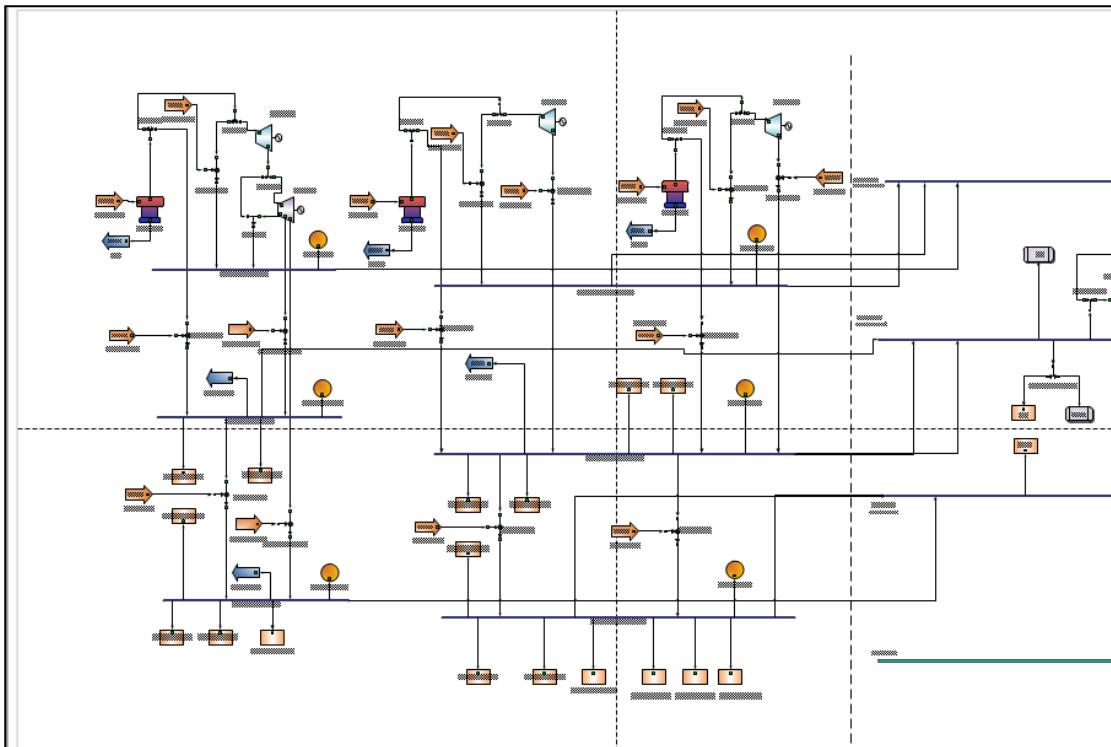


Issue and direction of Energy Network Optimization in Petrochemical Industry

Version 2.0



[Infotrol Technology, Co., Ltd.](#)

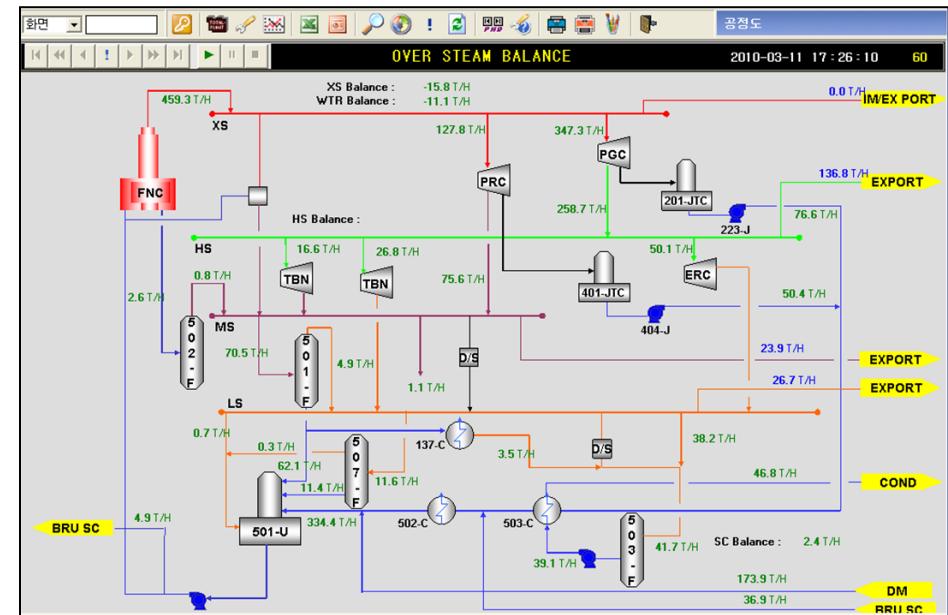
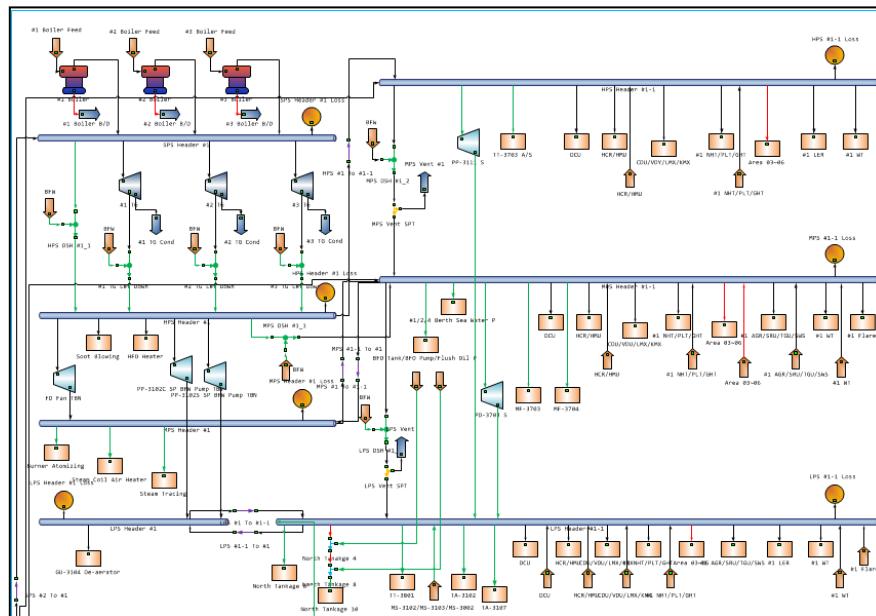
since 2004

Revision History

Date ↴	Version	Author	Comment ↴
2015. 10. 15	1.0	KTW	Presentation Content Scheme ↴
2015. 10. 16	1.7	KTW	Presentation Content Scheme update ↴
2015. 10. 19	2.0	WHK	Review and update ↴

Energy Network in Process Industry

- ❑ **Definition:** Network of energy production, distribution and consumption
- ❑ **Network composition:** Furnace, Boiler, gas turbine, HRSG, turbine, heat exchanger, electrical/steam motor, let down equipment, heat pump, header line and users, etc.
- ❑ **Application area:** Process industry such as petrochemicals, refinery and chemical companies etc



Energy Network Management Issues & Solutions

Typical energy management issues and solutions with economic effect in process industries such as petrochemical, refinery, etc.)

Issues	Solutions	Estimated Effect
Steam production and consumption is not matched (energy imbalance)	Data reconciliation based steam balance	Increased steam data accuracy
Not concern on measurement error	Data reconciliation based steam balance	Erroneous measurement detection and management
Unknown energy loss	Systematic unknown loss identification through energy balance	Unknown loss identification and reduce energy loss
Building steam balance for an event takes a long time	Real time on-line steam balance system	Reduced engineer work load and improve energy system analysis
Energy intensity increase from the operational mistake	On-line operational surveillance and measure system	Improve energy intensity by reducing the operational mistake
Difficulty in setting new steam balance for operational and/or process changes	Build what-if utility simulator	Complex-wide economic analysis for process and /or operational changes
Do not know whether the current steam operation is optimal	Need to build the optimal steam system	Reduce energy intensity while supplying the required energy
Do not fully utilize the steam potential energy (exergy)	Build the steam utilizing maximization system	Maximizing the steam energy utilization
Lack of efficient response for the electric price change	Build the optimal system considering the electric price	Economic benefit from optimal operation of electric production and import

Required energy management system to minimize the energy intensity

Area	Required Function	Estimated Effect
Plant-wide energy network steam/energy balance and Energy management system	<ul style="list-style-type: none"> Provide plant-wide energy network overview Data Reconciliation based energy mass balance Real time on-line management of energy production and consumption Energy loss identification Easily maintenance and update of the system 	<ul style="list-style-type: none"> Capturing plant-wide energy flow Enhanced accuracy of energy balance Real time on-line energy management Reduce energy loss Fast respond for process and/or operational change
Energy system what-if simulation	<ul style="list-style-type: none"> Simulate for the process and/or operational change Evaluate complex-wide benefit from the sub process energy reduction Define new energy projects 	<ul style="list-style-type: none"> Establish new steam balance for changed process and/or operation Economic analysis of each sub process energy reduction Prioritize energy projects with estimated economic benefit
Optimization	<ul style="list-style-type: none"> Real time on-line optimal operational guide while keeping the energy requirement Provide breakdown effect of optimal operation Closed-loop optimization if necessary 	<ul style="list-style-type: none"> Keeping real time optimal operation Identify the operational change resulting in optimization Automatic optimal operation
Abnormal detection and root cause analysis of energy intensity	<ul style="list-style-type: none"> Abnormal detection and root cause analysis of Energy intensity by providing logical detection of abnormality 	<ul style="list-style-type: none"> Fast detection and measure for increasing energy intensity
Support ISO50001 and greenhouse gas emission trading scheme	<ul style="list-style-type: none"> Support ISO50001 Support emission trading scheme Support energy accounting system 	<ul style="list-style-type: none"> Support standardized energy management procedure Provide energy accounting data, more accurate and credible

Project Objective

Construct Energy Management system to optimize complex-wide energy network and minimize plant energy intensity▷

□ Energy Network Optimization System▷

- Complex-wide Energy Balance
- Complex-wide Energy Network Optimization
- Main Energy Equipment Efficiency Management
- What-if simulation of energy network

□ Complex-wide Energy Management System▷

- Energy intensity management by plant or process
- Energy Network optimization and management system
- Energy balance and optimization report
- Energy Usage Management by quantity and price base

Note : Induce energy innovation by sharing company-wide information sharing using Web technology

Proposed Solution

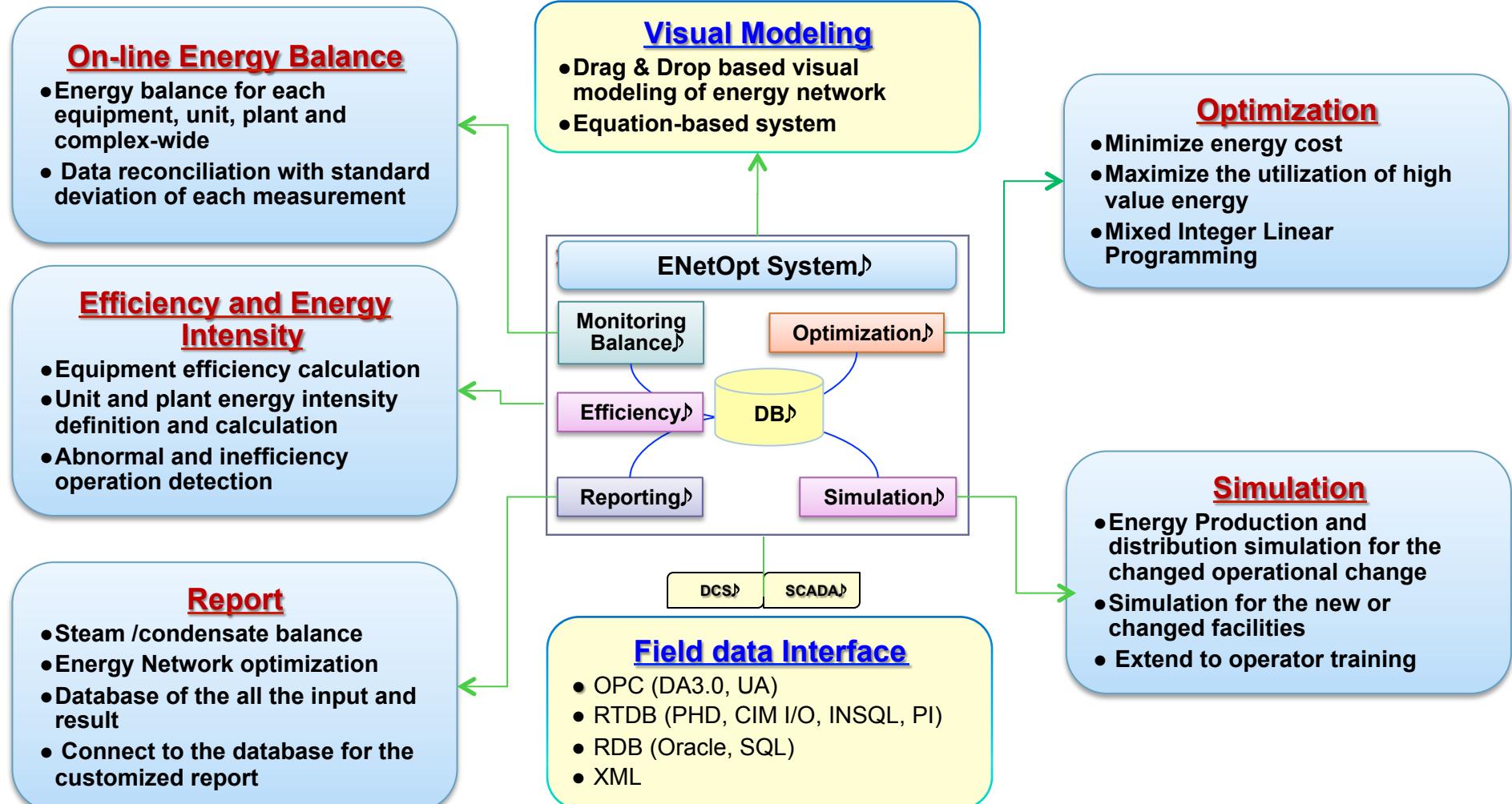
ENetOPT

- Energy balance**
 - Steam production and consumption balance
 - Analyze erroneous measurement
 - Analyze the energy & mass loss identification (steam, trap, tracing)
- Simulation**
 - Simulate Effect of New energy equipment installation
 - ✓ Boiler, HSRG, Turbine investment effect
 - Simulate Effect of Plant Operation Condition
 - ✓ MP, LP usage change (change due to product output or process revamp)
- Energy equipment efficiency**
 - Boiler, Turbine, Pump, Heat exchanger efficiency calculation and analysis
- Optimization**
 - Load balance considering boiler efficiency
 - Optimize Turbine exhaust, condensing and electricity

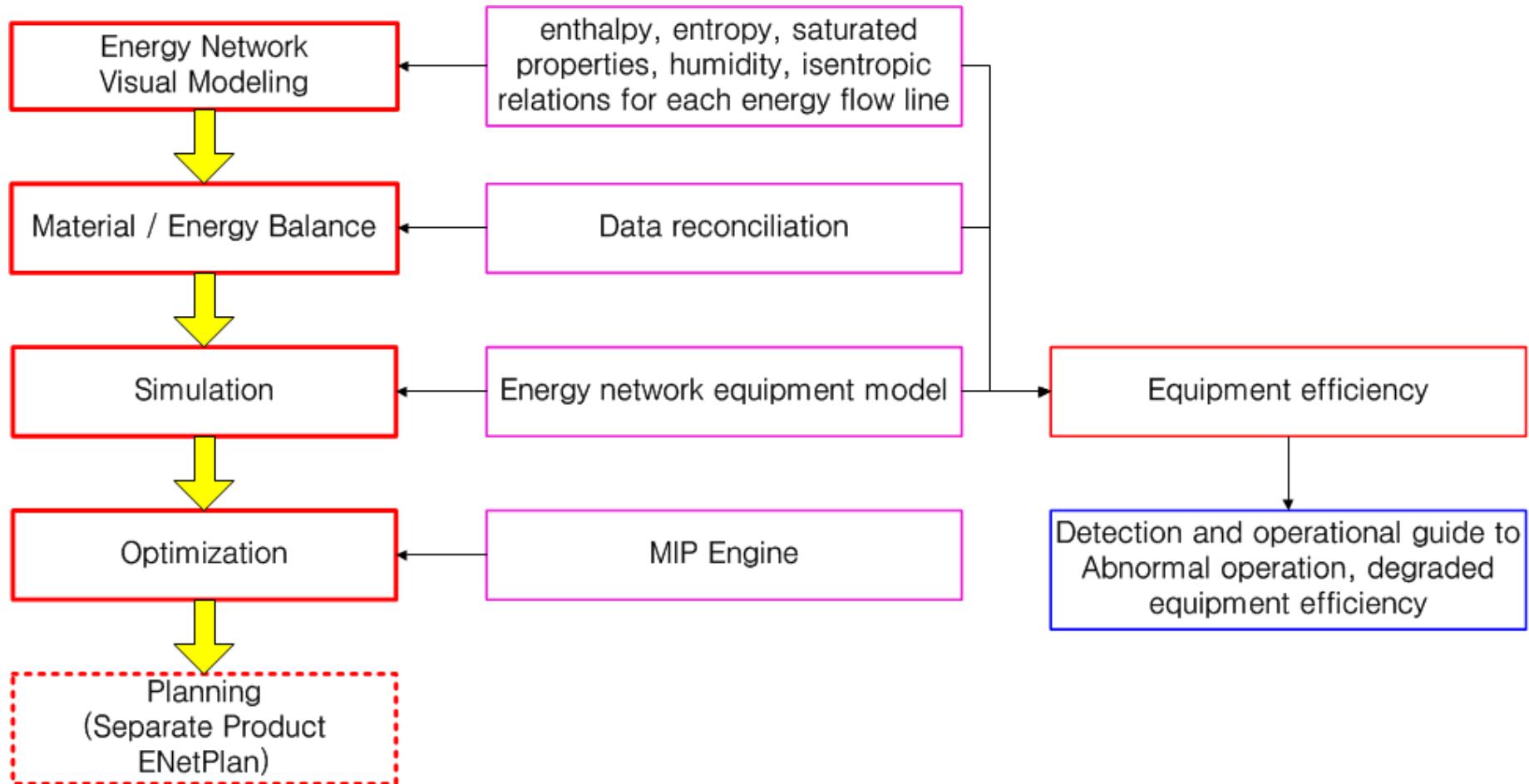
EMS

- Energy Network Monitoring**
 - Complex wide summary and detailed plant energy network
 - Steam/Condensate measured, balance and optimization
- Inter-company utility trading history**
 - Histories utility trading and reports via various diagram
 - Calculates optimum trade amount
- Greenhouse emission management**
 - Histories and report green house gas emission
- Energy Intensity**
 - Analyze the cause of plant energy intensity increase
- Optimization**
 - Display and Report energy optimization condition and result
- Equipment Efficiency**
 - Equipment Efficiency calculation and monitoring
 - Analyze abnormal operation cause

ENetOPT: Functional Configuration

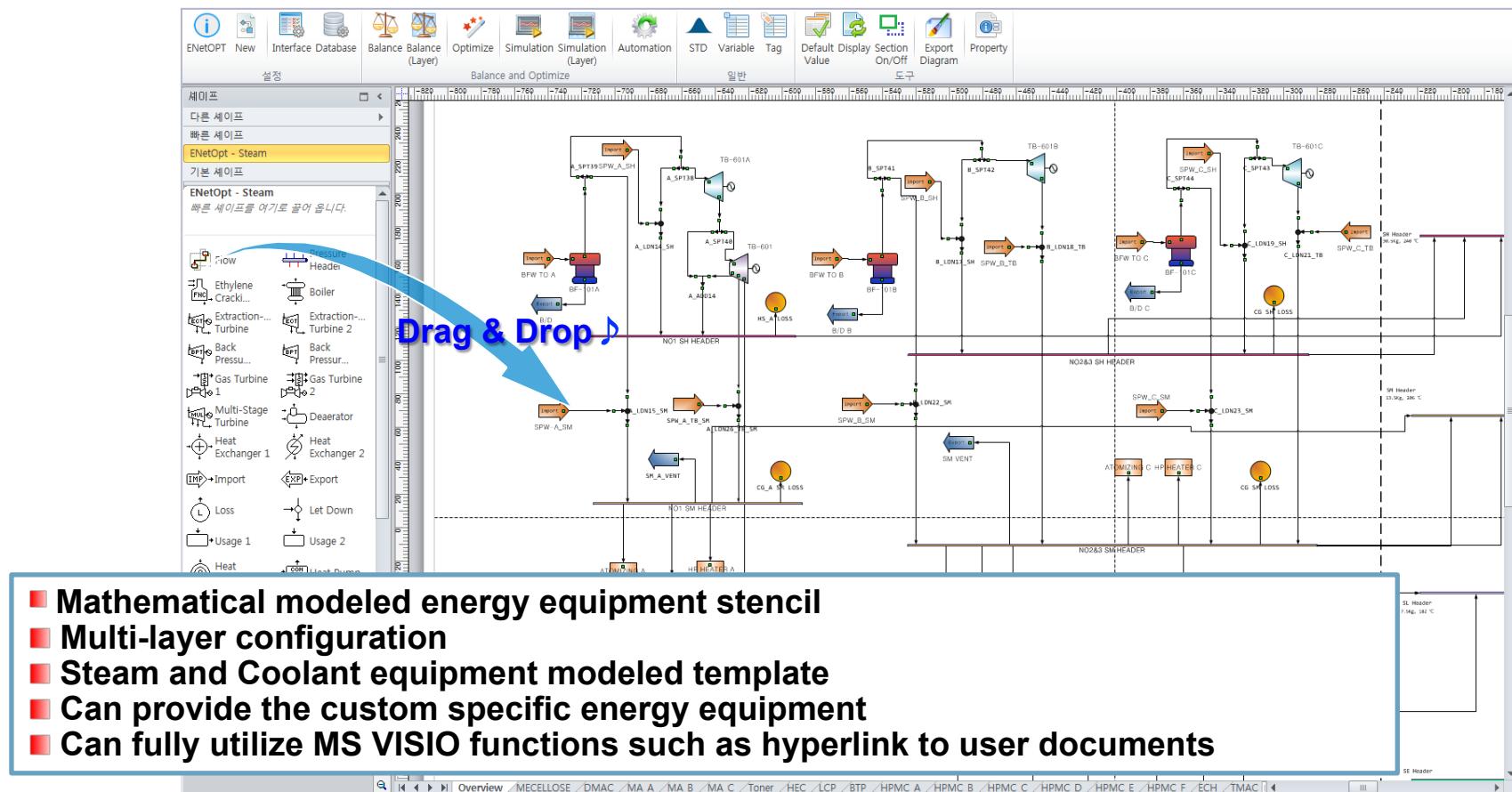


ENetOPT Applied Technology

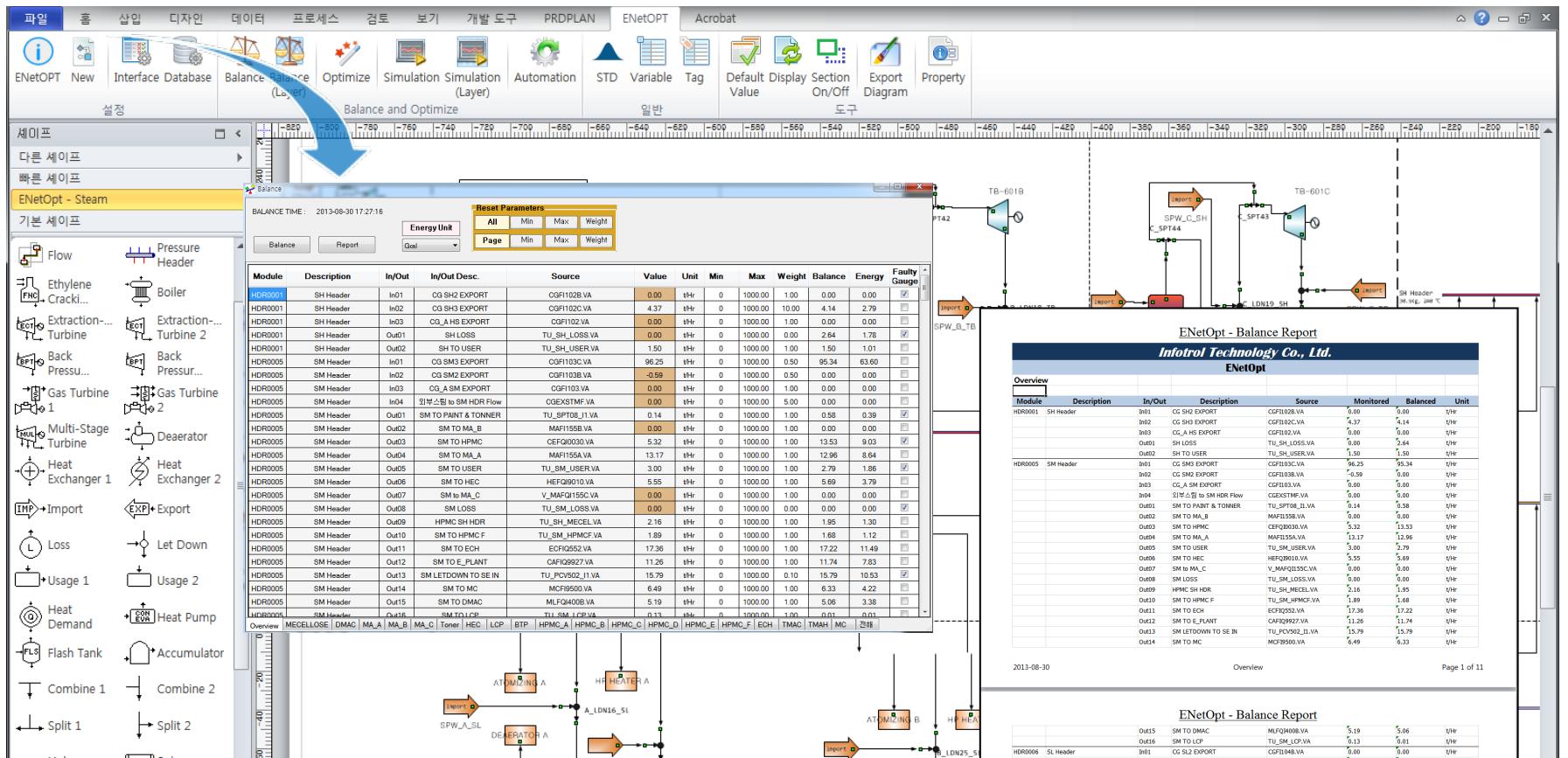


ENetOPT: Visual Modeling

- Easily build the Energy Network by drag & drop energy equipment stencil
 - Easily build and modify the energy network without any hard coding program
 - ENetOPT creates automatically equation based code

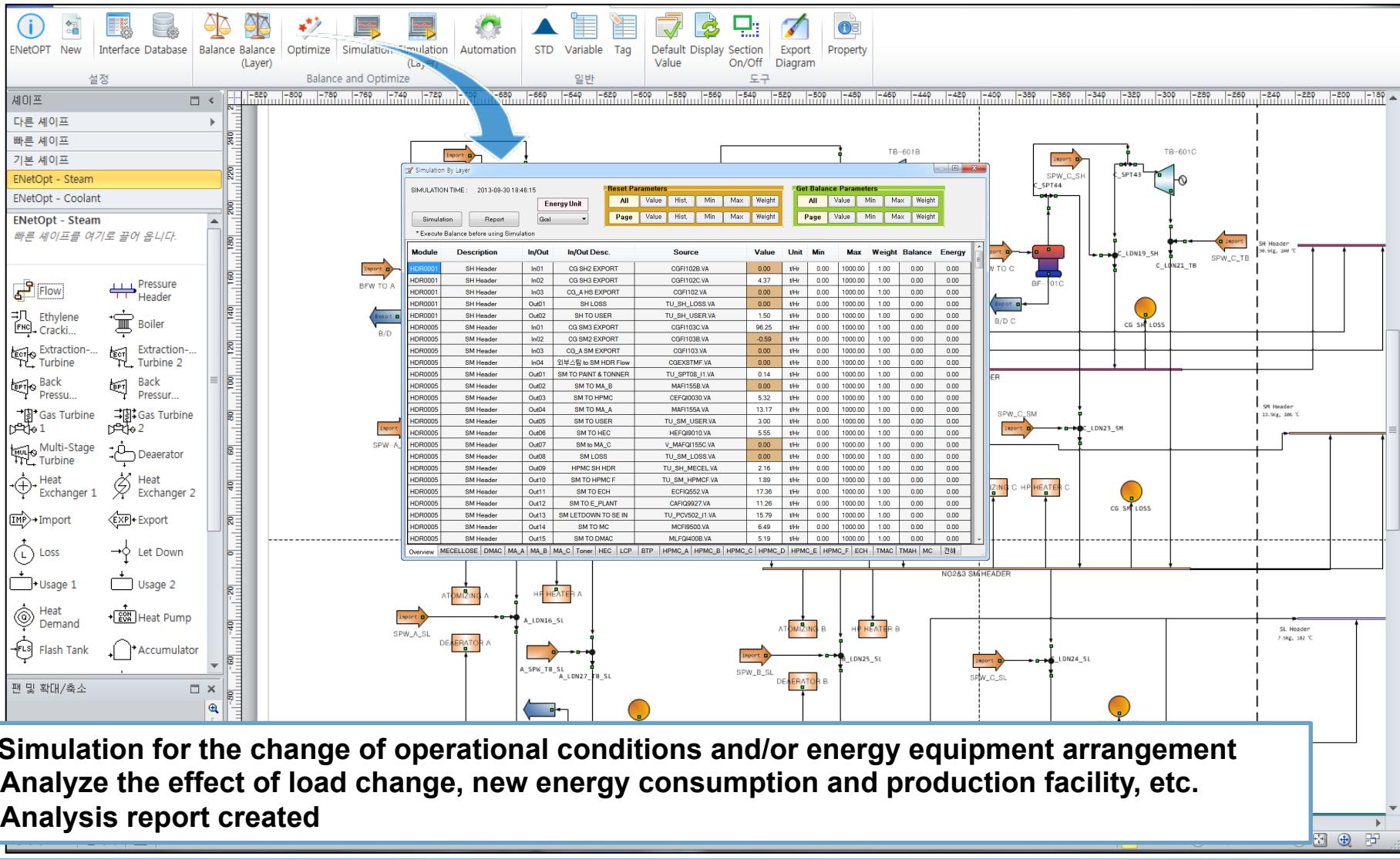


ENetOPT: Plant-wide Energy Balance



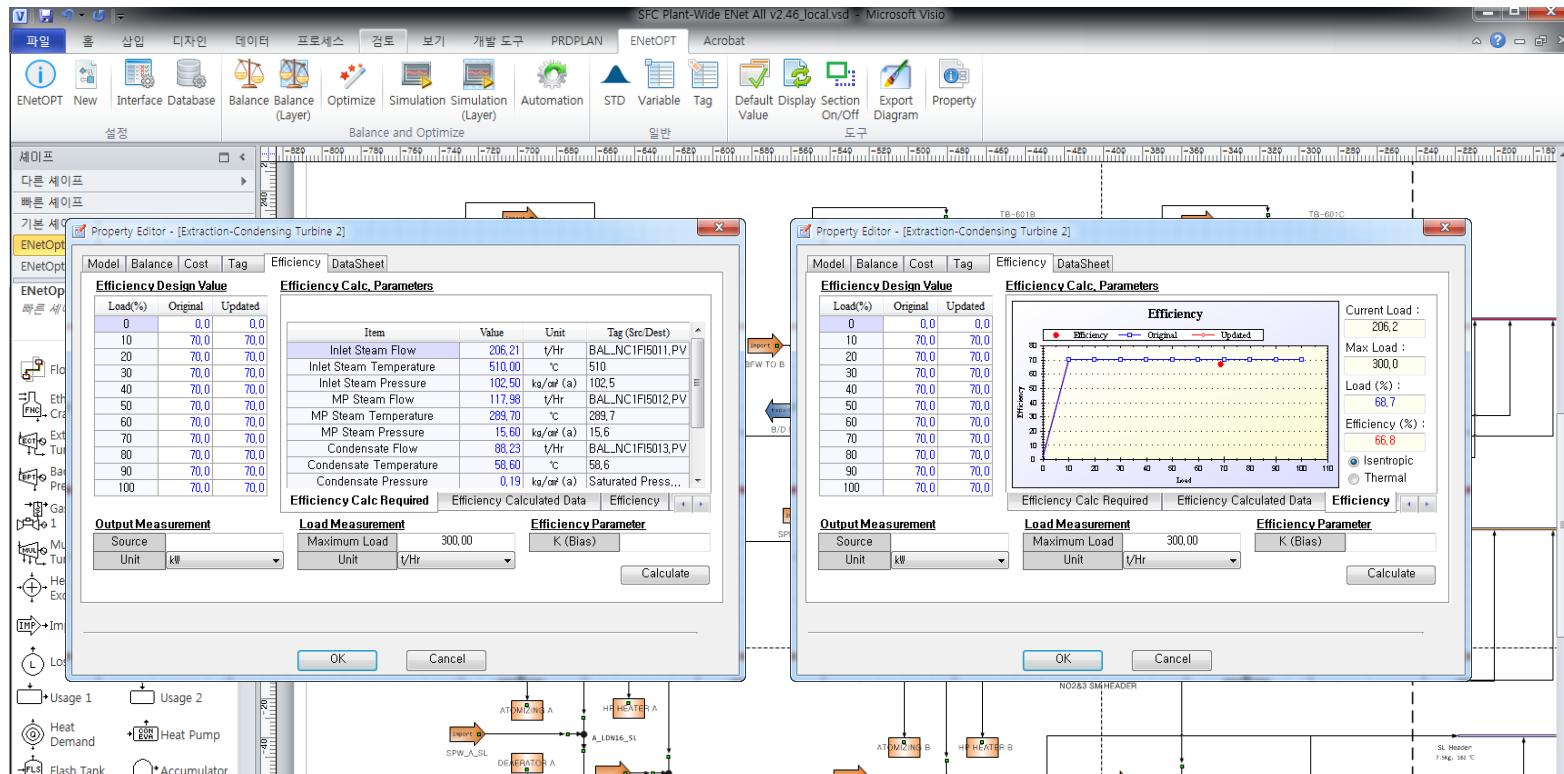
- Data Reconciled material balance and energy calculation based on the status of the flow
 - Balance report created
 - Automatic periodic running at the frequency given by user
 - Use to analyze the energy loss identification, erroneous measurement, etc.

ENetOPT: What-if Simulation



- Simulation for the change of operational conditions and/or energy equipment arrangement
- Analyze the effect of load change, new energy consumption and production facility, etc.
- Analysis report created

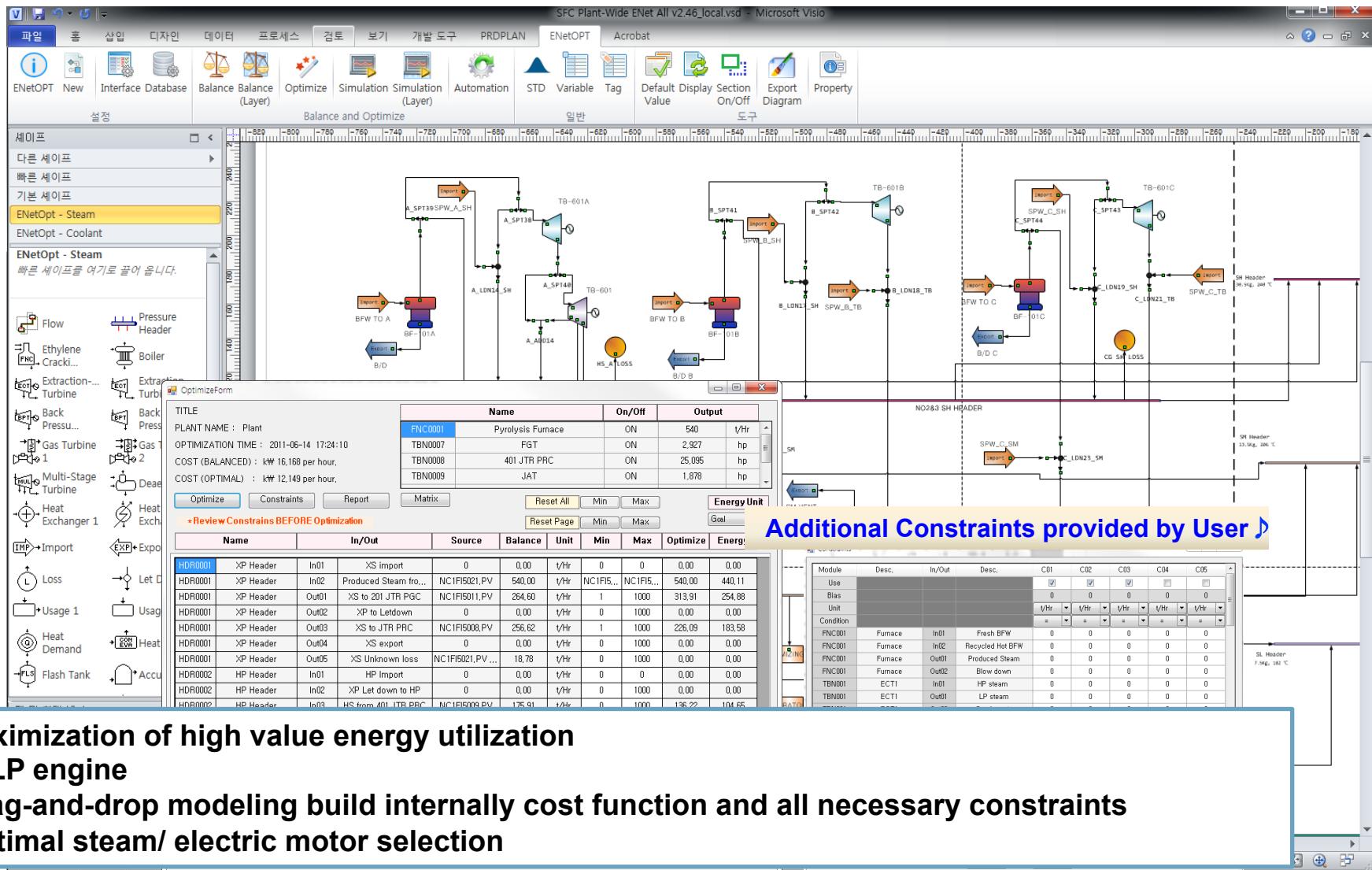
ENetOPT: Equipment Efficiency Management



Calculation and management of each equipment and unit section's performance efficiency

- Early detection of inefficient equipment or unit section
- Analyze the performance trend of each equipment daily, monthly and yearly
- With logical flow chart program such as Infotrol's IPOES to detect the source of efficiency deterioration and to suggest the improvement

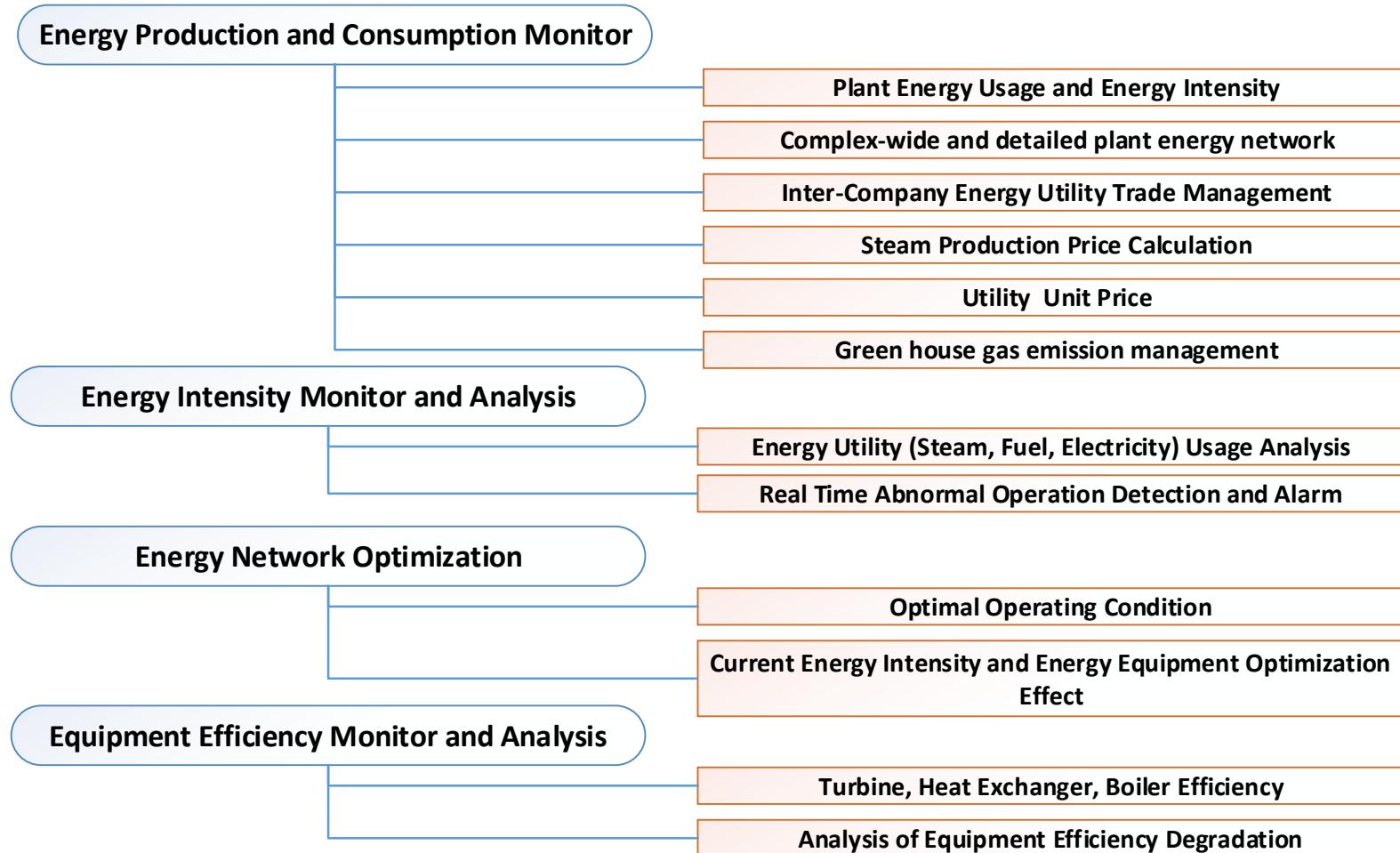
ENetOPT: Optimization



- Maximization of high value energy utilization
- MILP engine
- Drag-and-drop modeling build internally cost function and all necessary constraints
- Optimal steam/ electric motor selection

EMS : Web-based EMS (Energy Management System)

□ HTML5 based Energy Management System configuration



EMS : Energy Produce and Consumption Monitoring

- Plant Energy Usage and Energy Intensity
- Complex-wide and detailed plant energy network
- Utility Cost Calculation
- Energy information including inter-company utility trading and green house gas management

네트워크 | 에너지 등록부 | 최적화 및 문전감시 | 레포트 | 운전정보 | 에너지 경영 | 개시판 | 시스템 관리

2015-06-09 10:42 | << < 기준일 > >> | 자동고침 | 새로고침 | 시간설정 | 매 5분 새로고침 / 5분 평균 데이터 / 1시간 평균 2시간 트렌드

Energy Map

원단위 달성을(%)

105% 이상 100% 이상 95% 이상 90% 이상 85% 이상 80% 이상 80% 미만 S/D

에너지 사용 및 비용 현황 (일간)

구분	에너지 사용		에너지 비용(백만원)
	Ton	Gcal	
스팀	3,780	3,204	252
연료	3,855	45,509	3,709
전력	947	2,386	54
합계	8,582	51,100	4,014

에너지 및 유틸리티 단가 (2015년 6월 단가)

구분	에너지원	단위
전기	전기	원/kWh
	XS	원/Ton
	HS	원/Ton
	MS	원/Ton
	LS	원/Ton
스팀	BRU_CH4	원/Ton
	EG_WASTE_GAS	원/Ton
	EG_GAS	원/Ton
	HDPE_GAS	원/Ton
	LLDPE_CH4	원/Ton
	NBR_CH4	원/Ton
	NCC_C3LPG_FUEL	원/Ton
NCC_FURNACE_CH4	원/Ton	
	SI/Ton	

최적화 결과

ITEM	구분	현재 비용(천원/hr)	최적화 비용(천원/hr)
보일러	#1	0	0
	#2	0	0
	#3	0	-314
	#4	4,323	2,700
	#5	4,511	2,699
	소계	8,834	5,086
STG#1	전력	0	0
	소계	0	0
	STG#2	전력	-264
소계		-264	-264
SS IN		0	0
SS OUT		0	0
HS IN		0	0

EMS : Plant Energy Network Monitoring

- Report current fuel, steam, electricity usage, and trend
- Monitors the cost of energy utility and Greenhouse gas emission
- Induce energy usage reduction

네트워크 에너지 등록부 최적화 및 운전감시 레포트 운전정보 에너지 경영 개시판 시스템 관리

NCC 에너지 사용/비용 일일 현황 (일간 총량 데이터)

구분	항목	에너지 사용			에너지 비용		온실가스	
		단위	전일(A)	현재(B)	증감(B-A)	전일(천원)		현재(천원)
연료	C3LPG_FUEL	Ton	-896,103	-956,385	▼ -60,282	-708,988	-756,682	0,000
연료	C3LPG_FUEL	Gcal	-10,200,339	-10,886,526	▼ -686,187			
연료	Fuel Gas	Ton	148,210	154,640	▲ 6,430			
연료	Fuel Gas	Gcal	1,816,314	1,895,113	▲ 78,800	164,770	171,918	23,244,125
연료	FURNACE_CH4	Ton	1,453,901	1,420,776	▼ -33,125			
연료	FURNACE_CH4	Gcal	18,019,654	17,609,103	▼ -410,551	1,476,946	1,443,296	215,980,861
연료	HDOG	Ton	6,961	6,304	▼ -657			
연료	HDOG	Gcal	78,624	71,204	▼ -7,421	10,031	9,084	0,000
연료	HP_CH4_GTG	Ton	123,379	123,097	▼ -283			
연료	HP_CH4_GTG	Gcal	1,488,697	1,485,287	▼ -3,410	125,335	125,048	17,828,060
연료	ETHANE	Ton	118,427	153,018	▲ 34,591			
연료	ETHANE	Gcal	1,341,659	1,733,541	▲ 391,881	103,248	133,405	0,000
연료	소계	Ton	954,776	901,451	▼ -53,325			
연료	소계	Gcal	12,544,609	11,907,722	▼ -636,887	1,171,342	1,126,069	257,053,047
스팀	XS	Ton	-44,721	-46,287	▼ -1,566	-3,272	-3,396	-711,685
스팀	XS	Gcal	-40,293	-41,704	▼ -1,411			
스팀	HS	Ton	-2,848,780	-2,985,858	▼ -137,079	-200,332	-209,972	-43,310,648
스팀	HS	Gcal	-2,421,463	-2,537,980	▼ -116,517			
스팀	MS	Ton	-3,543,479	-3,653,664	▼ -110,185			

NCC 에너지원별 추이

기간 : 2015-05-10 ~ 2015-06-09 조회 엑셀

NCC 원단위 일일 현황 (일간 총량 데이터)

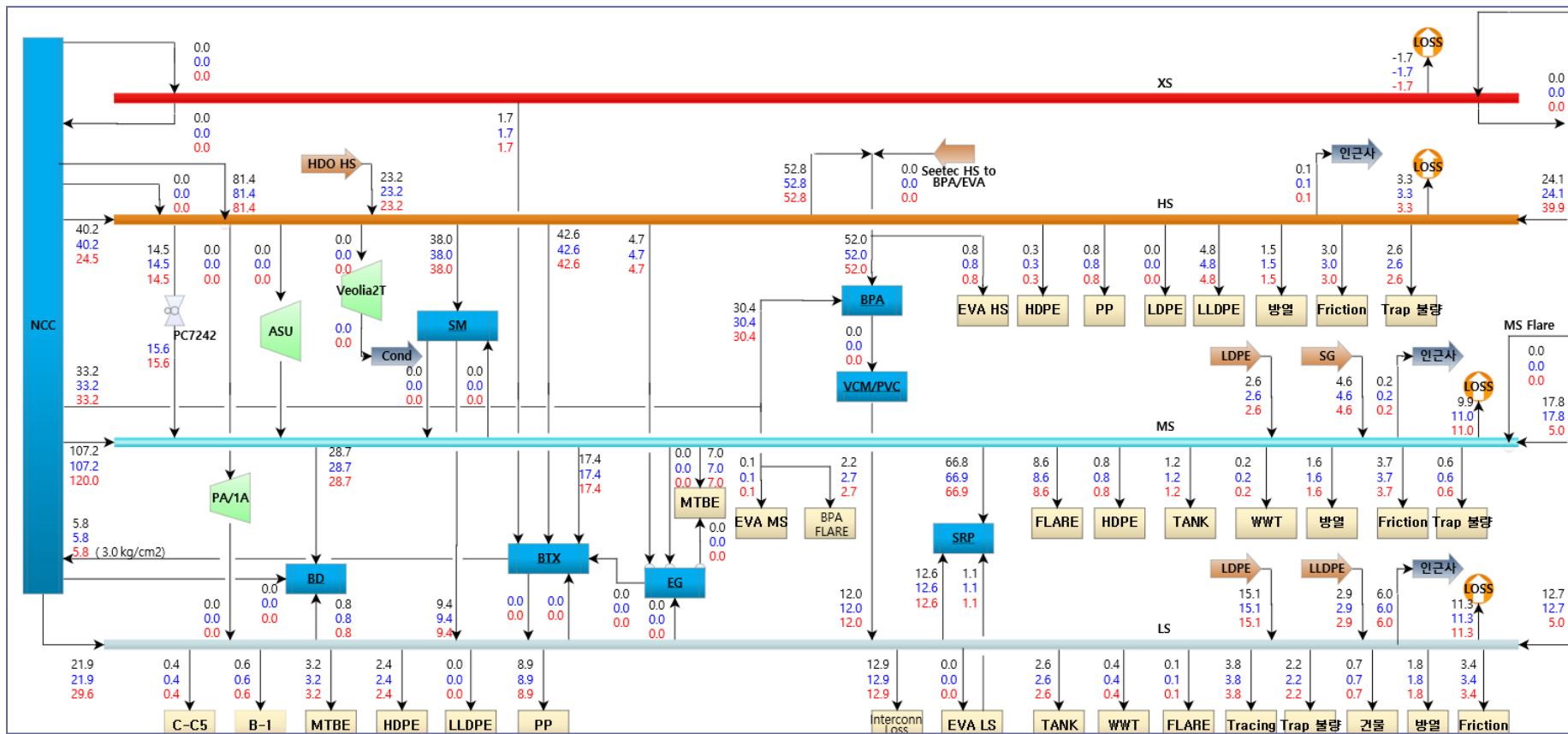
항목	단위	원단위			월 목표	World Best	달성률(%)	상태
		전일(A)	현재(B)	증감(B-A)				
C2	GCAL/TON	0.402	0.120	▼ -0.282	4,384	4,382	197.3	●
C2+C3	GCAL/TON	0.116	-0.145	▼ -0.260			0.0	
FEED	GCAL/TON	0.057	-0.070	▼ -0.126	1,316	1,315	205.3	●

NCC 원단위 추이

기간 : 2015-05-10 ~ 2015-06-09 조회 엑셀

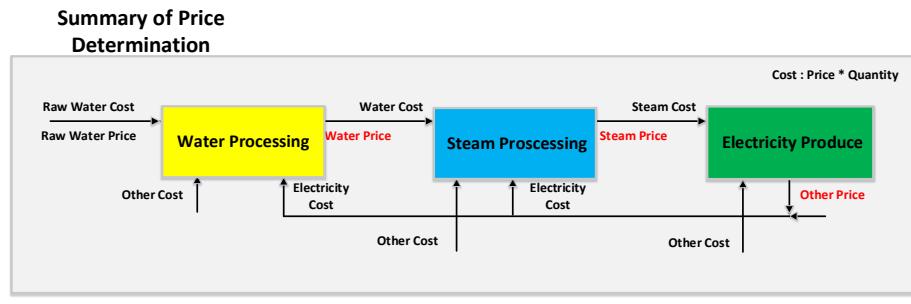
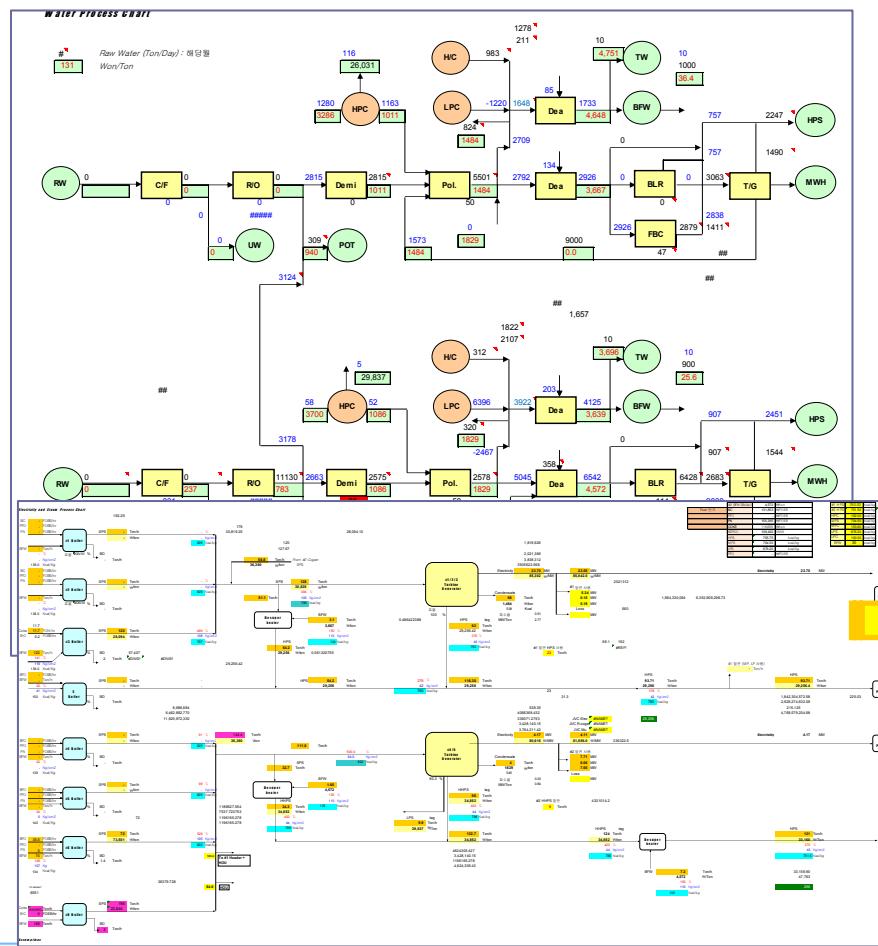
EMS : Energy Network Monitoring

- Complex wide overview energy network summary
 - Detailed plant energy network
 - Steam/condensate measured, balance and optimization result



EMS : Steam Cost Calculation and Management

- Real time and Monthly utility price calculation
 - Water, Steam, Electricity, and Steam price calculation and management
 - Systemize the utility product price calculation



Determination of Price by LS (Linear least squares)

EMS : Inter-company energy utility history

- Reports inter-company energy utility history categorized by product and company
- Calculates Optimum Amount of Trade

에너지관리시스템(EMS)

공정 TII 유필리티 사용량 유필리티 단가 운전관리

Home > 사간거래 > 거래처 > STC

```

graph TD
    HPC[HPC] -- "HPS, MPS, LPS, PWW, BFW, MCW, CCW, UW, FFO, Air, FFG" --> HSB[HSB]
    HPC -- "HPS, MPS, LPS, BFW, MCW, CCW, UW, FFO, Air, FFG" --> KII[KII]
    HPC -- "HPS, MPS, LPS, BFW, MCW, CCW, UW, FFO, Air, FFG" --> HDO[HDO]
    HSB -- "HPS, MPS, LPS, MPC, LPC, F/G" --> KII
    HSB -- "HPS, MPS, LPS, MPC, LPC, F/G" --> HDO
    KII -- "HPS, MPS, LPS, BFW, MCW, CCW, UW, FFO, Air, FFG" --> HDO
    KII -- "HPS, MPS, LPS, BFW, MCW, CCW, UW, FFO, Air, FFG" --> STC[STC]
    HDO -- "HPS, MPS, LPS, MPC, LPC, F/G" --> STC
    HDO -- "HPS, MPS, LPS, MPC, LPC, F/G" --> HCP[HCP]
    STC -- "MPS, LPS, MPC, LPC, F/G" --> HCP
  
```

EMS 관리자 (시스템관리자) [로그아웃]

HOME | SITEMAP

● 사간거래 > 거래처 > STC

조회날짜: 2014-08-24

품목	구분	항목	단위	누적			정산			비고
				현월	전월동기간	차이	현월예정	전월결과	차이	
고순도수소	구매	골급 물량	Nm3	22,821,405	15,533,216	7,288,189	20,936,074		20,936,074	
	구매	정산단가	원/Nm3	247	247	0	247		247	
수소혼합가스	구매	거래금액	원	234,468,311	159,589,073	0	215,098,316		215,098,316	
	구매	거래량	MT	2,218,911	2,445,429	-226,518	3,296,013		3,296,013	
	구매	열량단가	원/MT	1,926,553	1,926,553	0	1,926,553		1,926,553	
	구매	#2 PSA 수소 생산물	Nm3	12,460,975	12,913,056	-452,081	17,404,554		17,404,554	
	구매	거래마일 배분	원/Nm3	1,027	996	31	1,027		1,027	
	구매	거래금액	원	171,466,698,300	188,911,295,500	0	254,619,572,196		254,619,572,196	

Item	Remark
Company & Product	Histories inter-company energy utility categorized by company and product
Trade Scheme	Report Trade quantity using various diagram
Report	Generate Trade quantity report in monthly or in user defined interval

EMS : Green house gas emission management

- ❑ Histories basic green house gas emission data
- ❑ Report Greenhouse gas emission



에너지 관리 시스템(EMS)

EMS 관리자 (시스템 관리자) 로그인

온정 대 | 유필리티 사용량 | 유필리티 단가 | 온천관리 | 시각화 | 온실가스 | 시스템 관리 | HOME | SITEMAP

Home > 온실가스 > 배출량

온실가스 배출량 > 배출량 실적

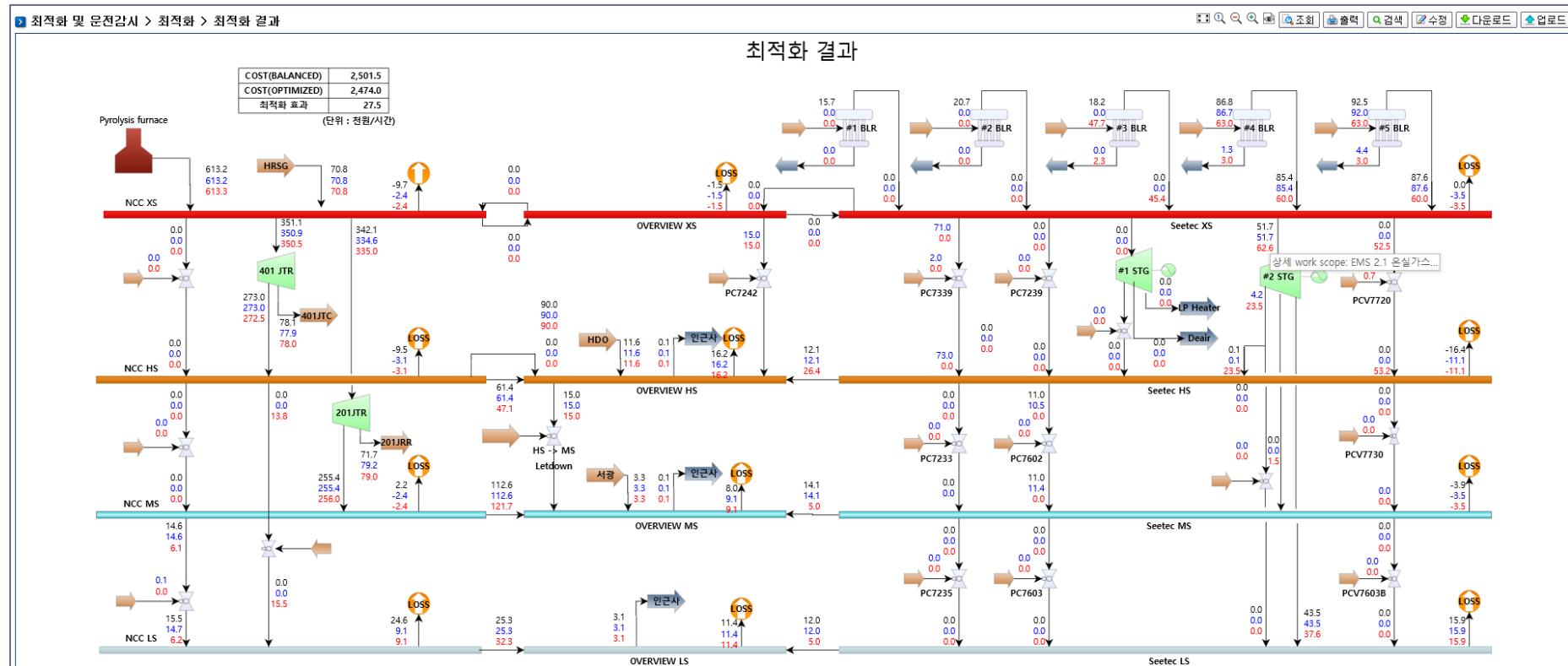
날짜: 2014-01-01 ~ 2014-08-24 | 조회: [수정] [목록]

구분	부분	팀	과	공정	배출시설	연료명	단위	연료 사용량	CO2(ton)	CH4(kg)	N2O(kg)	tCO2eq		
고정원출	HDD	정유 1팀	#1 CDU	HF1001	B-C	Nm ³	8,912	21,520	382	38	23,590			
			#1 VDU	HF1002	B-C	L	0	0	0	0	0	0	0	
			#1 DCU	HF1101	B-C	L	0	0	0	0	0	0	0	
			#1 HMU	HF1151	#1 F/G	Nm ³	3,355	8,123	144	14	8,130			
			#1 HCU	HF1601	#1 F/G	Nm ³	7,160	17,307	307	31	17,323			
			#1 PLT	HF2001	Naphtha	L	0	0	0	0	0	0	0	0
			#1 HCR	HS1901	#1 F/G	Nm ³	339	821	15	1	822			
			#1 HMU	HS1993	#1 F/G	Nm ³	2,399	5,783	102	10	5,789			
			#1 HCU	HS2001	#1 F/G	Nm ³	3,842	9,305	165	16	9,313			
			#1 TGU	HF1601	#1 F/G	Nm ³	884	2,135	38	4	2,137			
제조부문	HDD	정유 2팀	#1 PLT	HF1602	#1 F/G	Nm ³	407	985	17	2	987			
			#1 GHT	HF1602	#1 F/G	Nm ³	471	1,141	20	2	1,142			
			#1 SRU	HF1603	#1 F/G	Nm ³	187	454	8	1	454			
			#1 TGU	HF1701	#1 F/G	Nm ³	637	1,545	27	3	1,546			
			#1 SRU	HL2201	#1 F/G	Nm ³	92	225	4	0	226			
			#1 TGU	HL2202	#1 F/G	Nm ³	9	22	0	0	22			
			#1 SRU	HL2203	#1 F/G	Nm ³	8	20	0	0	20			
			#1 TGU	HL2301	#1 F/G	Nm ³	232	562	10	1	563			
			#2 SRU	HLB2201	#2 F/G	Nm ³	620	1,502	27	3	1,503			
			#2 TGU	HLB2202	#2 F/G	Nm ³	2	1	0	0	1			
#2 SRU	HLB2301	#2 F/G	Nm ³	0	0	0	0	0						
#2 TGU	HLB2302	#2 F/G	Nm ³	273	341	6	1	342						
#2 SRU	HNB2302	#2 F/G	Nm ³	432	501	9	1	502						

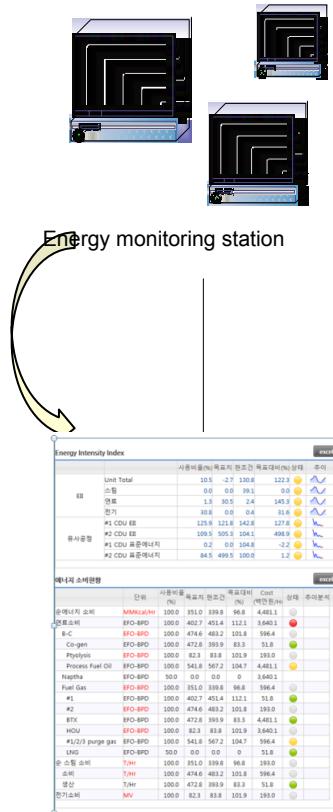
항목	내용
Summary	Emission
	Manage allowable emission quantity, accumulation in month term
	Emission Report by Sector
Emission Report by Team	Manage greenhouse gas emission categorized by plant (Monthly Trend)
Company wise emission report	Report fuel usage and emission categorized by plant and equipment

EMS : Energy Network Optimization

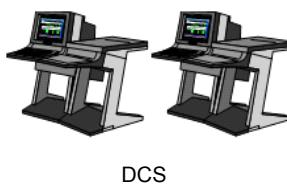
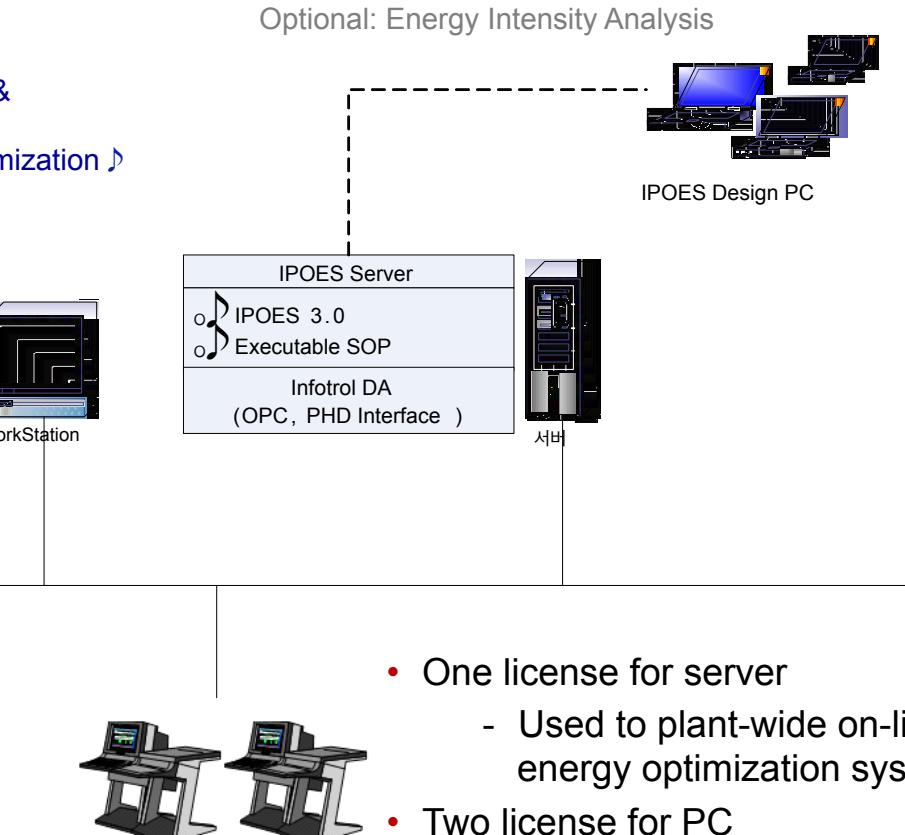
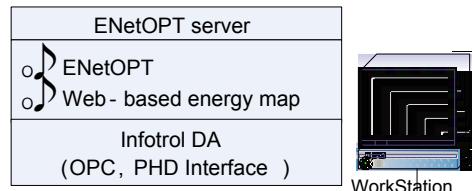
- Displays the result of energy network operating cost optimization
- Report Optimum Operating Cost
- Optimization can be interfaced to DCS



Typical System Configuration



Web based Energy Monitoring & Management:
- Field Data, Balance and Optimization ↗



- One license for server
 - Used to plant-wide on-line energy optimization system
- Two license for PC
 - Used normally for design, simulation and off-line optimization

Issues and direction

ENetOPT

Steam mass balance

- For mass (steam/condensate) imbalance, it is not so sure whether it is caused by measurement error, or any loss, or tracing and/or tracking, etc.
- Unmeasured value is estimated, but the balanced value for the estimated value is changed significantly according to the operational condition.
- Gross error detection is very difficult since in most cases, measurement redundancy is not so sufficient

→ **Input data analysis for erroneous measurement**

→ **Gross error detection with logical analysis, statistical approach, and any neural and artificial approach**

Optimization

- It is necessary to include the planning functionality for On/Off and swing operation and minimum operating and standby times of the equipment
- It is frequently asked to show the bottleneck constraint

→ **Integrate utility planning and optimization**

→ **Search for active constraints**

Issues for the site application

EMS

Energy Intensity

- Root cause for energy intensity change of the plant is asked from clients
- It is necessary to compare the utility diagram and Process diagram

→ Statistical approach

Equipment performance

- User asked what is the main reason for the performance depreciation

→ Logical analysis for possible reason

Steam price

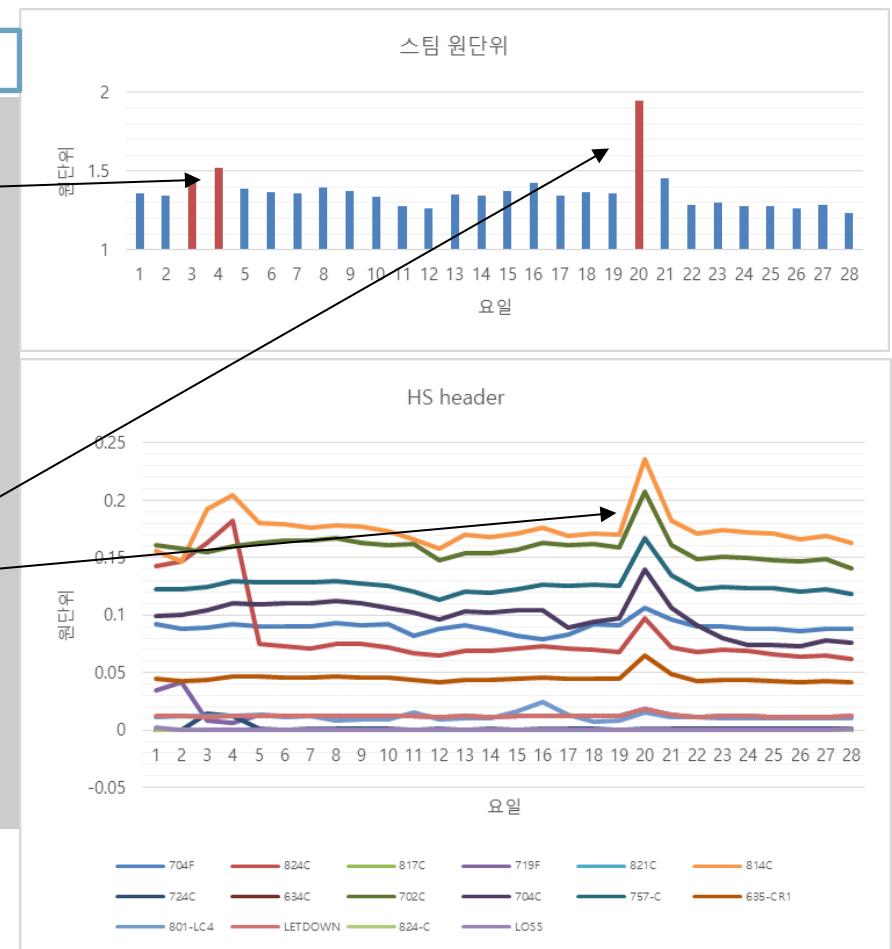
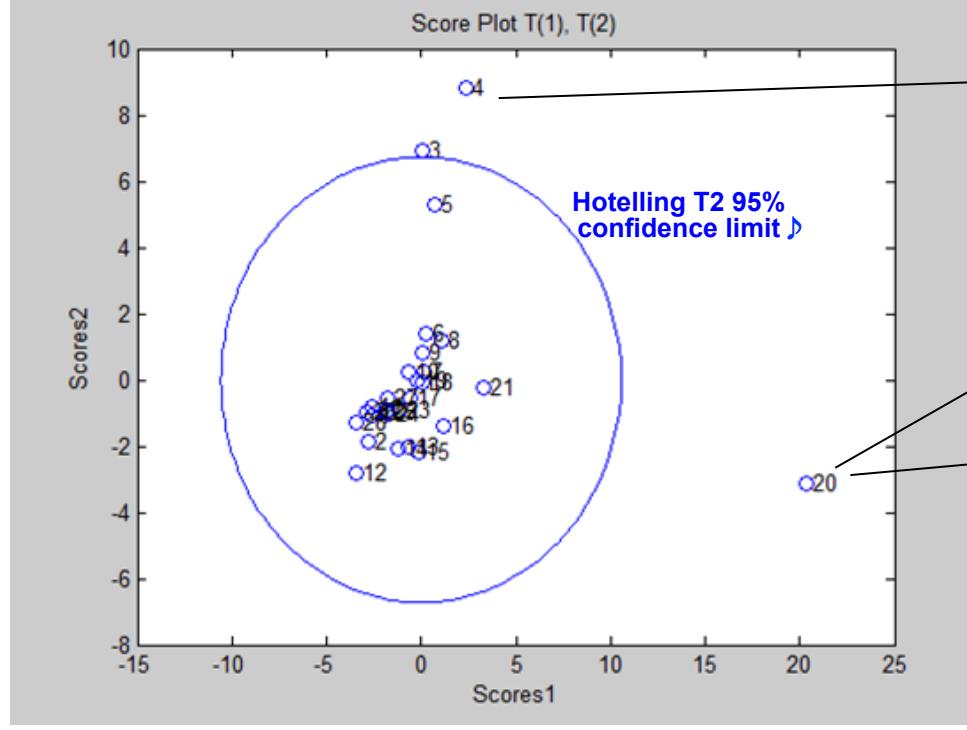
- It is necessary to calculate the steam price for each unit in real time

→ Real time estimation of steam value

EMS : Energy Intensity Analysis

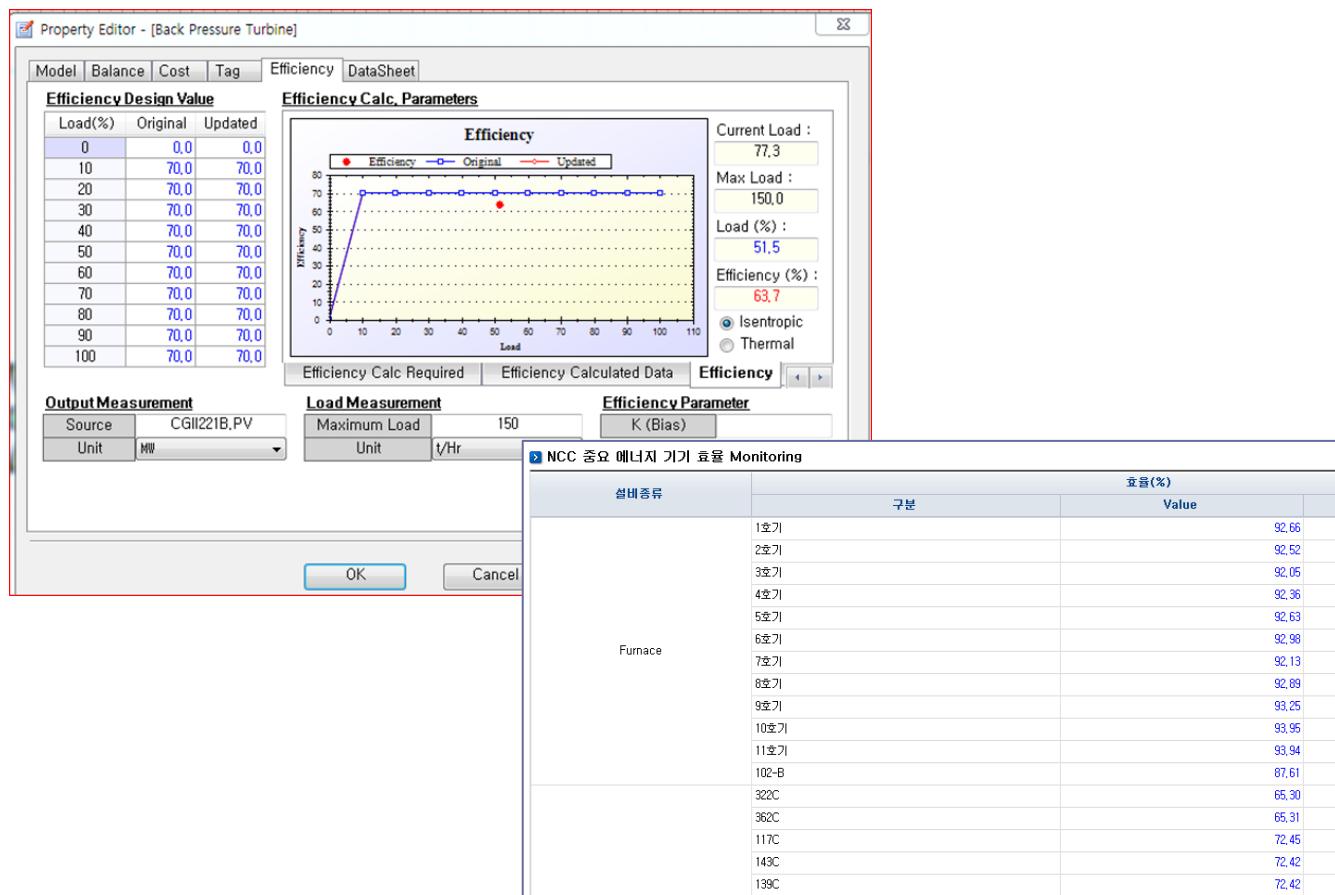
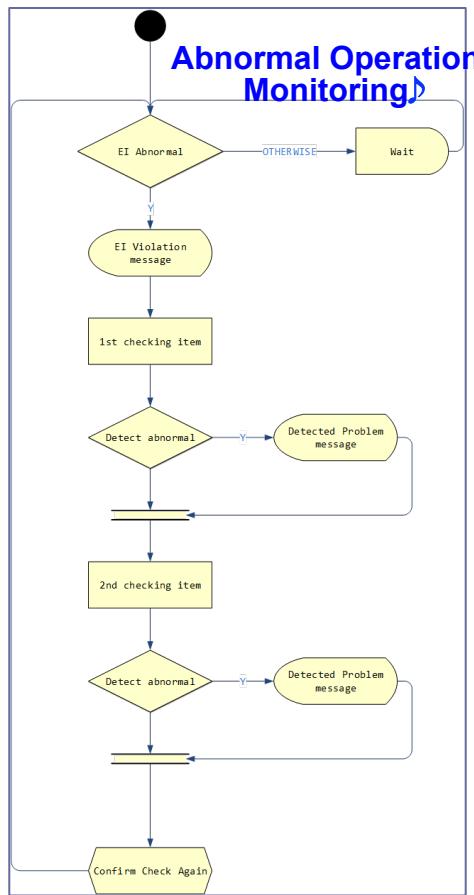
- Analyze the cause of plant energy intensity increase
- Reduced dimensional analysis by statistics

Real Time Reduced Dimensional Analysis



EMS : Energy Equipment Efficiency Monitoring and Analysis

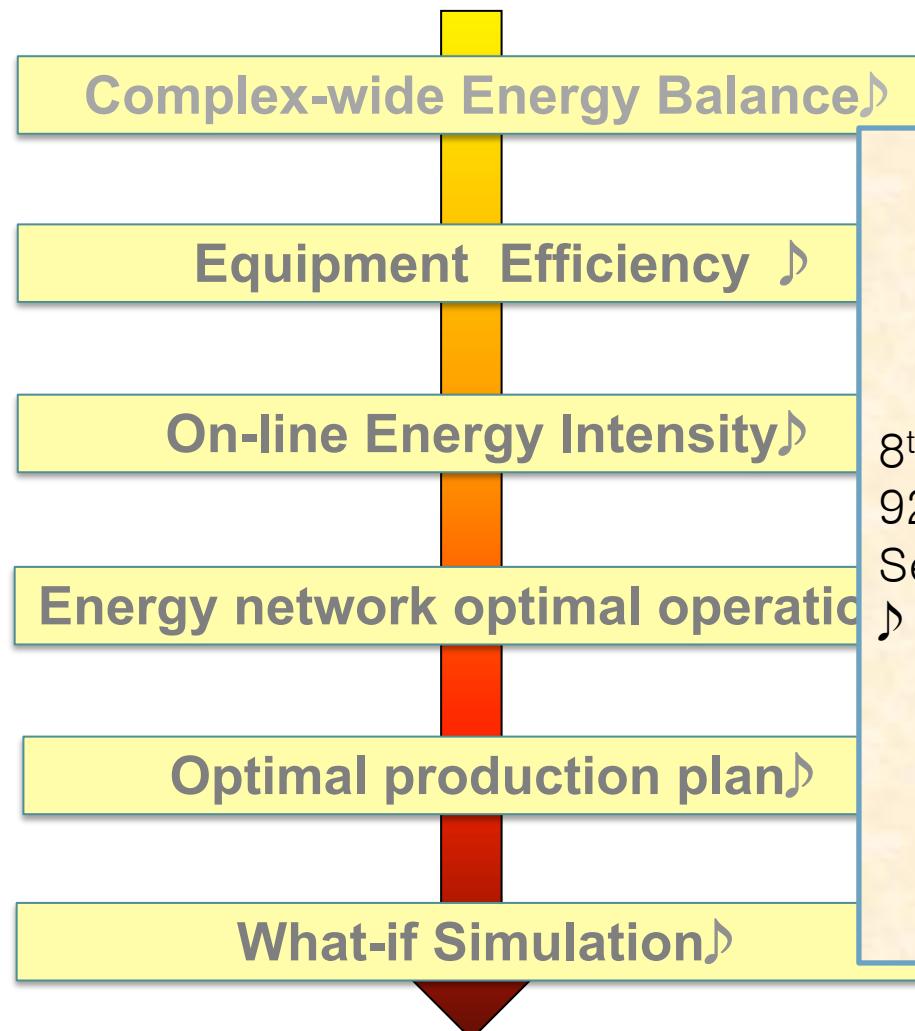
- ❑ Main Energy Equipment Efficiency Calculation
- ❑ Main Energy Equipment Efficiency Monitoring
- ❑ Analyze Abnormal Operation Cause



Conclusion

- **Typical approach of Energy Network optimization and management is well established**
 - Data reconciliation based energy balance
 - Energy Network optimization covering heat, electricity, fuel gas and hydrogen
 - Energy management of monitoring energy production and consumption
- **Further enhancement of energy network optimization**
 - Gross error detection for the balance
 - Energy Network optimization with planning functions
- **Further enhancement of energy management system**
 - Targeting on energy intensity reduction
 - Energy intensity analysis to figure out the root cause of inferior energy performance
- **Eventually extend to energy network of other industries and covering city**

ENetOPT, ENetPlan, ENetDisplay, IPOES & HIECON-I



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