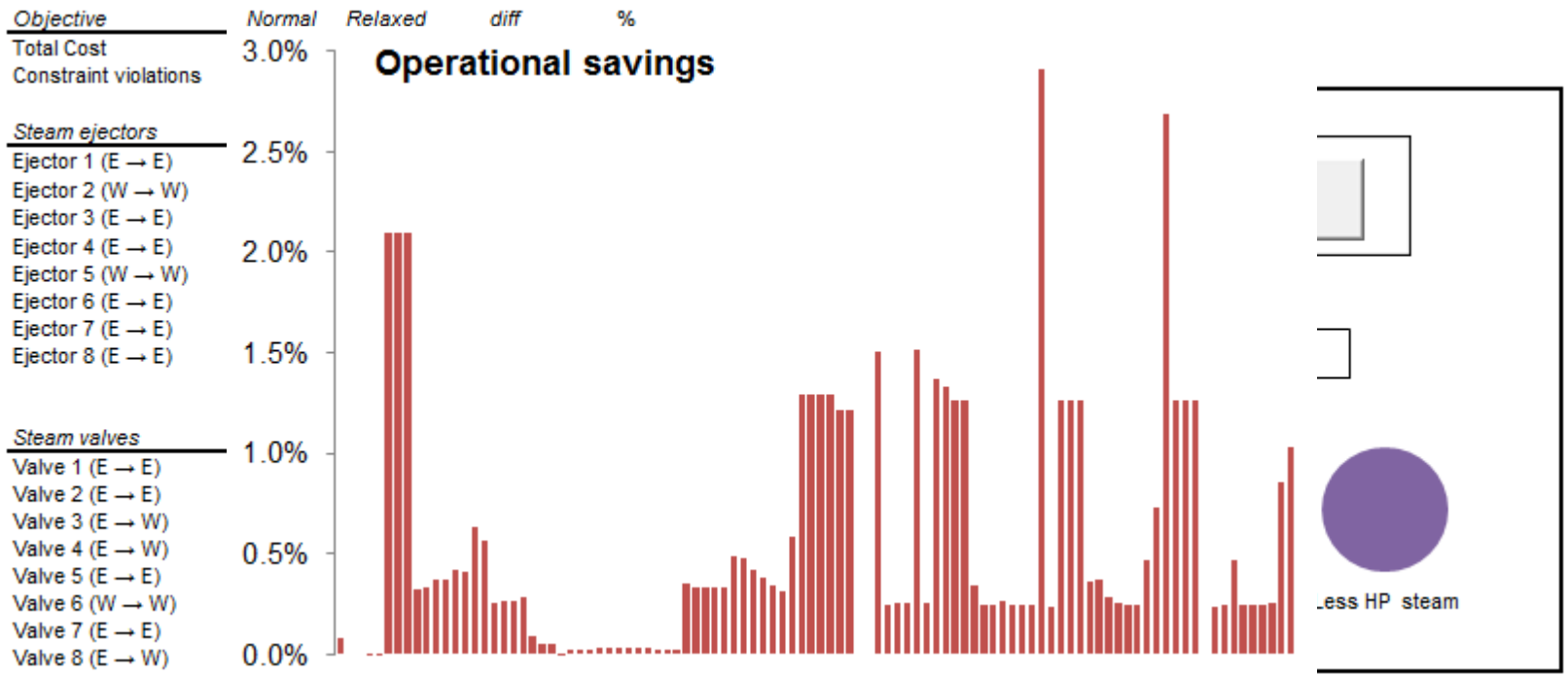
- Utility Management
  - Ensuring provision of utility demand across large chemical parks can be difficult and costly
  - Many options & constraints to consider
  - These and contracts are constantly varying

- Optimisation tools
  - gPROMS Utility optimiser developed jointly with DSM: currently finalising development
  - Model & optimise utility provision system, including supply & demand from individual plants, managed equipment and imported utilities
  - Link via interface to model database and/or directly to data historian

- Industrial use case
  - Key to carry out an initial assessment on site suitability
  - Optimiser valuable for both short term and long term planning
  - Significant savings are possible with respect to both managerial (e.g. contract negotiation) and operational (e.g. reduced blow-off) costs

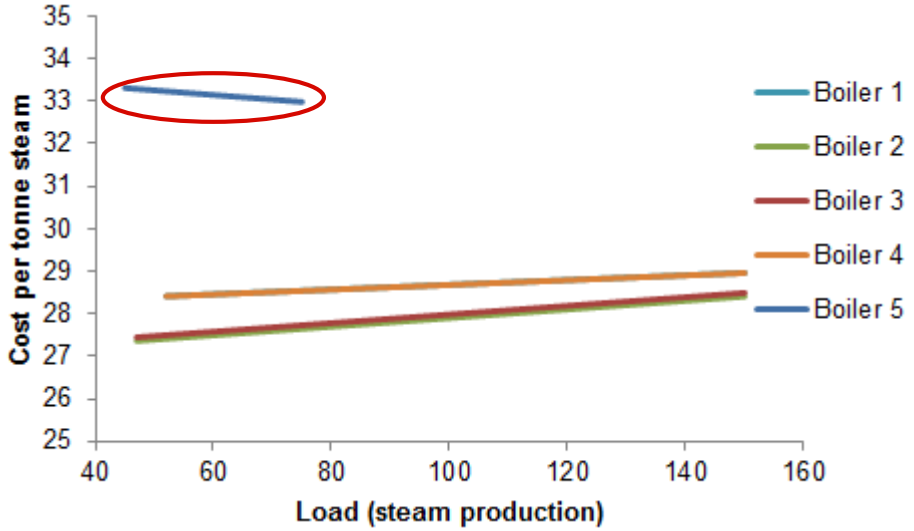
Analysis: route constraints



- Cheaper steam often not used due to distribution constraints
- Solution: isolate some headers and valves in West to reroute more flow via East

Analysis: boiler selection

- Boiler comparison (typical Offgas availabilities):



- In general, boiler selection is limited in order to use Offgas from plants – especially in Boiler 5 which is much more expensive (350 £/hr more)
- Normal boiler operating costs *roughly* 80% fuel and 20% steam: balance between fuel and steam usage could be manipulated according to the current cost & availability