The Association of Energy Engineers

Saudi Chapter

Monday Dec 12 2022

7:00PM – 8:00PM

The AEE Saudi Chapter cordially invite you to attend a webinar on:

Power & Steam Generation Optimization for Industrial Facilities: Towards Decarbonization by 2050

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Power & Steam Generation Optimization for Industrial Facilities: Towards Decarbonization by 2050

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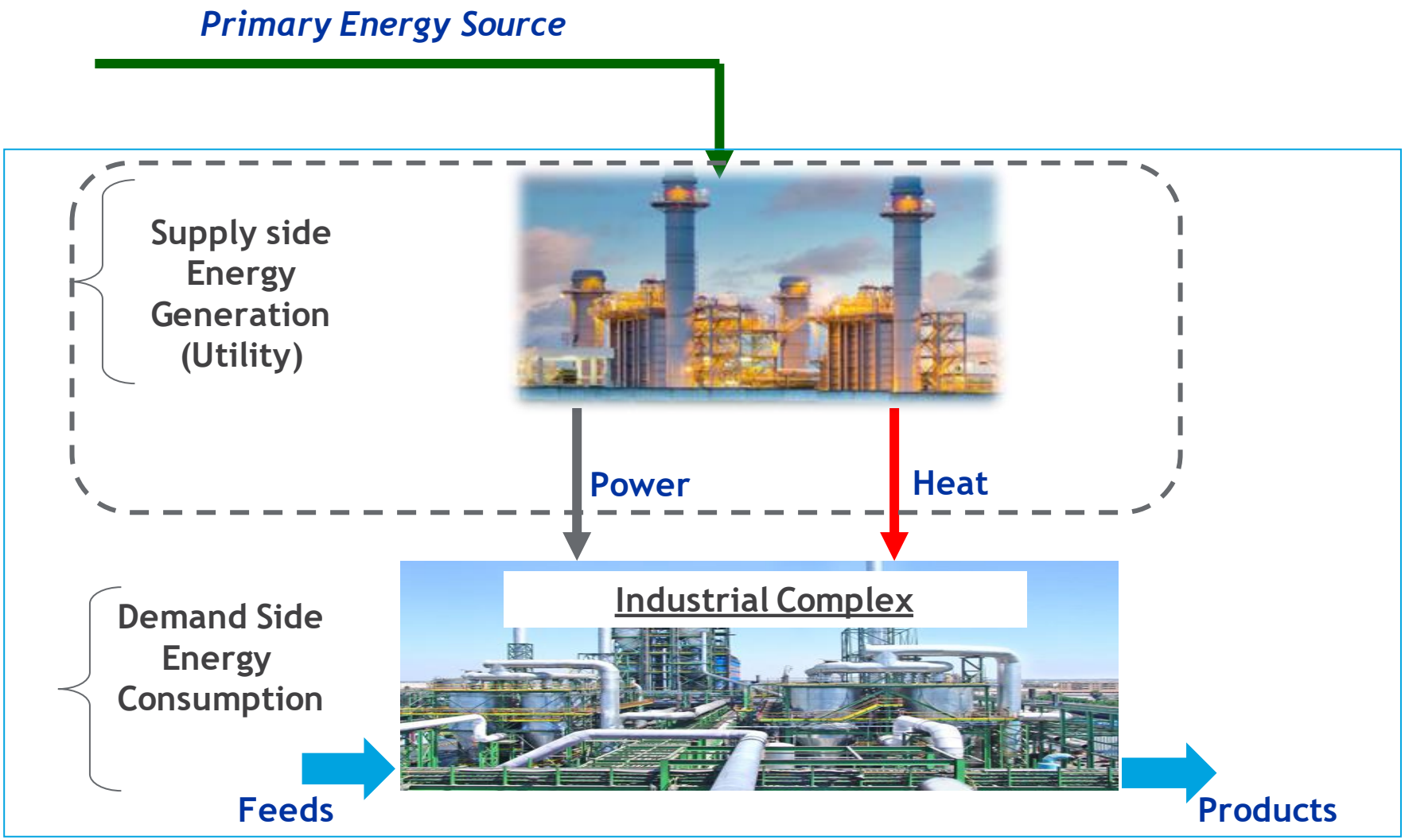
Energy Transition Engineering Department/ Energy Systems Division

where energy is opportunity™

Industrial Facility Energy Optimization



Outline:

- Conventional Power/Steam Generation Technologies
- Power/Steam Generation De-carbonization –Preliminary Road-map
- Existing Industrial facilities: "Operational Optimization"
  - Online CHP Optimization Solution – Single site
  - Online Optimization Solution – (Multiple sites Economic Dispatch)
- New Projects: "New Design Optimization"
  - CHP Model for Optimum design
- Summary and Conclusion

Conventional Power/Steam Generation Technologies

1

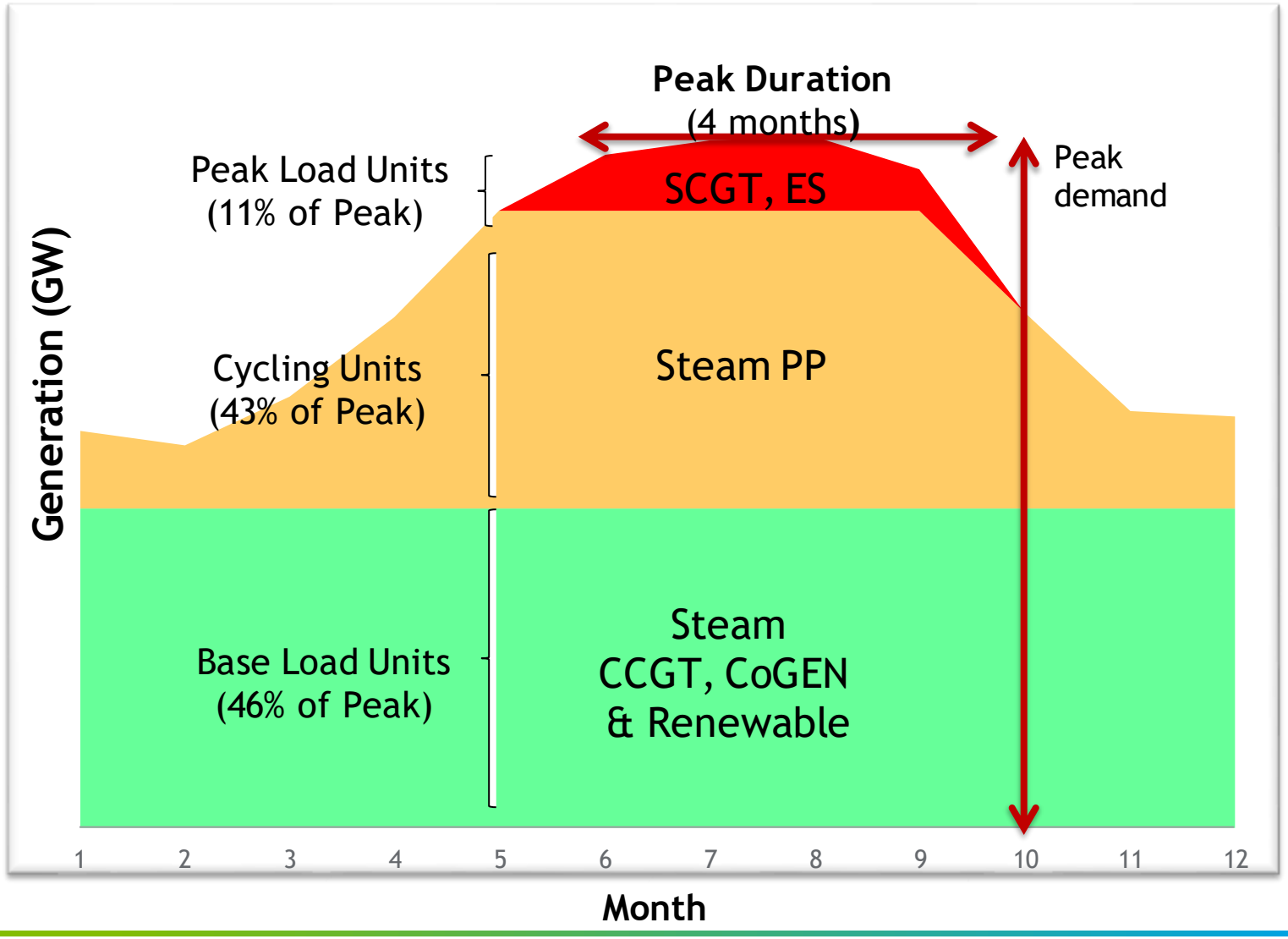
Common Conventional Power/Steam Generation:

- **Simple Cycle (SCGT):** Power generation technology using fuel to produce electric power while exhaust heat is lost.

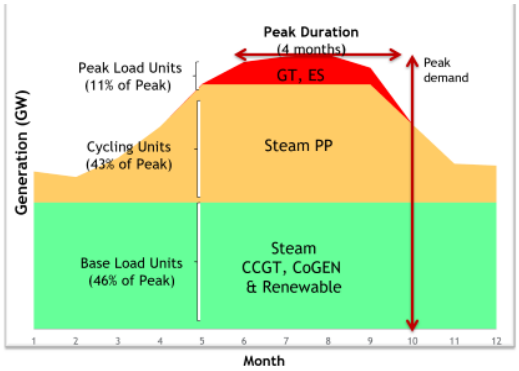
- **Combined Cycle (CCGT):** Power generation technology using fuel to produce electric power from two sides: Gas turbine side and Steam turbine side.

- **Cogeneration (CoGEN):** A technology that uses fuel to simultaneously produce two products (i.e. electric power and steam for process heating). Called Combined Heat & Power Technology (CHP).

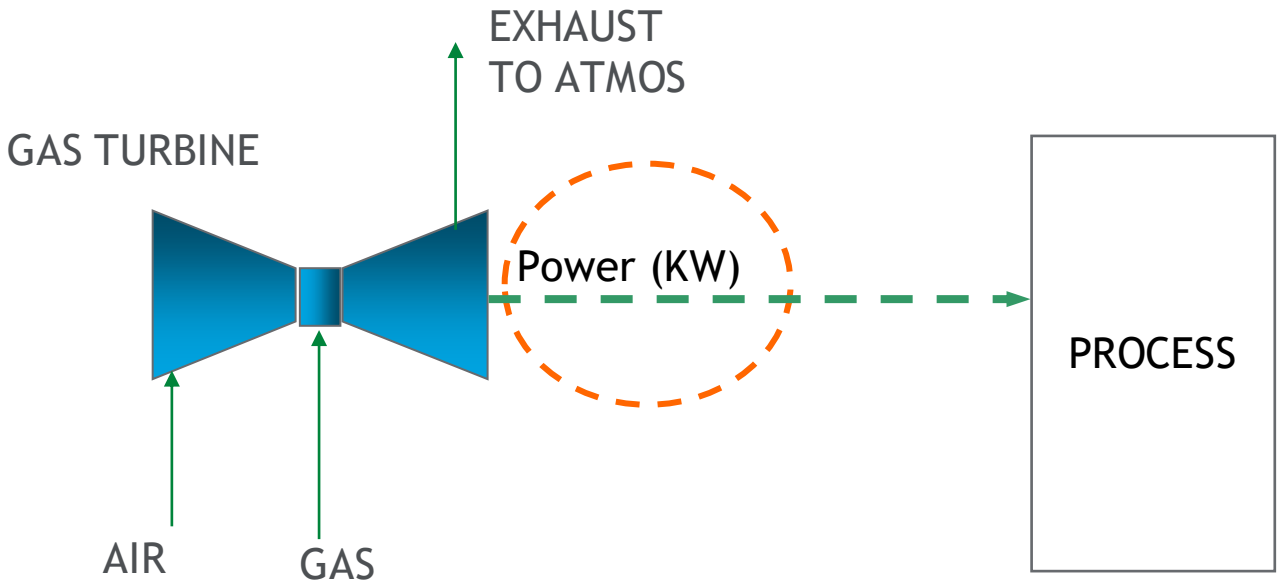
Power Demand Profile and Generation Mix:



Power Gen.: Simple Cycle- (SCGT)



HEAT IN GT EXHAUST IS WASTED



Positives:
- Quick response
- Used during peak

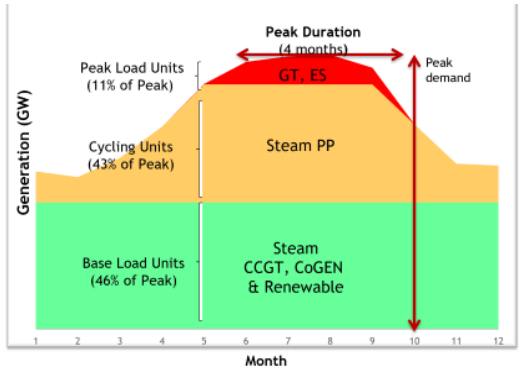
Negatives:
- Low efficiency
- High CO2 emissions

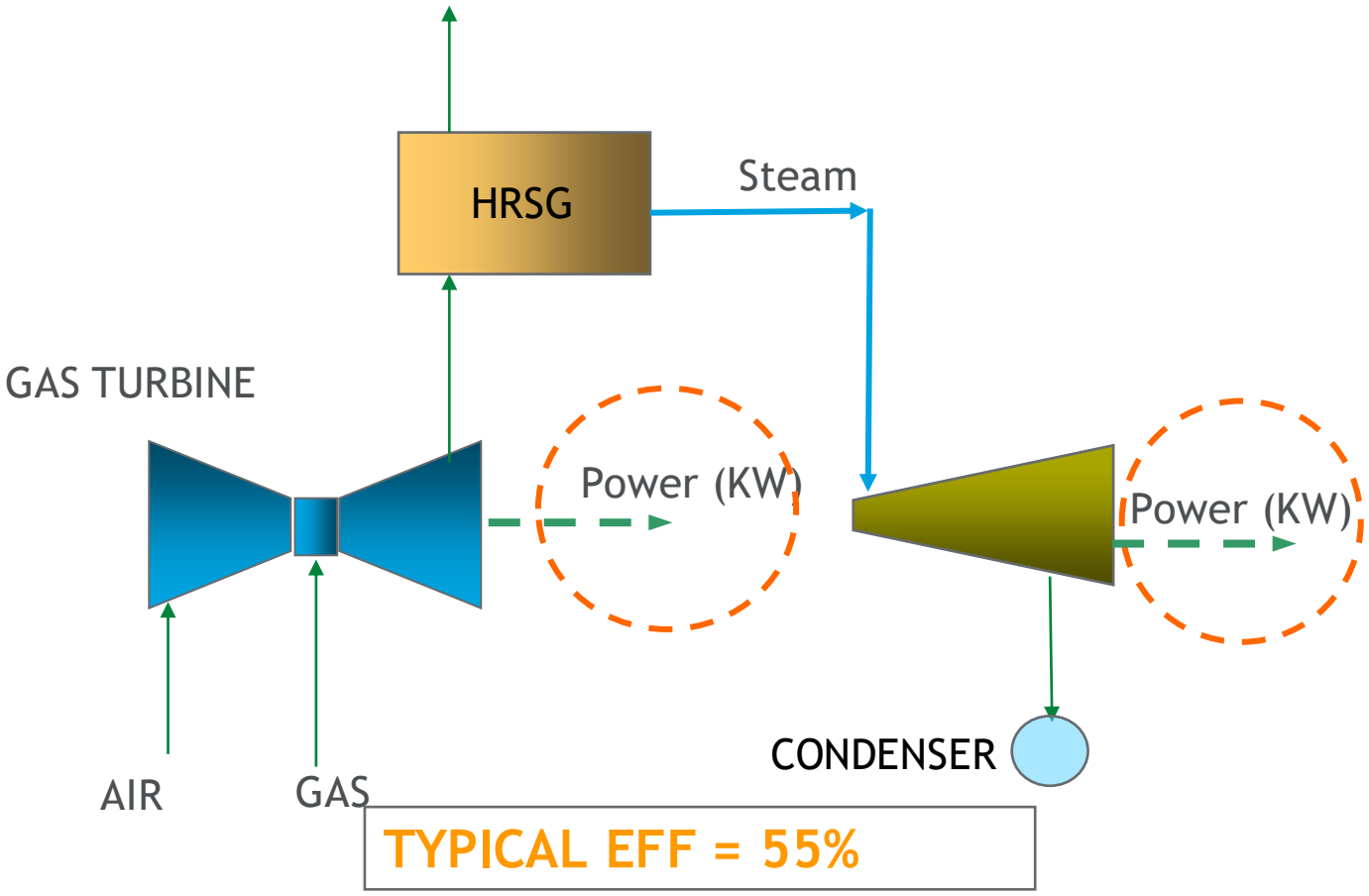
Recommendations:
Should be minimized & Converted to CC

TYPICAL EFF = 32 %

Power Gen.: Combined Cycle (CCGT)

HEAT IN GT EXHAUST IS USED FOR MAXIMIZE POWER RECOVERY





Positives:

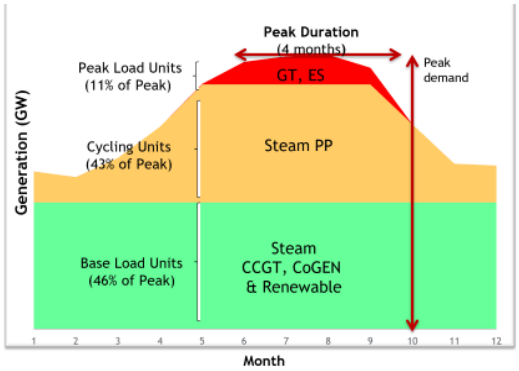
- Used for base-load
- High efficiency PP
- Low CO2 emissions

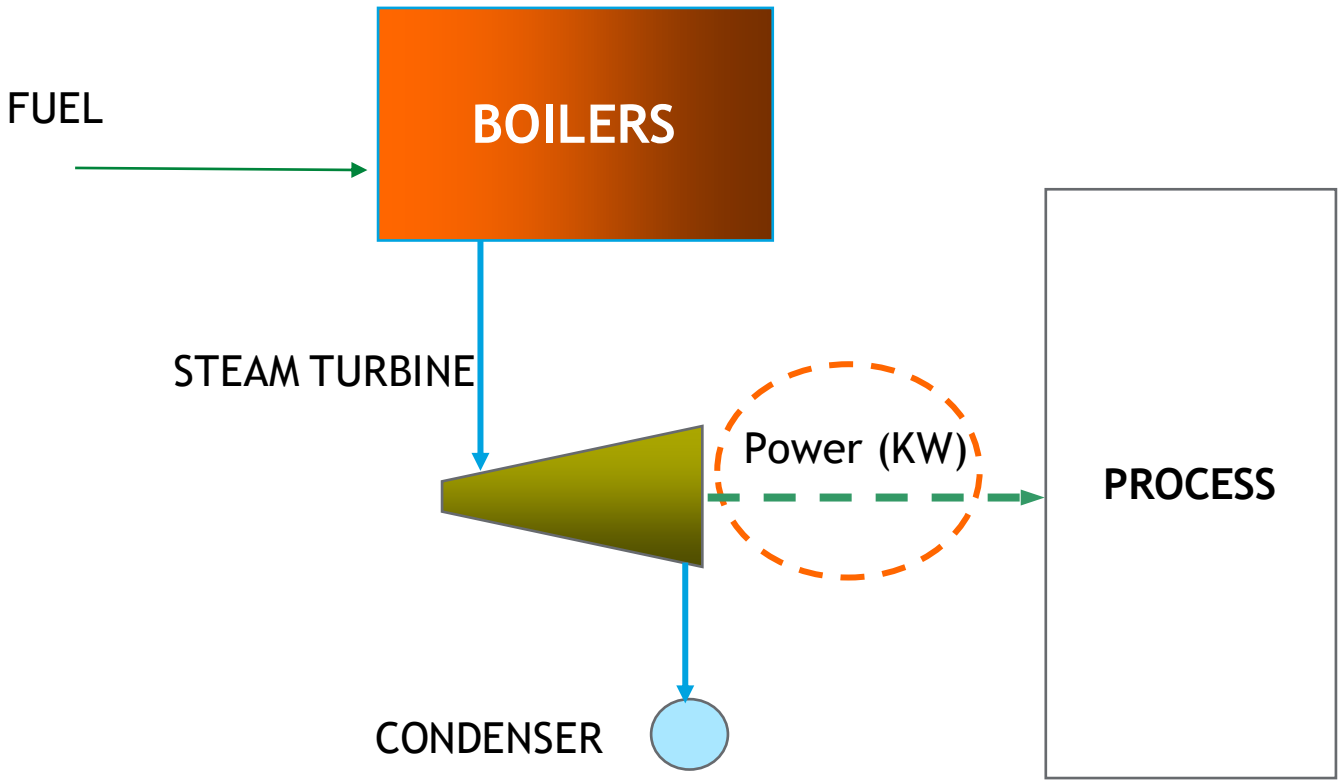
Negatives:

- Low efficiency at
- Partial load
- Latent heat not captured

Recommendations:
Should be maximized

Power Gen.: Steam Cycle- SCPP





Positives:

- Used as cycling
- Good response

Negatives:

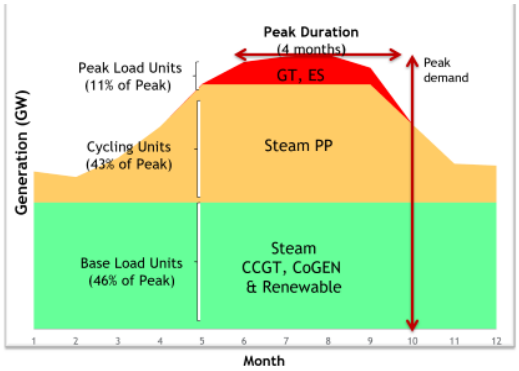
- Low efficiency
- High CO2 emissions
- Latent heat not captured

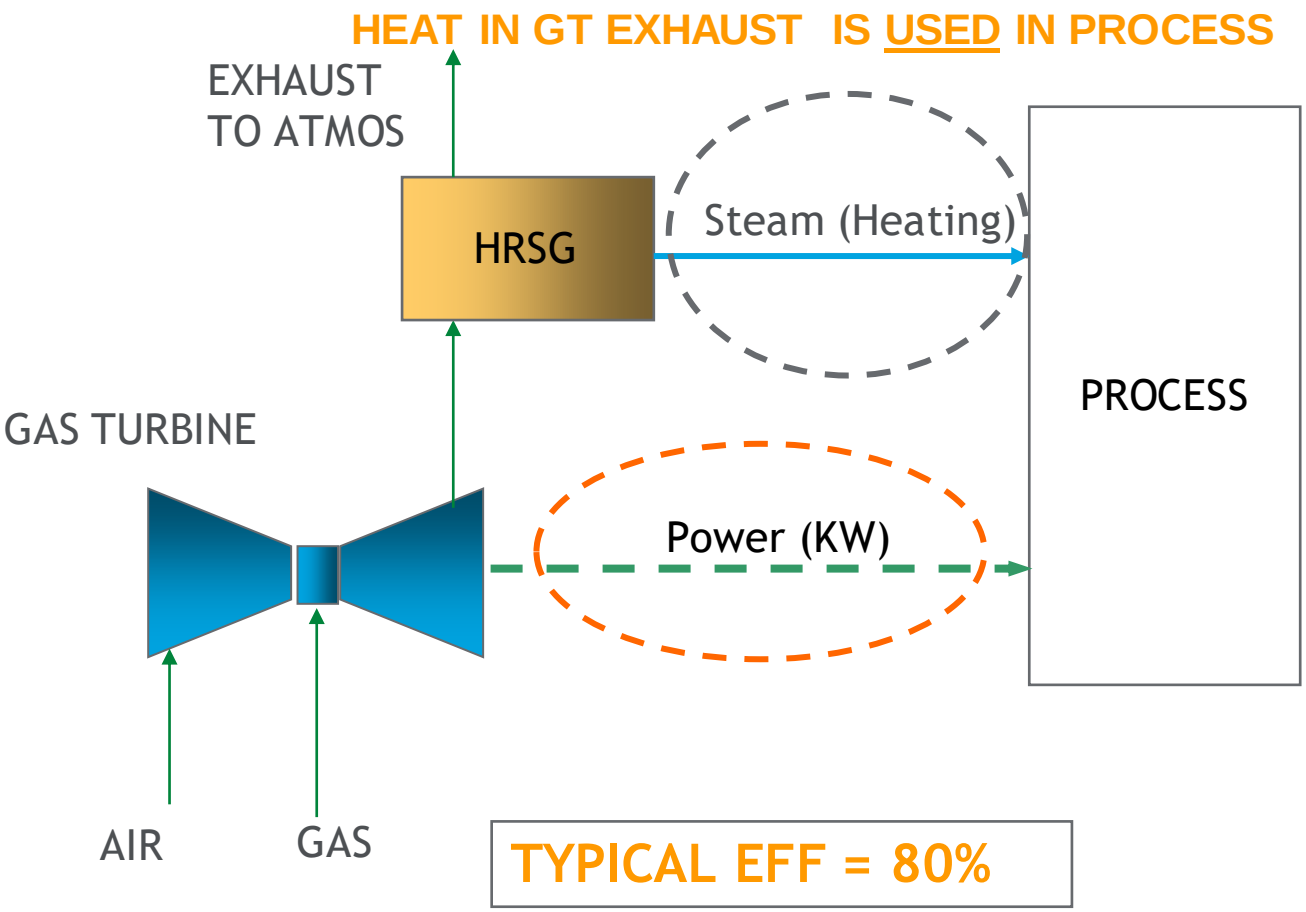
Recommendations:
Should be minimized & Replaced with CC

LATENT HEAT OF STEAM IS WASTED

TYPICAL EFF = 38%

Industrial: GT CoGEN (CHP)





Positives:

- Used as base-load
- For industrial complex
- High efficiency
- Low CO2 emissions
- Latent heat captured

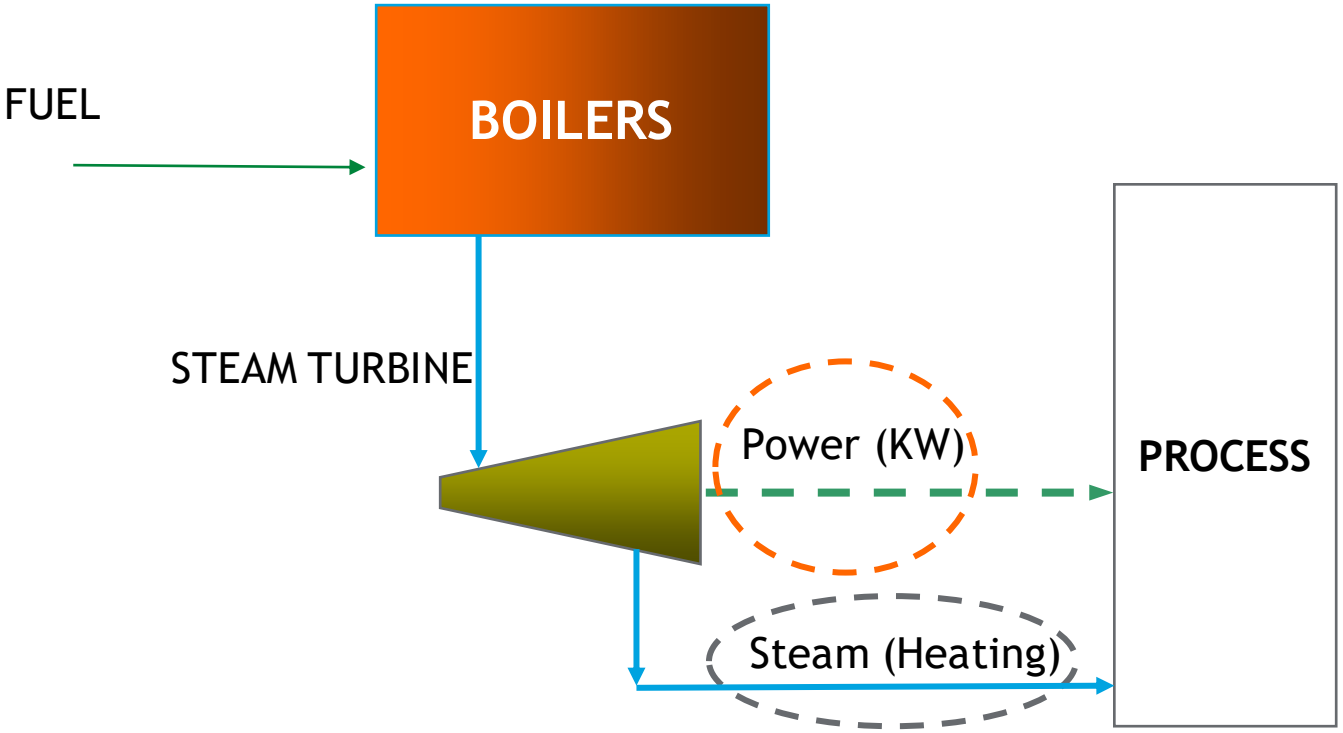
Negatives:

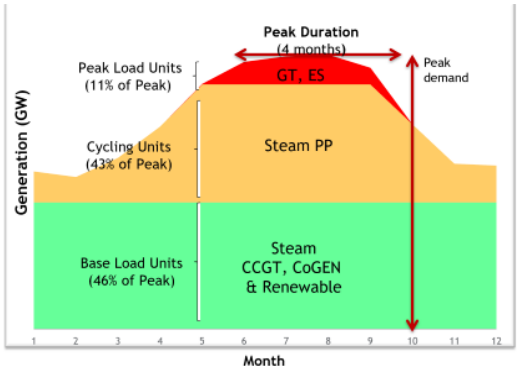
- Low efficiency at
- Partial load

Recommendations:
Should be maximized

Industrial: Boiler CoGEN (CHP)

LATENT HEAT OF STEAM IS USED IN THE PROCESS





Positives:

- Used as Base load
- Industrial application
- Good efficiency
- Latent Heat captured

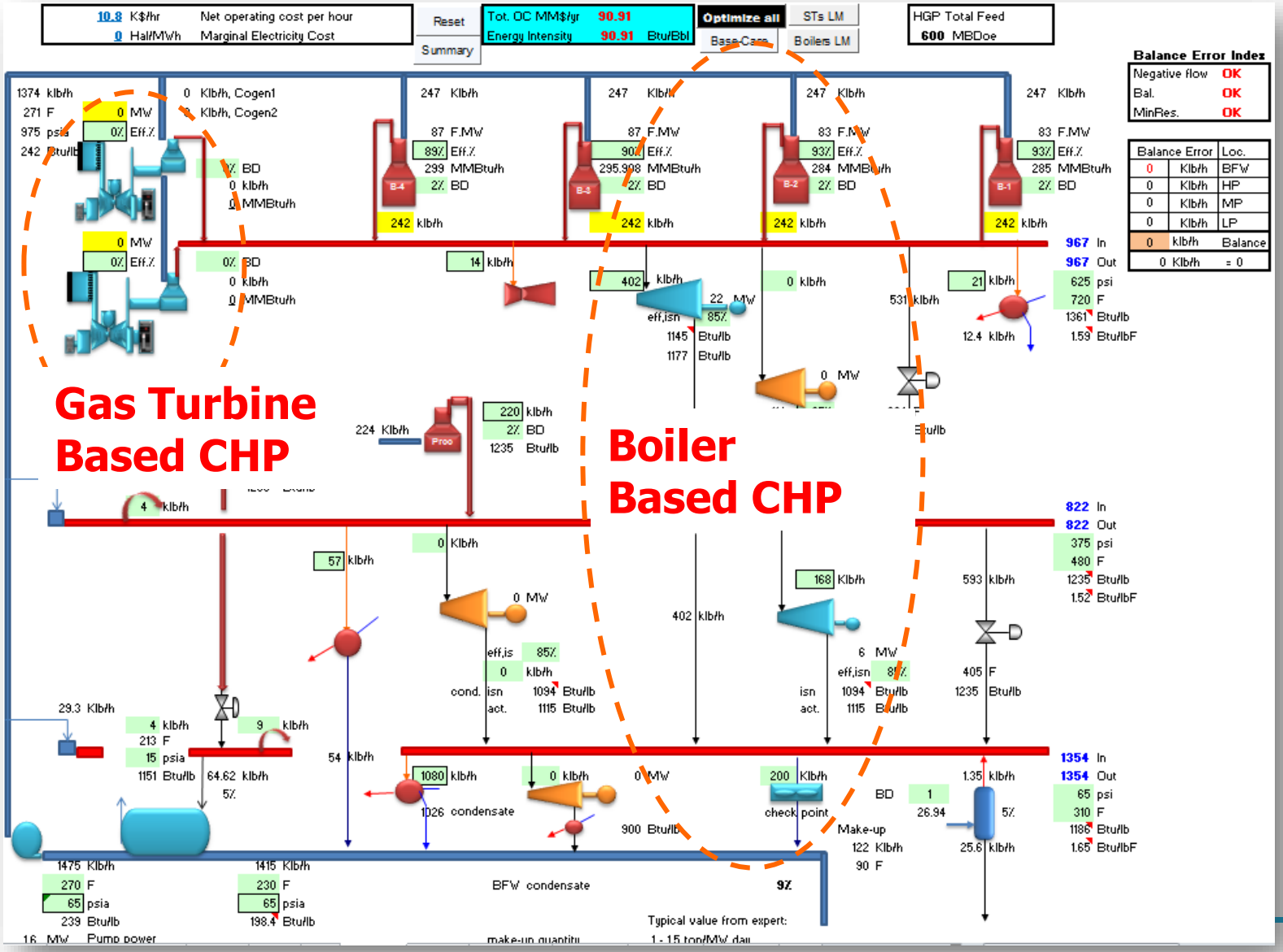
Negatives:

- Slow response
- Low power generation level

Recommendations:
Should be maximized

TYPICAL EFF = 70%

Industrial Complex Power & Steam Generation



Power/Steam Generation Decarbonization- Preliminary Roadmap

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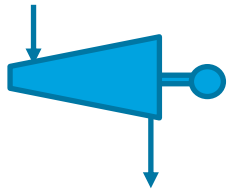
Proposed Power/Steam Generation De-carbonization Roadmap

Operational Optimization

- Load Management Optimization
- Economic Dispatch Model Deployment

EE Projects

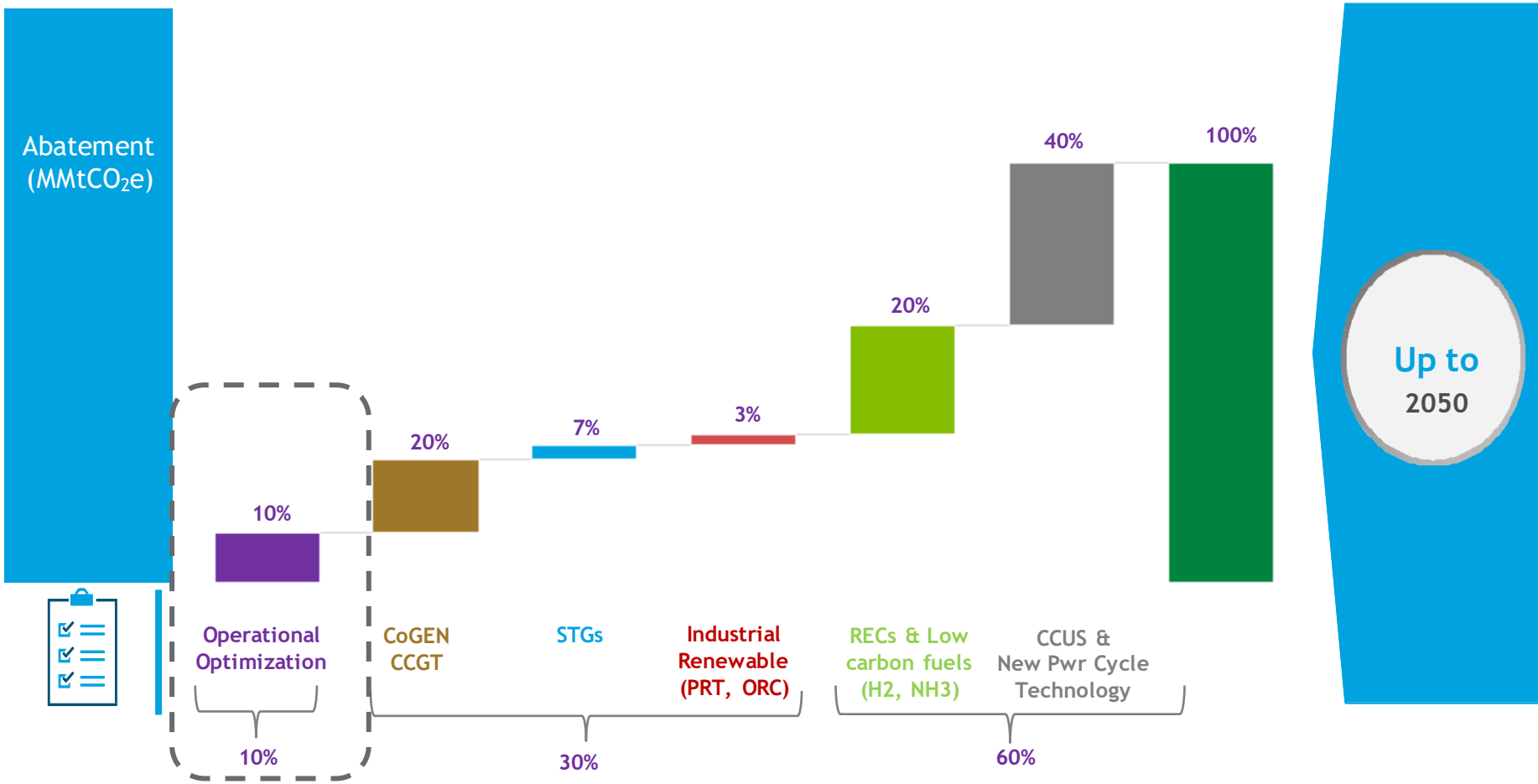
- Cogeneration
- Steam Turbine Generators
- Industrial Renewable (i.e. Turbo-expander, ORC)



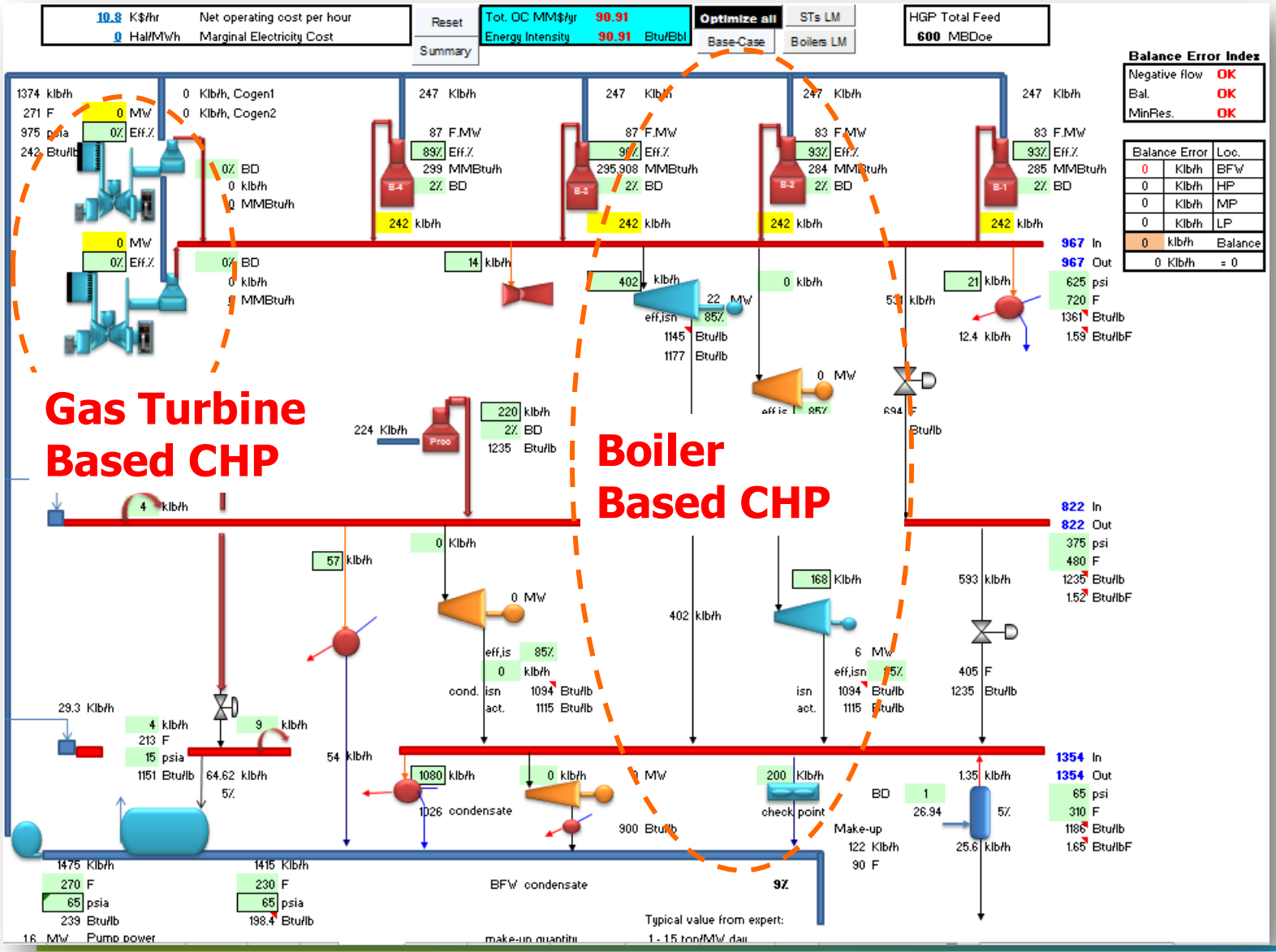
Decarbonization Alternatives

- Renewable Energy Certificates (RECs)
- Low carbon fuels (H2, NH3)
- New Pwr Gen. Cycle Technology & CCUS

Proposed Power/Steam Generation De-carbonization Roadmap



Industrial Complex Power & Steam Generation Optimization



Existing Facilities: "Operational Optimization"

- Online CHP Optimization Solution at Single Industrial Site

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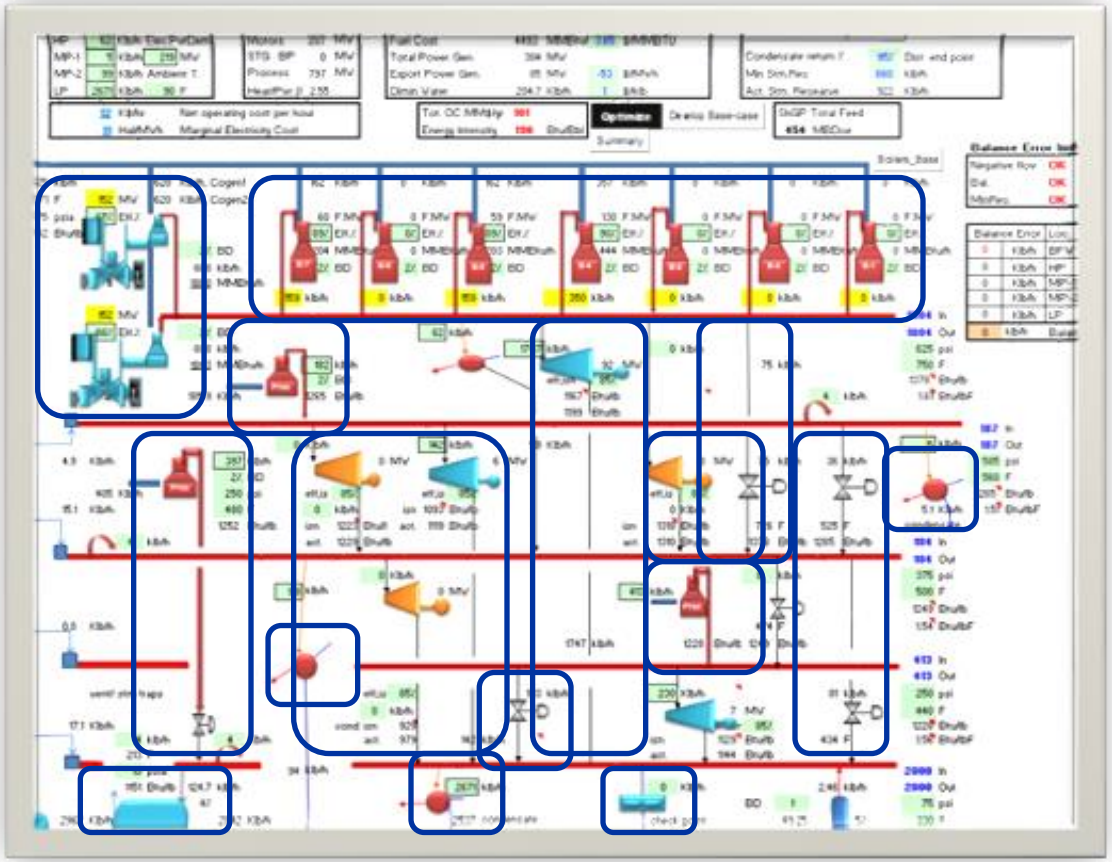
Online CHP Optimization Solution

- Boilers
- Cogeneration Units
- Process Steam Generators
- Steam Turbines
- Motors Switchable to STs
- Steam users
- Power users
- Steam System Network
- Letdowns/De-super-heater
- Fin-Fan Condensers
- Deaerator
- Condensate system



Online CHP Optimization Solution

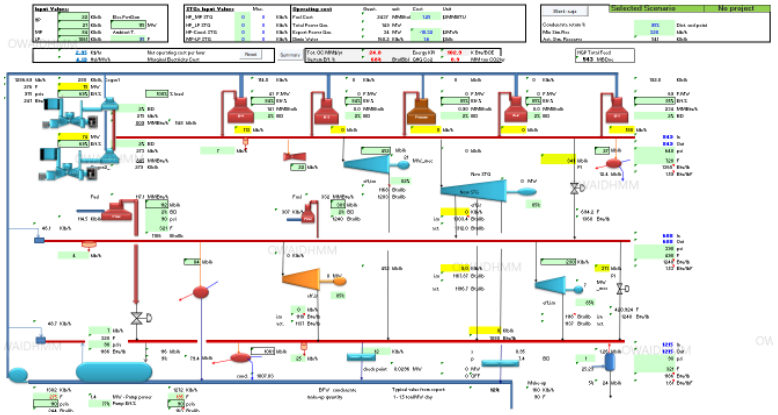
1 PI- Data Validation & Filtration Mechanism

Data filtration

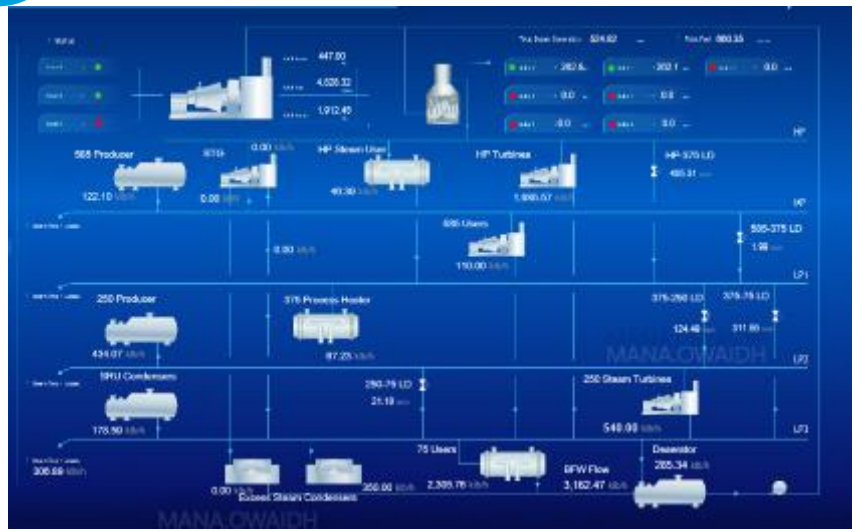
Data validation

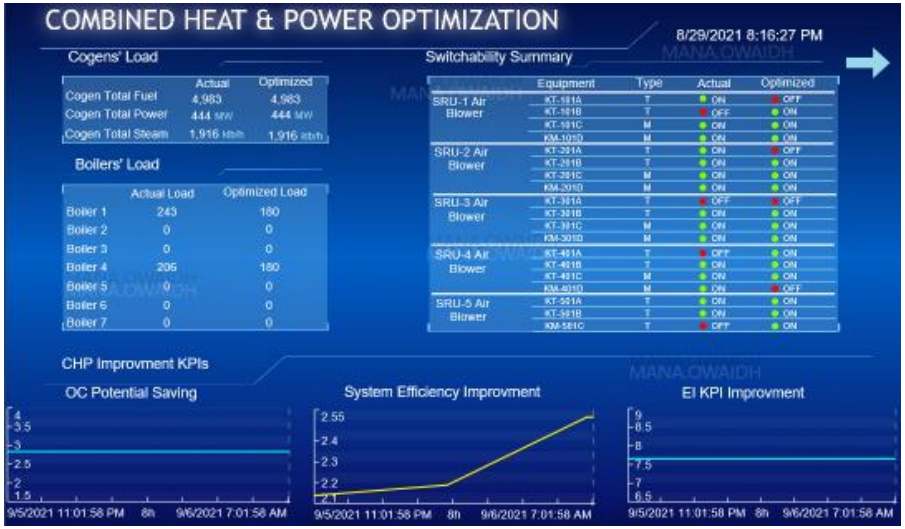
Reconciliation
- Equipment, ON/OFF
- Min and Max Limitation

2 CHP Optimization Engine & Schematic



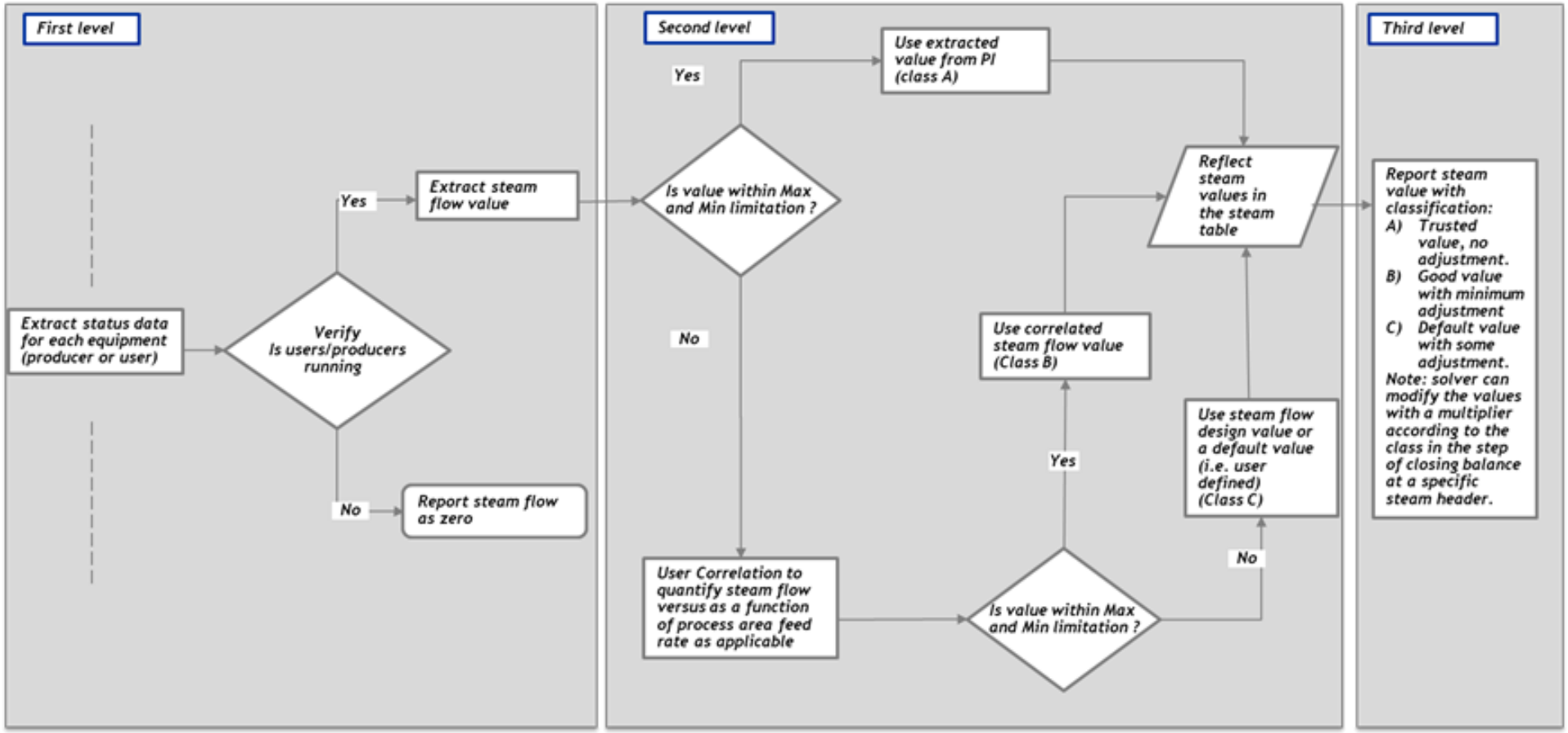
3 Dashboard & Recommendations





Online CHP Optimization Solution

1 PI- Data Validation & Filtration Mechanism



Online CHP Optimization Solution

2 CHP Optimization Engine & Schematic

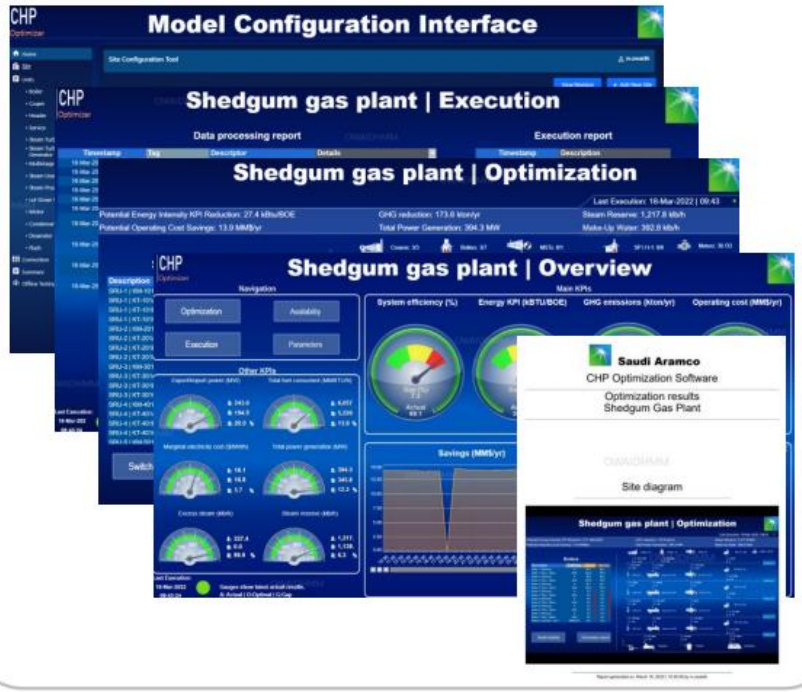
- Includes library of equipment with thermodynamic representation of equipment and systems
- Includes Optimization Engine to achieve:

Optimum loading of cogen fleet

Optimum loading of boilers & steam turbines

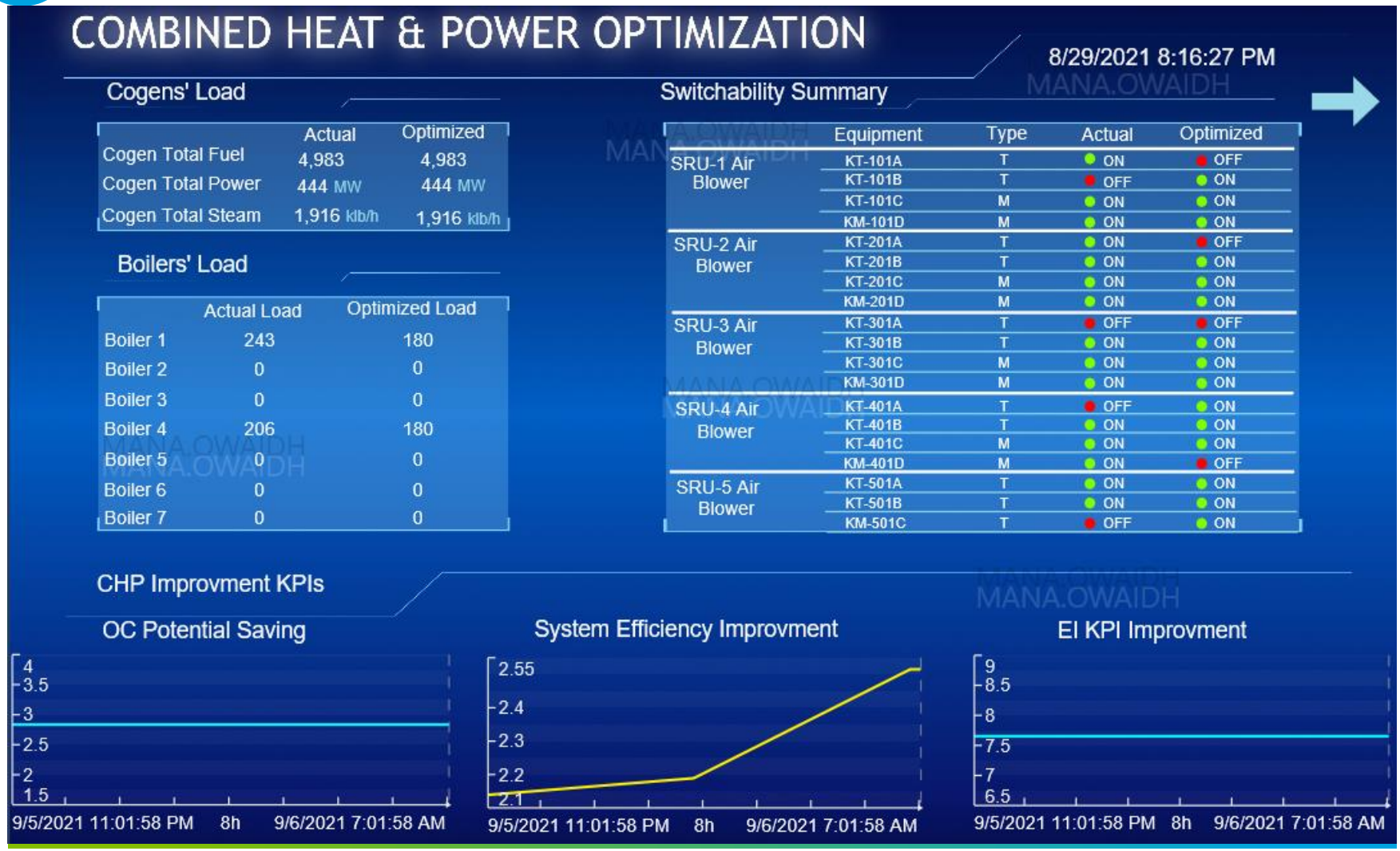
Drive down operating cost

Improve on Energy Intensity & CO2 emission.



Online CHP Optimization Solution

3 PI Vision Dashboard & Recommendations



Online Optimization Solution –
(Multiple sites Economic Dispatch)

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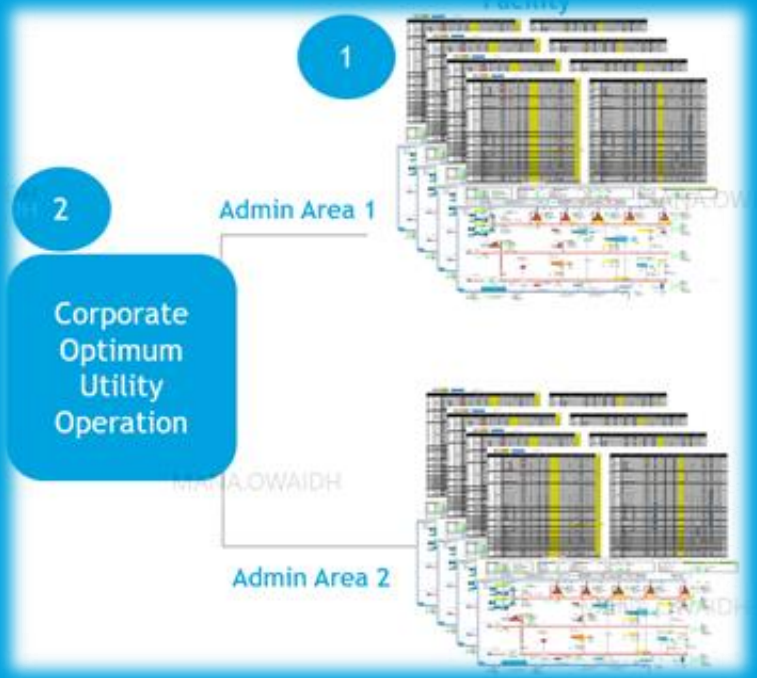
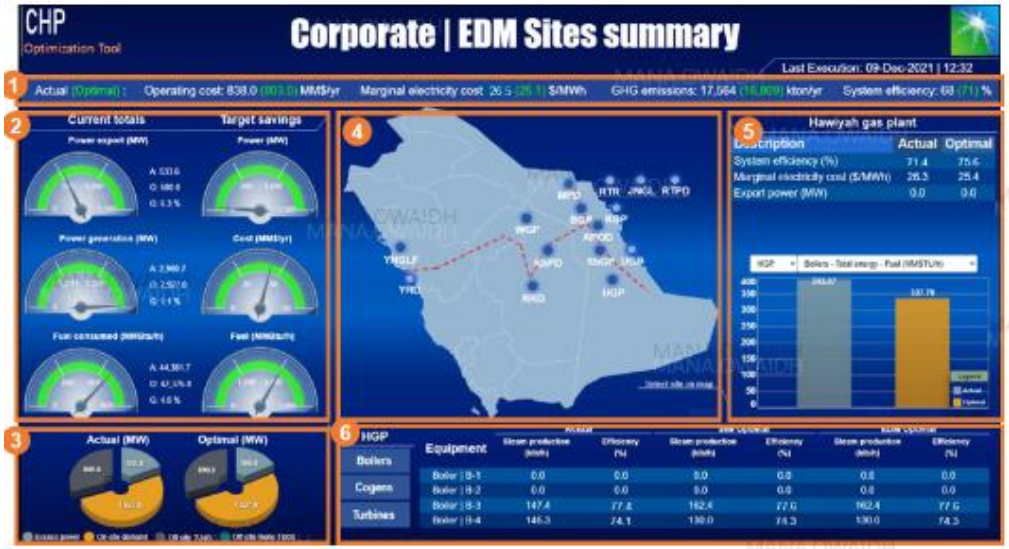


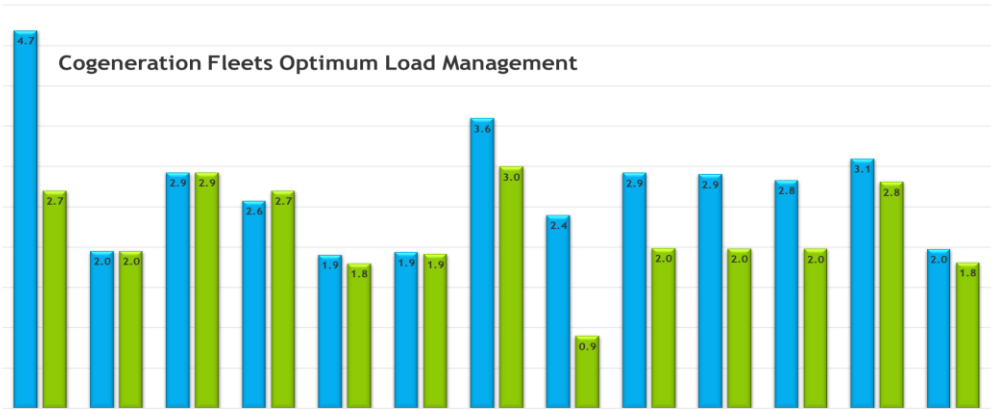
Multiple Industrial Sites- Cogen Economic Dispatch

Optimization Objective:

Aims to adjust Generation loading in a way the total operating cost is minimized while meeting required power and steam demand.

1. Optimize operation for each site
2. Reduce operating cost and CO2 emissions
3. Generate global optimization for the company and organization
4. Ensure meeting all constraints in the network, site level, multiple sites and corporate levels, such as:
   - Power & Steam reserve
   - Min and Max operational limits
   - Equipment availability (must run or must off)

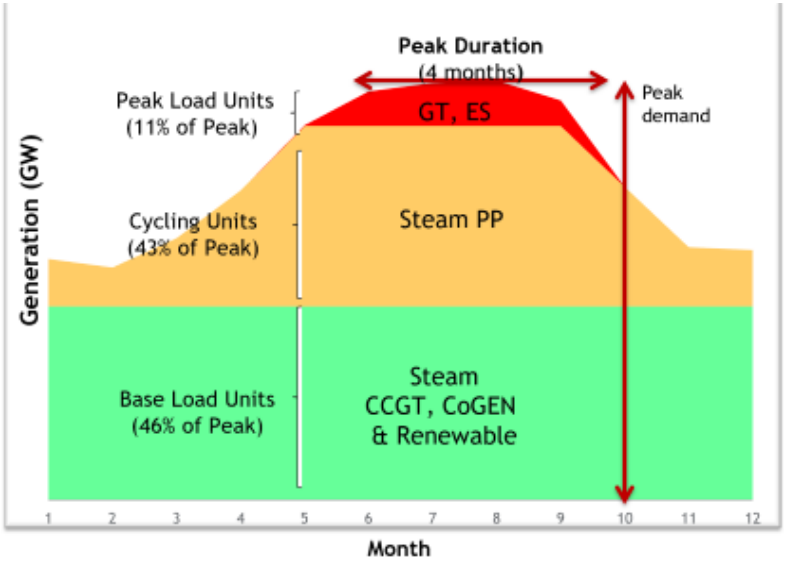


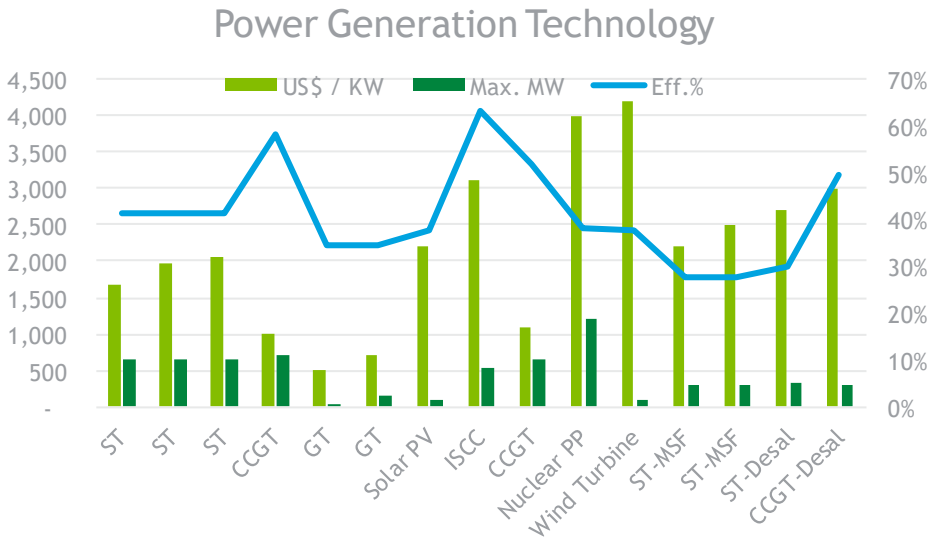


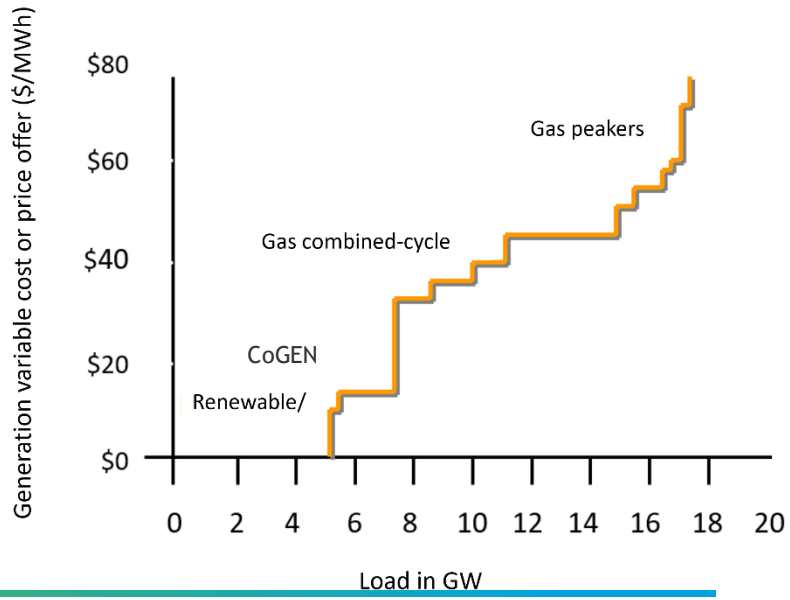
Power/Steam Generation Economic Dispatch

Optimization Formulation:

- **Objective function:** Min Operating Cost
- **Variables:** ON/OFF of units and loading of running units
- **Constraints:** Power Demand, Units Min/Max of units, fuel availability and reserve







New Projects: “Design Optimization”

- CHP Model for Optimum design

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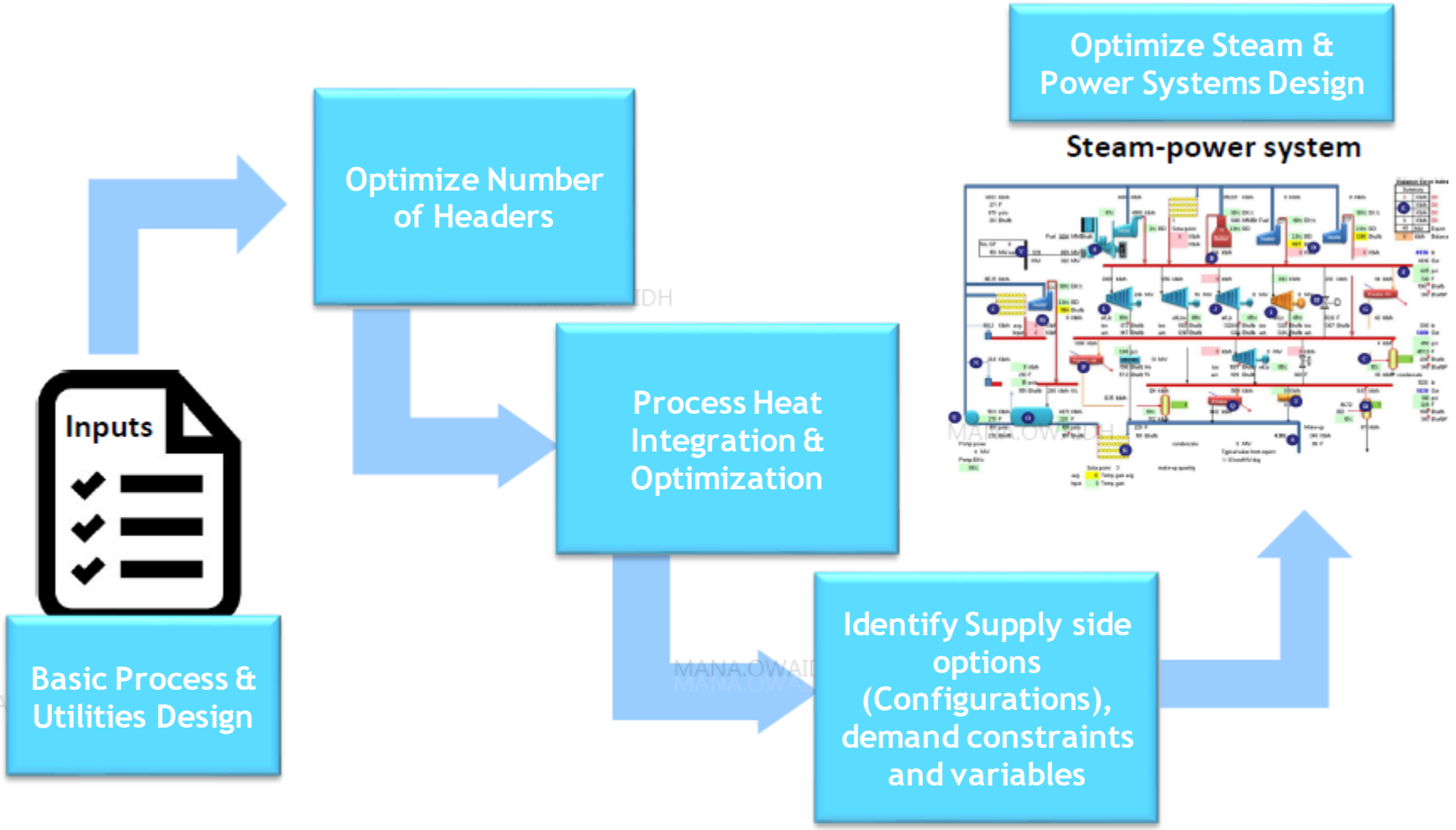
CHP Model for Optimum design



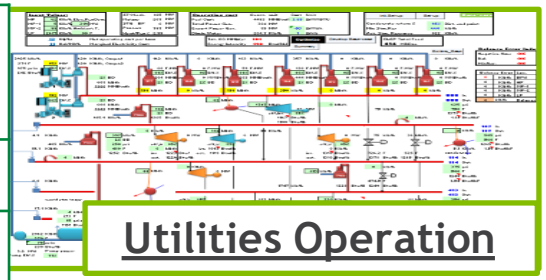
CHP Model for Optimum design

Example: Optimum Design of Steam and Power Systems

Facility Energy Demand		Value	Unit
Power Demand		200	MW
Steam Demand		1200	Klb/h
Steam Reserve Available	>=	One Unit	
Overall System Eff%	>=	70%	

Process Operation

Utility Design Configuration:
1. Boilers and Steam Turbines
2. Cogen and Steam Turbines
3. Cogen and Boilers and Steam Turbines

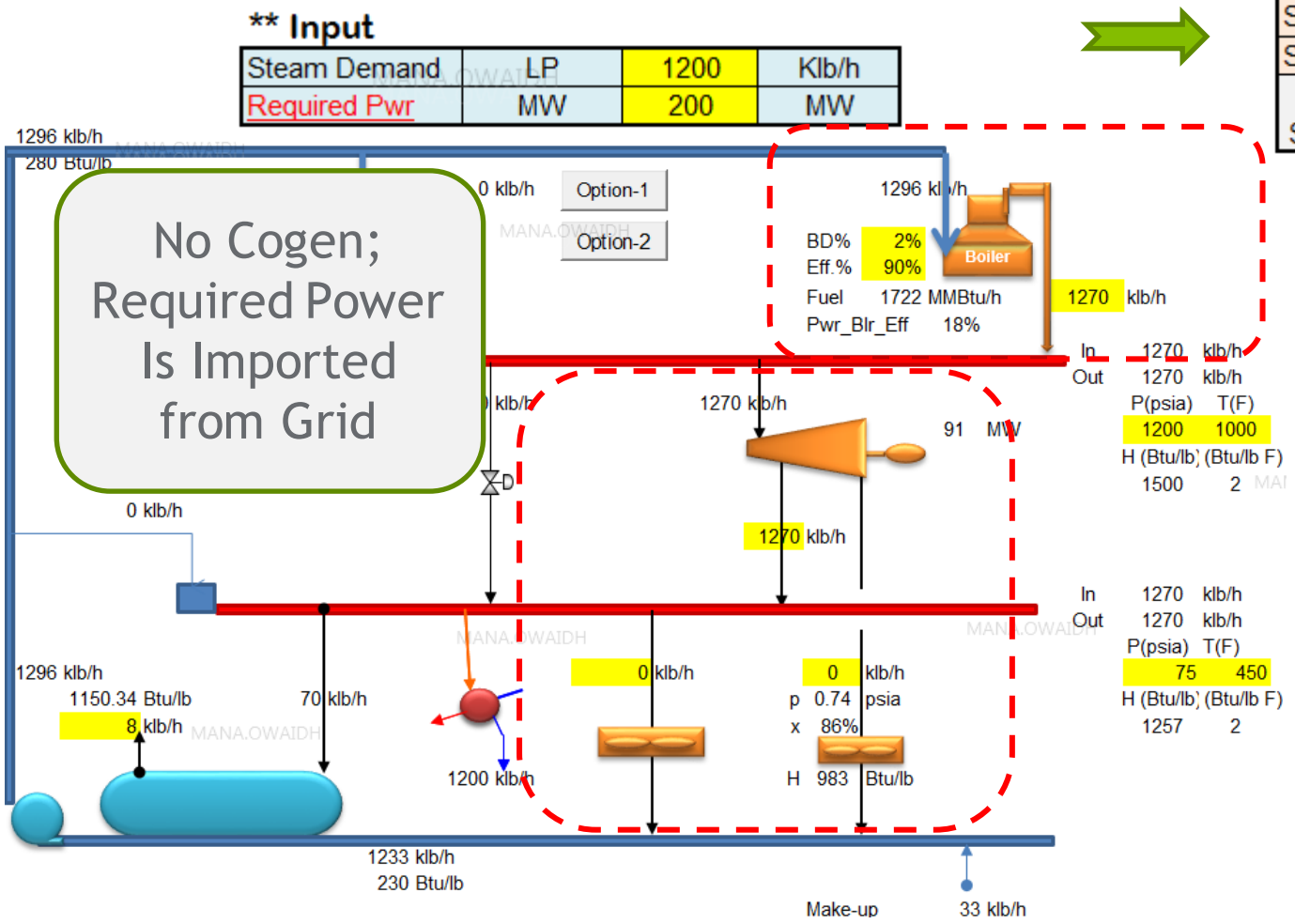


Utilities Operation

CHP Model for Optimum design

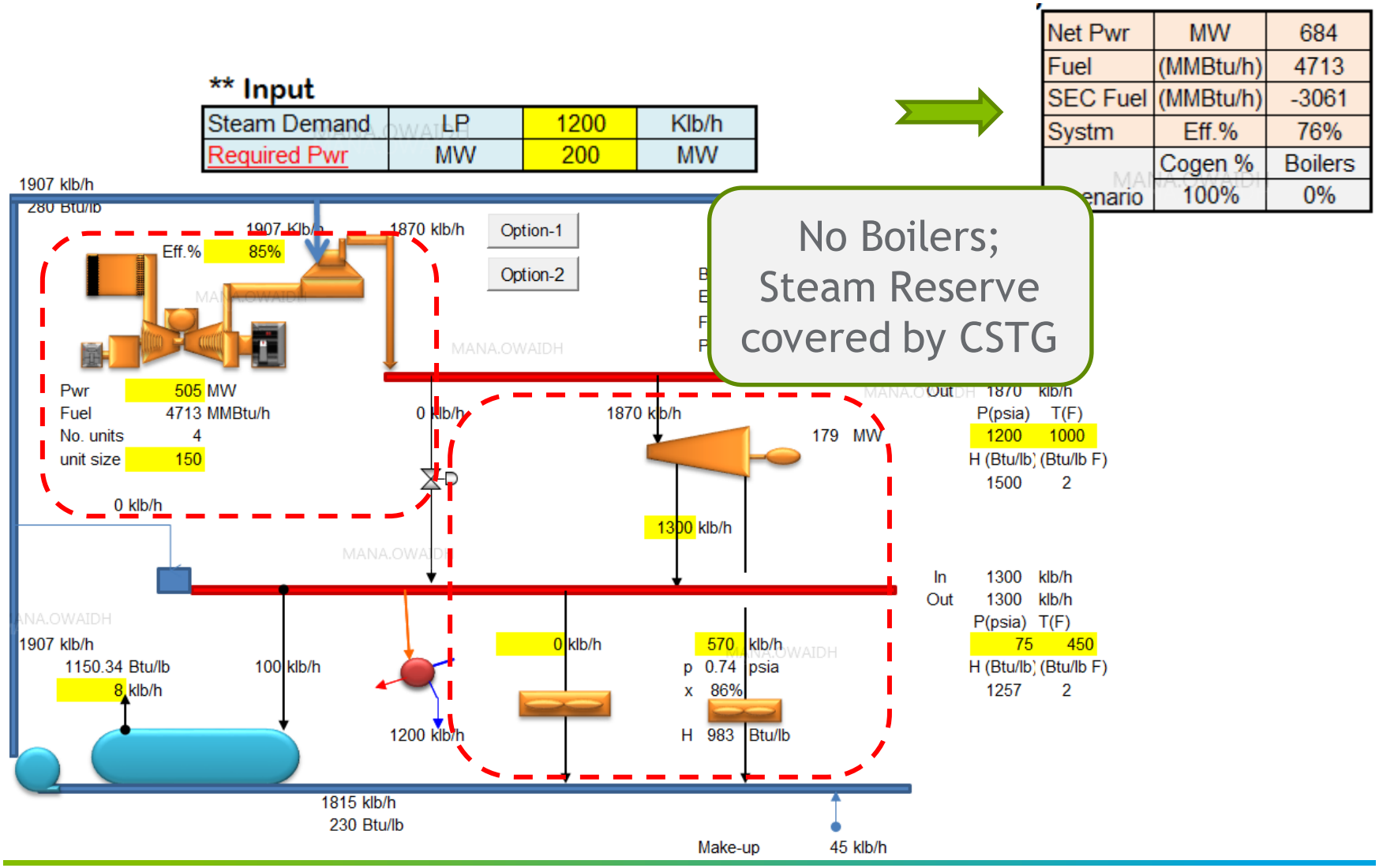
CHP System Thermal Efficiency- "Boiler Configuration"

Net Pwr	MW	91
Fuel	(MMBtu/h)	1722
SEC Fuel	(MMBtu/h)	691
Systm	Eff.%	64%
	Cogen %	Boilers
Scenario	0%	100%



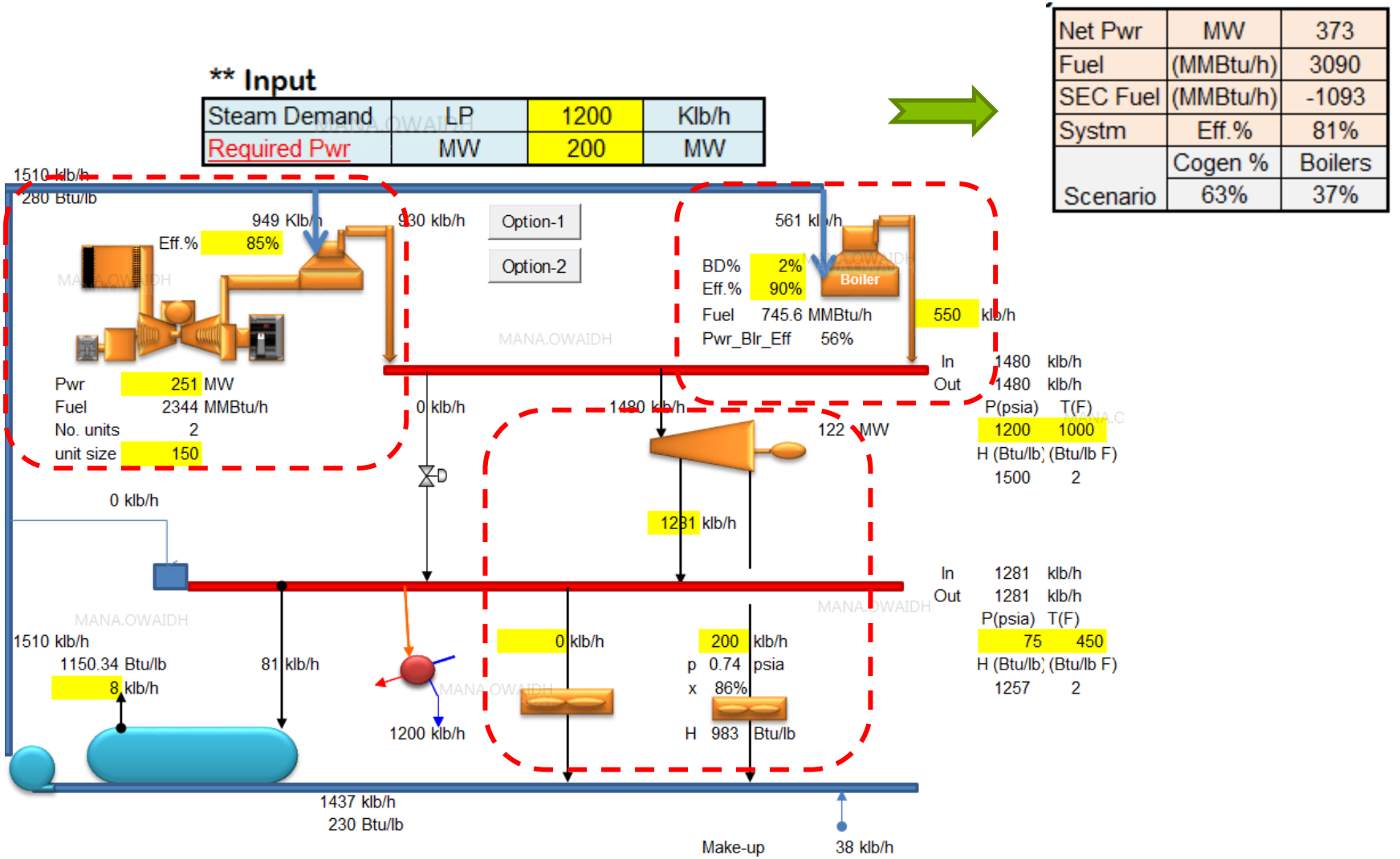
CHP Model for Optimum design

CHP System Thermal Efficiency- "Cogen Configuration"



CHP Model for Optimum design

CHP System Thermal Efficiency- "Cogen/Boiler Configuration"



CHP Model for Optimum design

Example – Result Summary

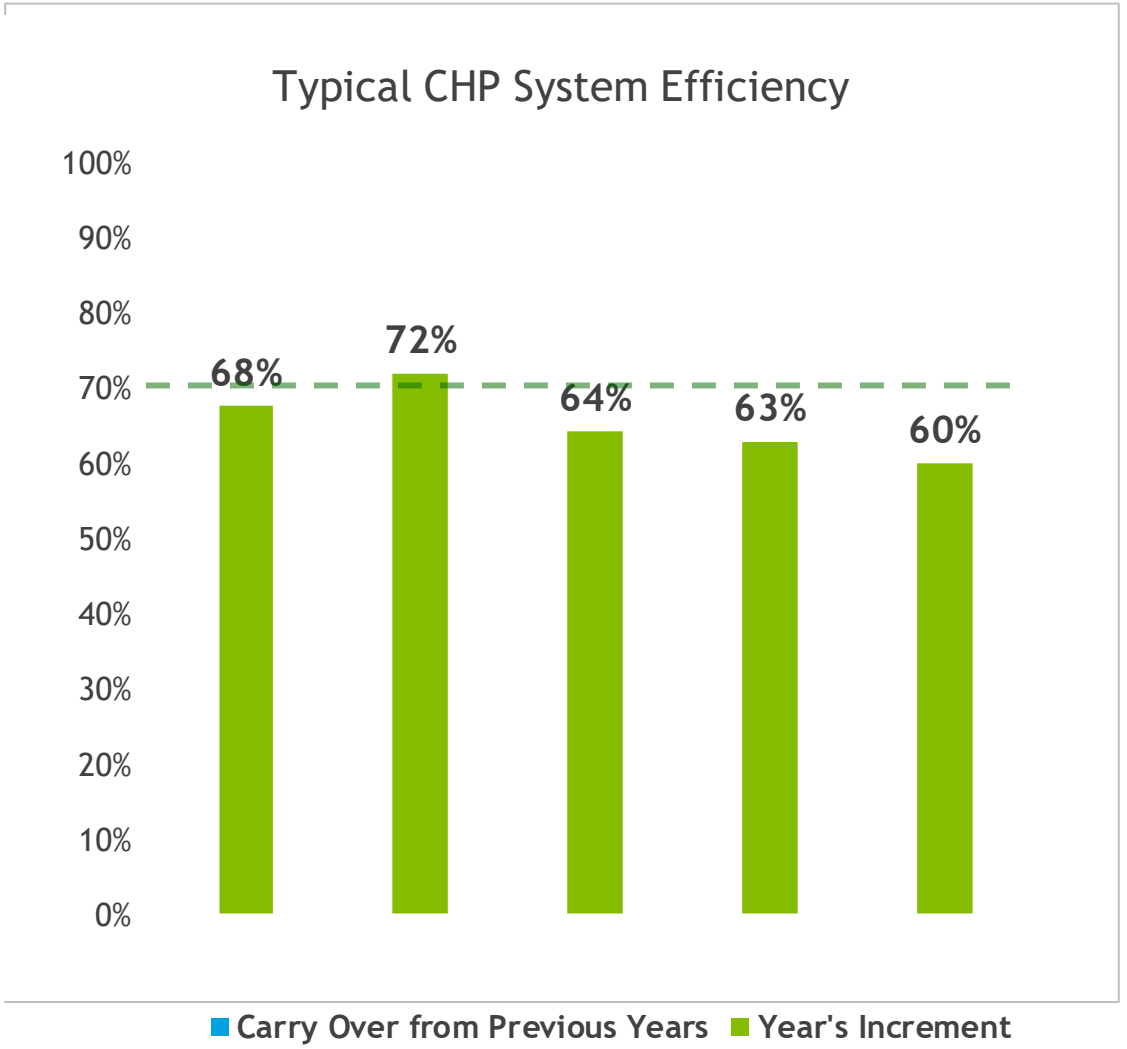
Facility Energy Demand		Value	Unit
Power Demand		200	MW
Steam Demand		1200	Klb/h
Steam Reserve Available	>=	One Unit	
Overall System Eff%	>=	70%	

Option	Fuel (MMBTU/h)	Power Gen MW	Capex MM $	Overall Supply Eff. %	NPV ($ MM)
Boilers Only	1722	91	304	62%	3rd
Cogen Only	4713	684	1085	76%	2nd
Cogen & Boilers	2642	373	663	81%	1st

Combined Heat & Power Systems Optimization

Takeaway

- CHP systems' Thermal Efficiency = Ratio between all useful energies generated by the system and total energy input as fuel
- Targeting 70% for new CHP systems projects
- Highly dependent on the design configuration
- Optimization models are important to find best design



Summary & Conclusion

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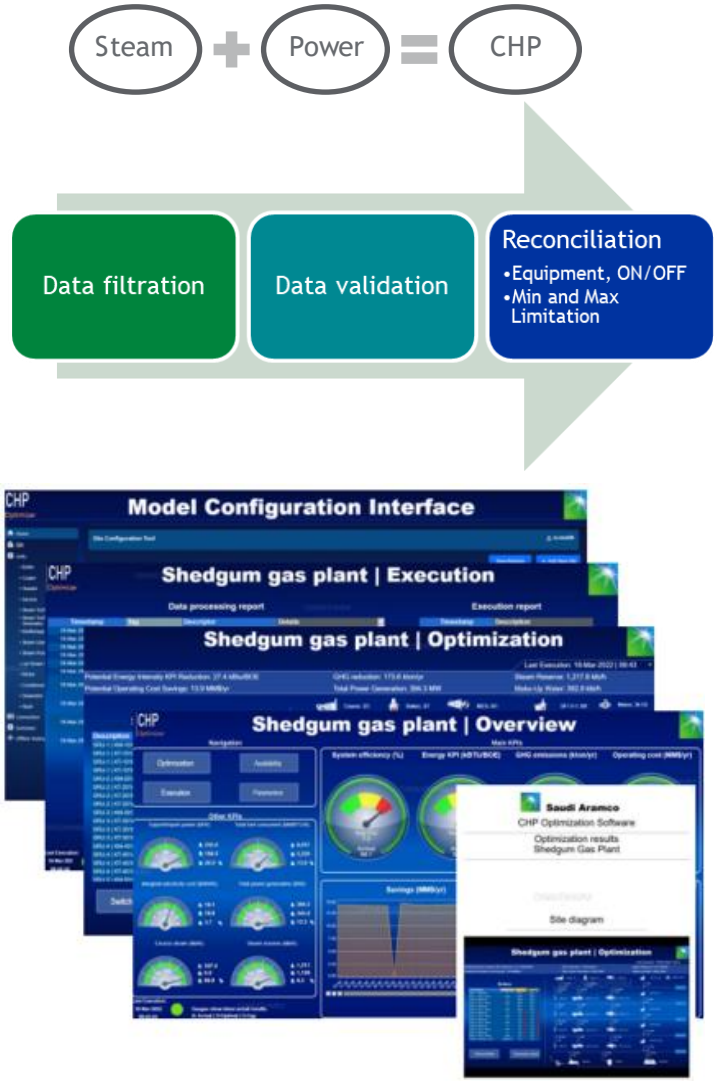
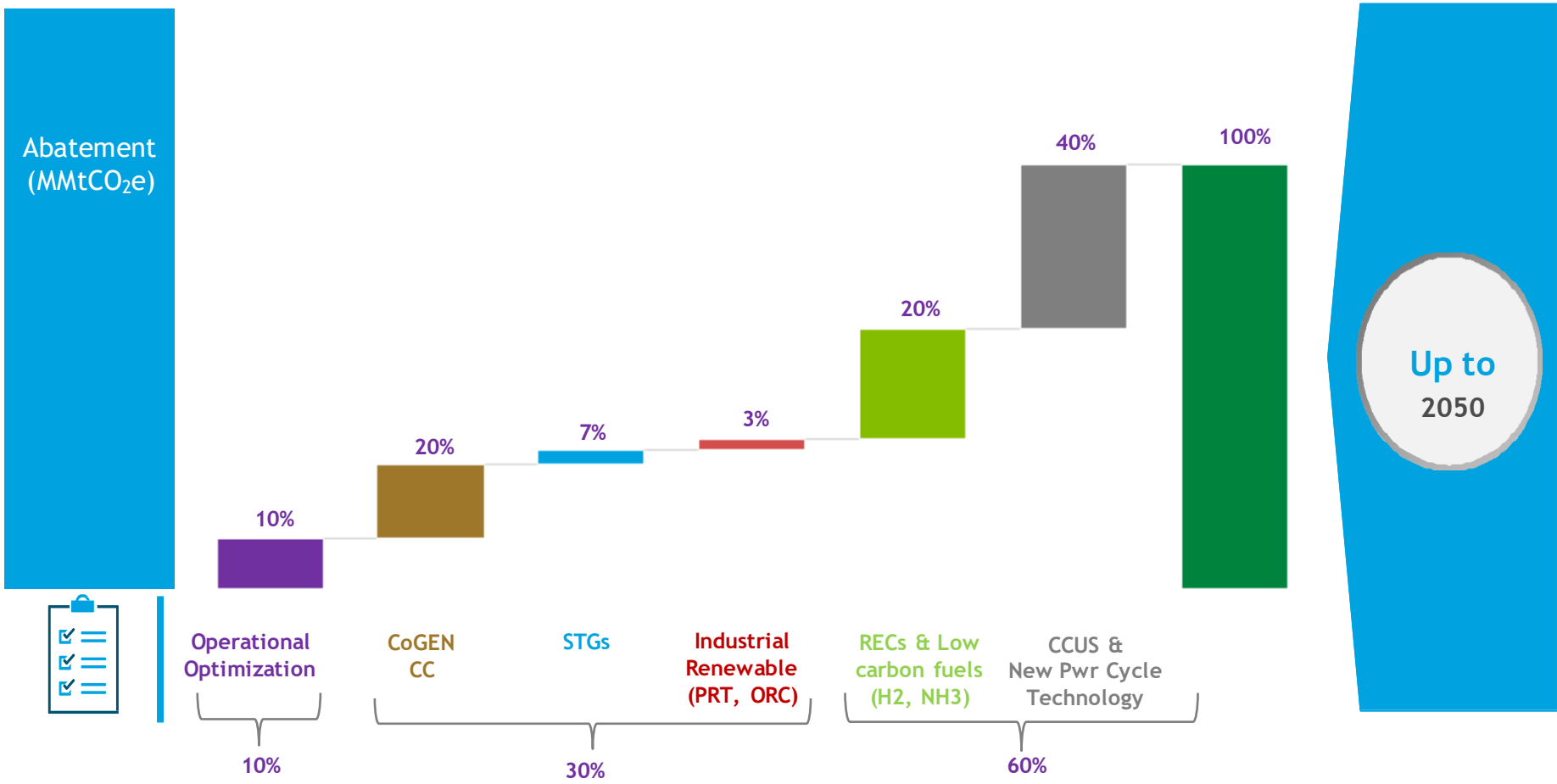
Power & Steam Generation Optimization for Industrial Facilities

- Industrial & Utility energy consumption exceeds 60% of Saudi Arabia internal energy consumption.
- Operational optimization and load management can provide 10% potential emission reduction.
- Saudi Aramco has developed solutions for operational optimization called online CHP optimization software.
- Accounts for all key constraints
- Provides real time recommendations for improving system efficiency, reducing operating cost and CO2 emissions.
- Developed CHP optimization solution for new design to identify the optimum configuration and sizing



Power & Steam Generation Optimization for Industrial Facilities



Thank you