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Printing material

From FEMS to IoT

～ Utilization of Energy-Saving Equipment in Our Factories ～

14 November 2018

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Contents

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Contents

1-1. Standards of Judgment of the Energy Saving Law

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Standards for rationalization of energy use

Regulates standards for 1) management, 2) measurement and recording, 3) maintenance and inspection, and 4) new measures, for all processes related to the use of energy

(1) Rationalization of combustion of fuels
(2) Rationalization of heating and cooling as well as heat transfer
(3) Recovery and utilization of waste heat
(4) Rationalization of conversion of heat into power
(5) Prevention of energy loss due to emission, conduction, resistance, etc.
(6) Rationalization of conversion of electricity into power, heat, etc. → Air compressors, etc.

Targets and measures to be taken systematically for rationalization of energy use

Regulates matters that businesses must examine and implement for major facilities

(1) Combustion facilities
(2) Heat-using facilities
(3) Waste heat recovery equipment
(4) Co-generation facilities
(5) Electricity-using facilities
(6) Air-conditioning, water heating, ventilation and raising and lowering equipment
(7) Lighting
(8) Factory energy monitoring systems

1-2. Industrial equipment management standards based on standards of judgment (air compressors)

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Management standards (Kanto Bureau of Economy, Trade and Industry)

Energy management standards based on the Energy Saving Law	**Management standards for "air compressors" (example)**	整理番号：A-2 改訂：　頁：1/1

1. Target
These energy management standards are aimed achieving rationalization of energy use via appropriate operation management, measurement and recording, maintenance and inspection and new measures based on Article 4 of the Act on Rationalizing Energy Use and notifications on "standards of judgment".
2. Scope of application
To be applied to air compressors installed in factories, etc.

Item	Details	Standards of judgment number	Management standard	Reference manual
Operation management	**1. Power using equipment** (1) Shut down when not needed (2) Adjust numbers in operation, appropriate allocation of load factor (3) Adjustment to discharge and discharge pressure by equipment: number control, change in frequency, change in piping, impeller cut and rotation control (4) Adjust voltage, current and frequency for each electric equipment (when carrying out inverter control)	(6-1)(1)ア (6-1)(1)イ (6-1)(1)ウ (6-1)(1)オ	・Define "not needed" times ・Adjustment methods ・Set up management of number of equipment pieces, speeds ・Management of rated value	Operation management manual
Measurement and recording	**1. Power using equipment** (1) Recording of voltage at power supply, current, frequency (for inverter control) (discharge, discharge pressure and shaft power as necessary)	(6-1)②	・Items, frequency	Logbook
Maintenance and inspection	**1. Power using equipment** (1) Less mechanical loss at power transmission parts ① Grease up of shaft and bearing parts as needed at the time of inspection ② Routine inspection and repair of shaft sealing (2) Lessen leakage prevention pipe resistance ① External inspection of machinery, leakage inspection of pipe connection parts ② Check for pipe obstruction and optimization of pipe size from pressure gauges upstream and downstream of pipes	(6-1)(3)ア (6-1)(3)イ	・Inspections per day ・Inspections per year ・Inspections per day ・Inspections per year	Maintenance/ Inspection manual Logbook
New measures	1　Introduction of measure to facilitate adjustment of operation state according to load change, such as rotation control device	(6-1)(4)		

改訂履歴	改訂年月日	改定内容	作成	承認
承認		照査	作成	実施年月日 制定年月日

※出典元：経済産業省関東経済産業局HP「管理標準の作成例」より抜粋

1-2. Industrial equipment management standards based on standards of judgment (air compressors)

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Management standards (our company)

Energy management standards	Management standards for compressors	整理番号	06
		改定・初版	頁：1/1

1. Equipment
These are energy management standards on operation/management, measurement/recording, maintenance/inspection are aimed at appropriate management and rationalization of energy use for "-factory's compressor equipment.
2. Scope of application
All compressors in "-factory

Item	Details	Standard of judgment	Management standard
Operation/ Management	1. Operation/Management 1) Compressors only operated upon air supply request form, otherwise are shut down. 2) Operation controlling number of equipment pieces based on pressure detection of air piping for standard machines 3) Operate 1 inverter to respond to load change amount 4) Rated voltage, current value within ±10% 5) Ventilation to prevent compressor room temperature from exceeding 40℃ 6) Do not place items within 1m around the compressor	6-1(1)①	
Measurement/ Recording	1. Measurement/Recording	6-1(2)	
	1) Operation time		Once/day
	2) Discharge pressure		Once/hour
	3) Oil temperature		Once/hour
	4) Voltage		Once/hour
	5) Current		Once/hour
Maintenance/ Inspection	1. Maintenance/Inspection	6-1(3)①	
	1) Amount and contamination level of lubricating oil		Once/month
	2) Insulation resistance		Once/year
	3) Wear and tear of power transmission parts		Once/year
	4) Air leaks from piping	6-1(3)②	Once/month
Measures for new installations	1. Measures for new installations 1) Application of high efficiency compressors (inverters) 2) Adoption of efficient method after deliberation on centralized/dispersed methods 3) Adopt efficient pipe size and routes based on pressure loss	6-1(4)	

改定履歴	改定年月日	制定・改定理由	作成	承認
承認		照査	作成	実施年月日 制定年月日

1-3. 【Reference】 “Long-term energy supply and demand outlook” EM Overall Image

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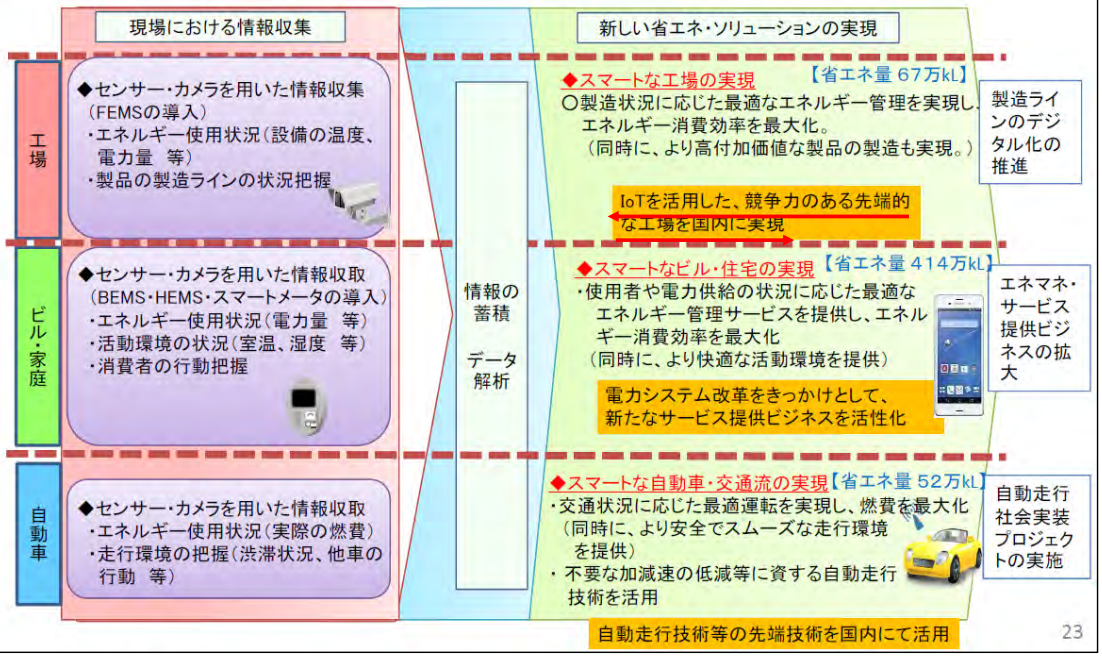
（参考）エネルギーマネジメントの全体像

エネルギーマネジメントの実現　～「我慢の省エネ」から「スマートな省エネ」へ

○センサー情報やネットワークを活用して情報収集を行い、そのデータの解析と課題解決手法を開発することで、競争力のある最先端の工場の実現、ビル・家庭に対し最適環境を提供するサービスを行うビジネスの活性化、社会システムとしてよりスムーズな交通流の実現を目指す。



※出典元：平成27年7月 資源エネルギー庁発行「長期エネルギー需給見通し関連資料」より抜粋

1-4. 【Reference】 “Long-term energy supply and demand outlook” on FEMS

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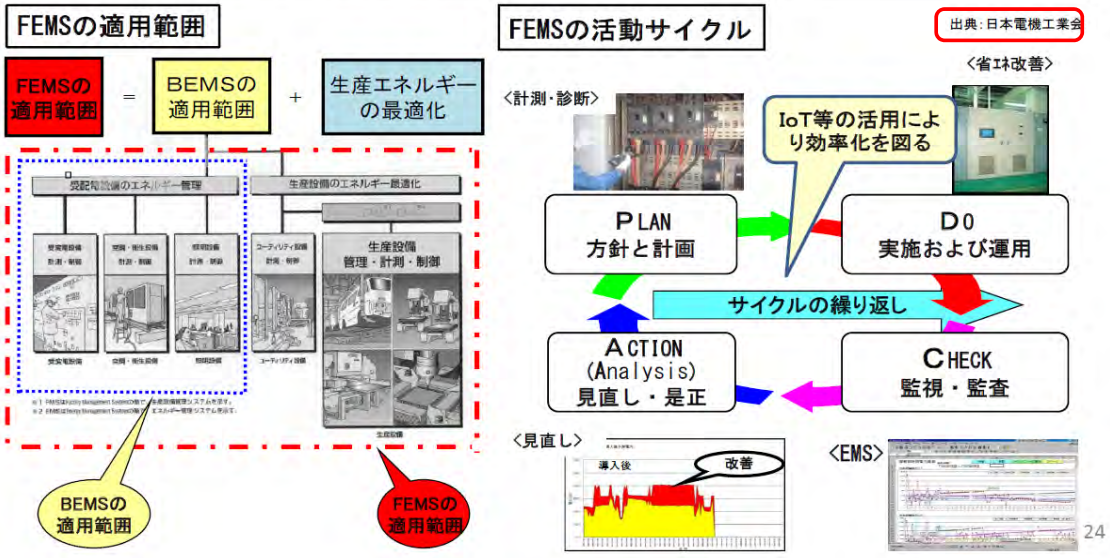
（参考）産業部門における徹底的なエネルギー管理の実施（FEMS等を用いたエネルギーマネジメントによる運用改善）

- 工場における生産設備のエネルギー使用状況・稼動状況等を把握し、エネルギー使用の合理化および工場内設備・機器のトータルライフサイクル管理の最適化を図るためにFEMS（Factory Energy Management System）の普及が必要
- 生産設備等をセンサーなどで計測・診断・解析するなどIoT（Internet of Things）を活用することで、柔軟な生産や設備の予知保全を行うことでエネルギー原単位の向上を図る。



※出典元：平成27年7月 資源エネルギー庁発行「長期エネルギー需給見通し関連資料」より抜粋

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Contents

2-1. (Generation Zero) Logging by manual meter-reading (recording & storage)

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【Objective】
1. Allocation of power to each division

【Manual meter reading】
1. Frequency : once/month
2. Personnel : 2 persons
3. Target circuits : about 100 circuits
4. Work content

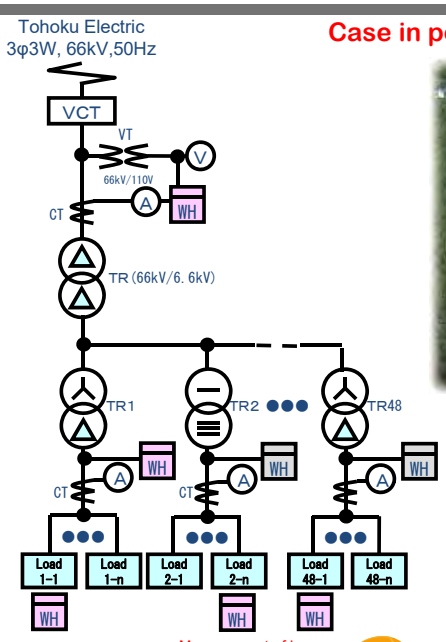
(1) Read integrating wattmeter (integrated value) and make handwritten note

(2) Copy current month's meter value (integrated value) onto energy use monthly report

(3) Subtract previous month's meter value from current month's meter value to calculate current month's power usage

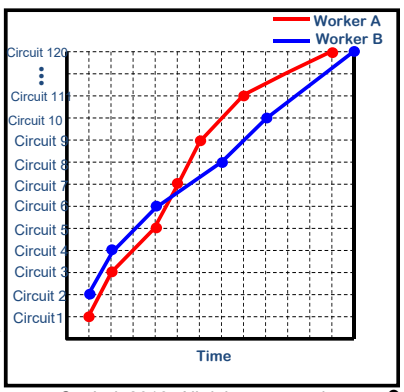
(4) Double check current month's usage (recalculate)

【Issues】
1. Point data once a month
2. No synchronism in power amounts for each circuit (off and on manner)
3. Hand written, manual calculations leave room for error



Case in point: our company's Nakajo plant

Meter time chart



2-2. (1st Generation) Power monitoring system (H-NET) configuration

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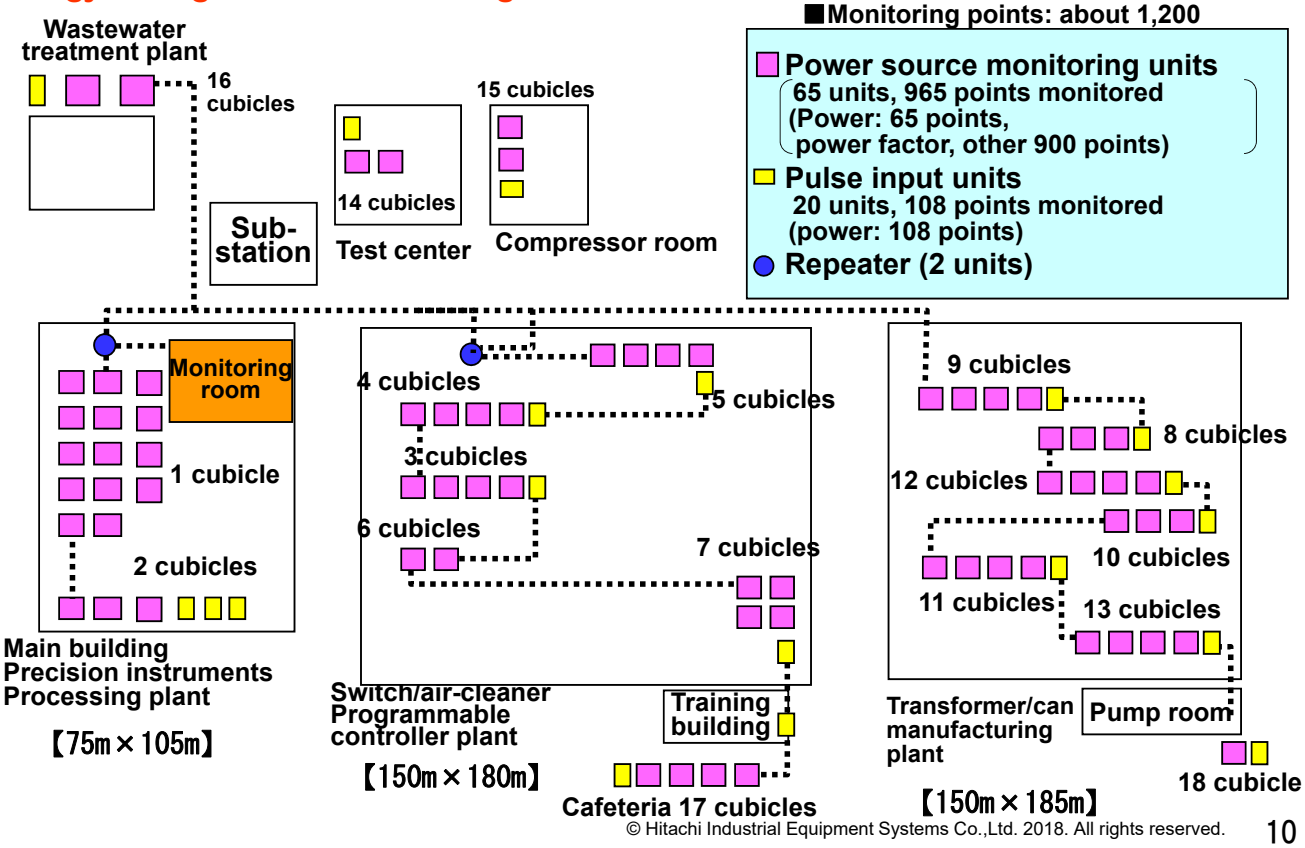
《Energy-saving starts with knowing actual conditions》 ■Monitoring cable length: about 4,000m
■Monitoring points: about 1,200



2-3. (1st Generation) Power monitoring system (H-NET) Map 1/2

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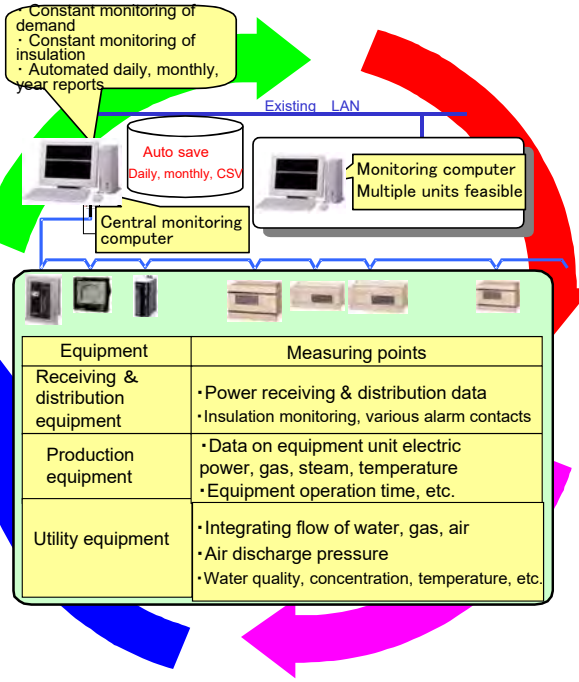
Energy-saving starts with knowing actual conditions
Utility monitoring/Insulation monitoring (H-NET system)

PLAN
《Energy-saving/Preventative maintenance master plan》
- Creation of measurement and weighing systems
- Changing to energy-saving equipment
- Consolidation of incoming and transforming/utility equipment
- Improved power factor
- Repairs to insulation degradation detection equipment

DO
- Installation of utility monitoring units
- Installation of insulation monitoring units
- Introduction of super amorphous transformer
- Appropriate number of units
- Installation of condenser for power factor improvement

CHECK
- Analysis of current conditions and confirmation of results based on H-NET system data
- Monitoring the state of current, voltage, power factor demand, etc.
- Monitor state of insulation of equipment

ACTION
- Based on data analysis determine problems and responses and create next equipment improvements



2-3. (1st Generation) Power monitoring system (H-NET) Map 2/2

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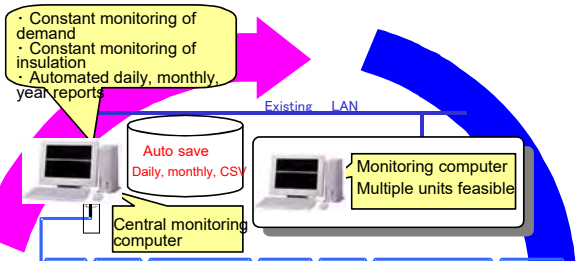
Energy-saving starts with knowing actual conditions
Utility monitoring/Insulation monitoring (H-NET system)

C HECK
- Analysis of current conditions and confirmation of results based on H-NET system data
- Monitoring the state of current, voltage, power factor demand, etc.
- Monitor state of insulation of equipment

・Constant monitoring of demand
・Constant monitoring of insulation
・Automated daily, monthly, year reports



A CTION
- Based on data analysis determine problems and responses and create next equipment improvements

Equipment	Measuring points
Receiving & distribution equipment	・Power receiving & distribution data ・Insulation monitoring, various alarm contacts
Production Equipment	・Data on equipment unit electric power, gas, steam, temperature ・Equipment operation time, etc.
Utility equipment	・Integrating flow of water, gas, air ・Air discharge pressure ・Water quality, concentration, temperature, etc.

D O
- Installation of utility monitoring units
- Installation of insulation monitoring units
- Introduction of super amorphous transformer
- Appropriate number of units
- Installation of condenser for power factor improvement

P LAN
《Energy-saving/Preventative maintenance master plan》
- Creation of measurement and weighing systems
- Changing to energy-saving equipment
- Consolidation of incoming and transforming/utility equipment
- Improved power factor
- Repairs to insulation degradation detection equipment

Changing the order a bit

2-4. (1st Generation) Power monitoring system (H-NET) Energy-saving performance

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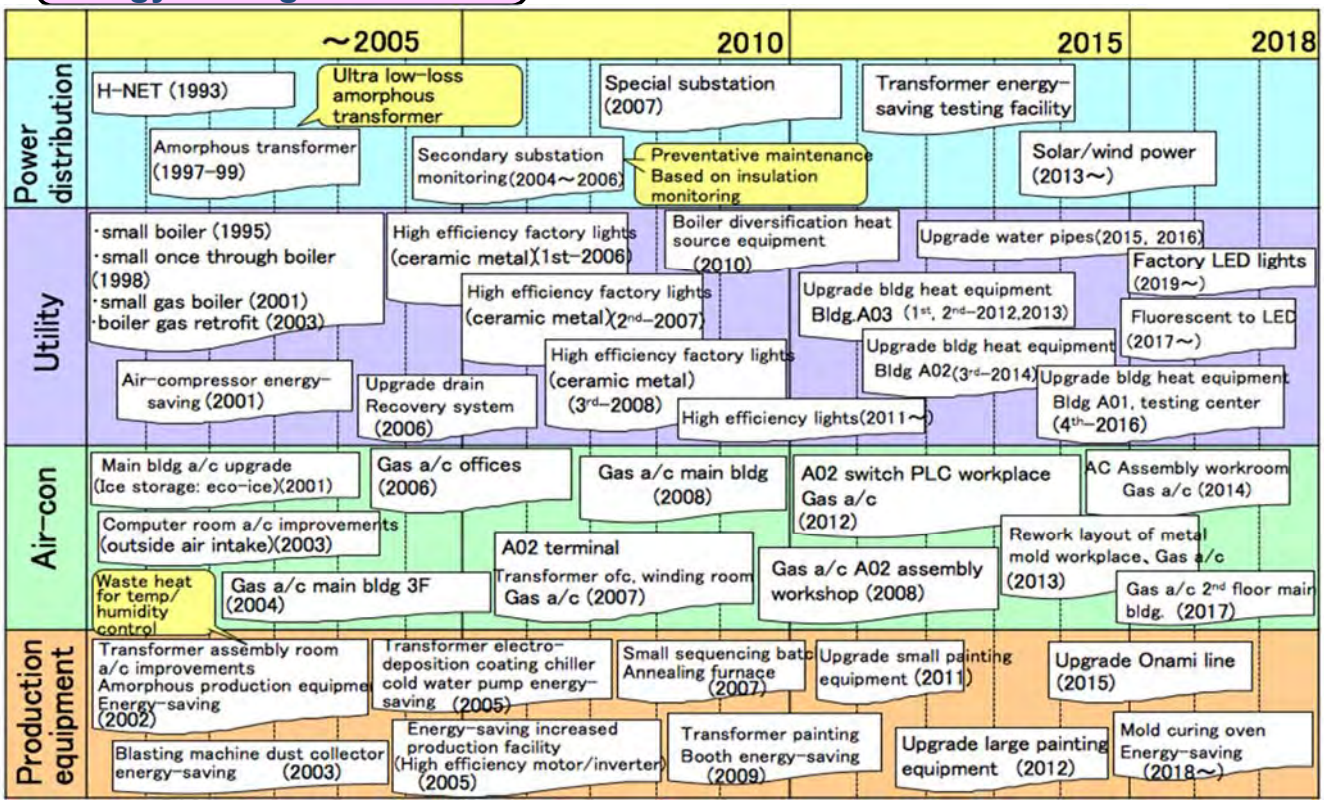
Energy-saving Master Plan



2-5. (1st Generation) Example of H-NET Use I 【transformer】-1/4

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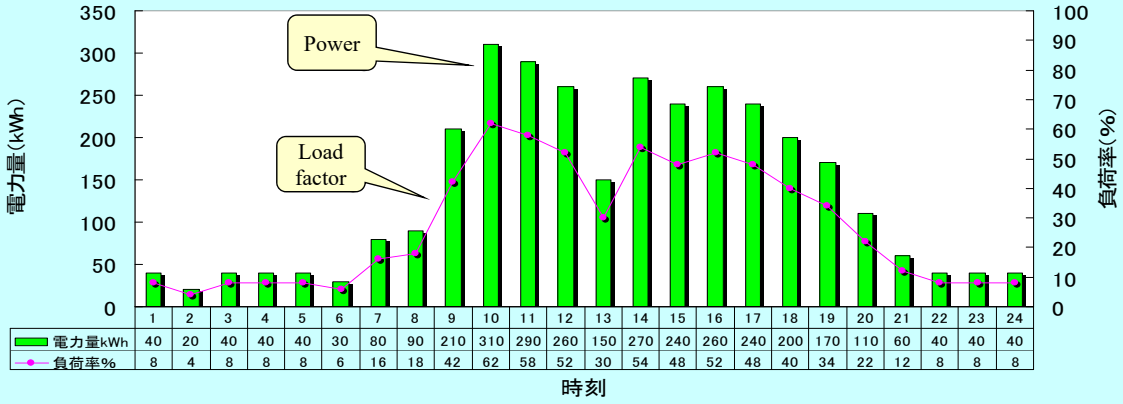
【Point】
Thoroughly check the state of use of transformers with H-NET to enable consideration of elimination/consolidation

【Outcome】
Elimination/consolidation and update to low loss transformers
- Reduced power and fees with less loss
- Enhanced reliability

Daily power use of cubicle no. 8 500kVA (before update)



時刻	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
電力量kWh	40	20	40	40	40	30	80	90	210	310	290	260	150	270	240	260	240	200	170	110	60	40	40	40
負荷率%	8	4	8	8	8	6	16	18	42	62	58	52	30	54	48	52	48	40	34	22	12	8	8	8

Not only is loss great with old transformers, insulating paper is deteriorated. Upgrades to ultra low-loss super amorphous planned from the viewpoint of energy conservation and reliability.

2-5. (1st Generation) Example of H-NET Use I 【transformer】-2/4

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Results of analysis of transformer capacity and number of units

H-NET data on transformer operation used for consolidation

	Cubicle No. 8	Cubicle No. 9
Prior to upgrade	3φ500kVA 2 units 1φ50kVA 1 unit	1φ50kVA 1 unit 3φ500kVA 2 units
After upgrade	3φ500kVA 1 unit Discontinue 1φ75kVA 1 unit Change 3φ750kVA 1 unit	

- Smaller load
- No impact on noise, voltage fluctuation (drying furnace, press)

- Smaller load
- Capacity increase with expected load for cubicle no. 8 (general power, outlets)

- Allowance for intermittent load capacity
- No impact on workability even with lower capacity (welding machine, press)

2-5. (1st Generation) Example of H-NET Use I 【transformer】-3/4

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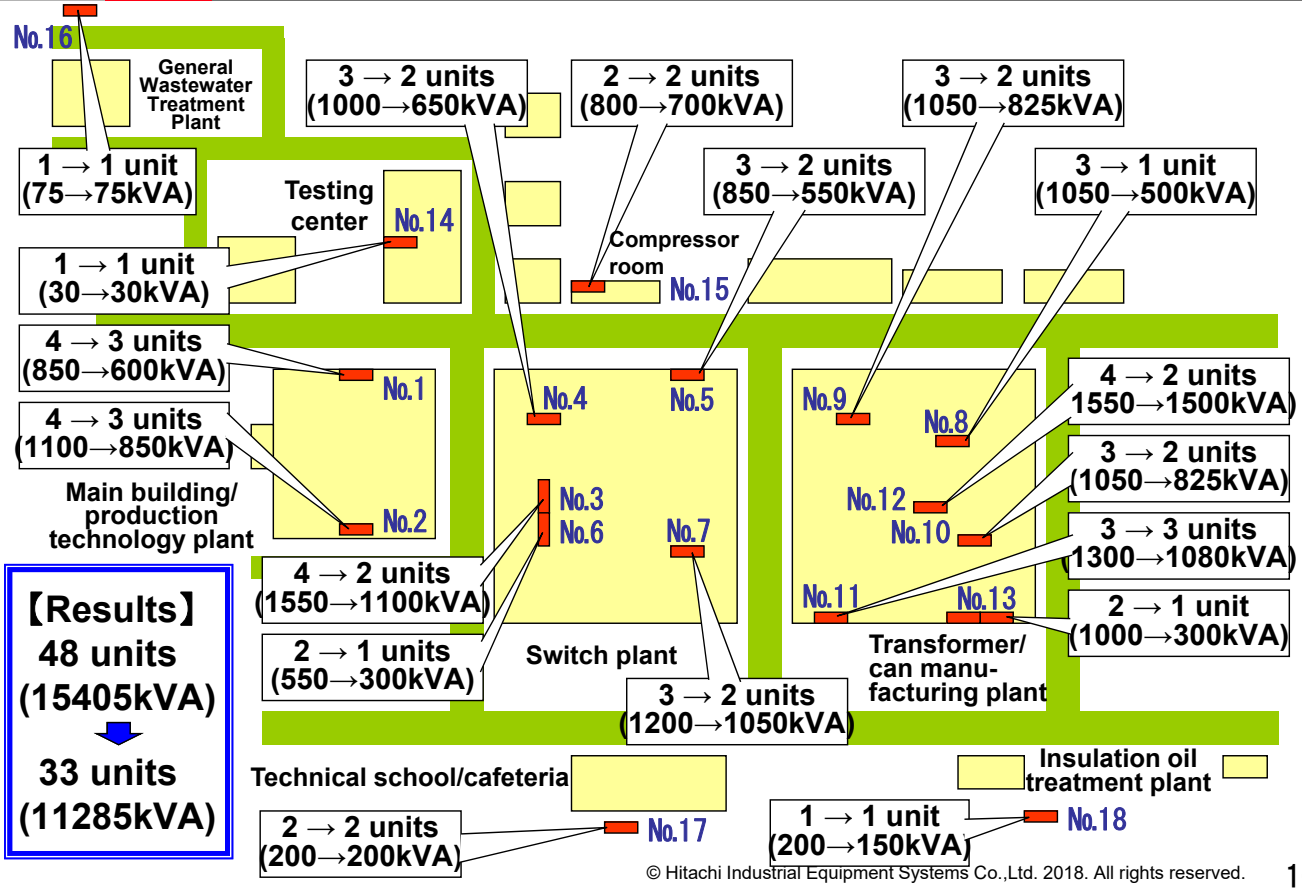

2-5. (1st Generation) Example of H-NET Use I 【transformer】-4/4

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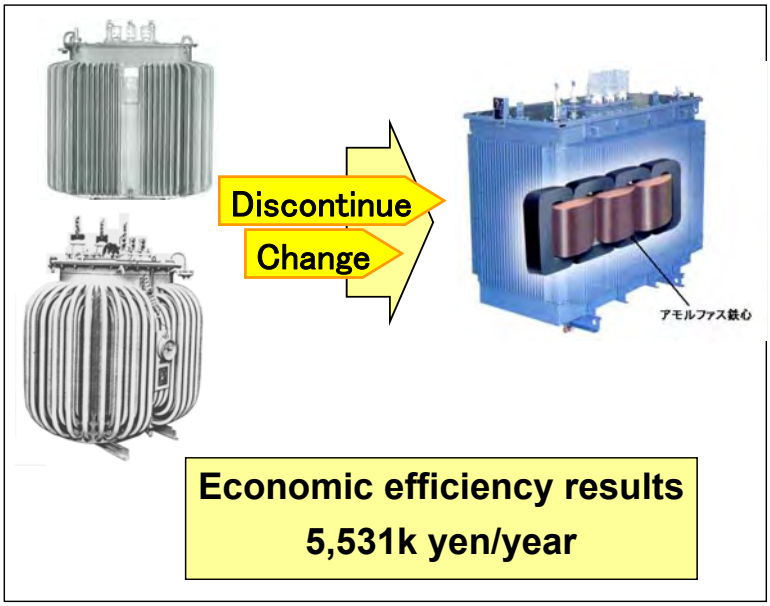
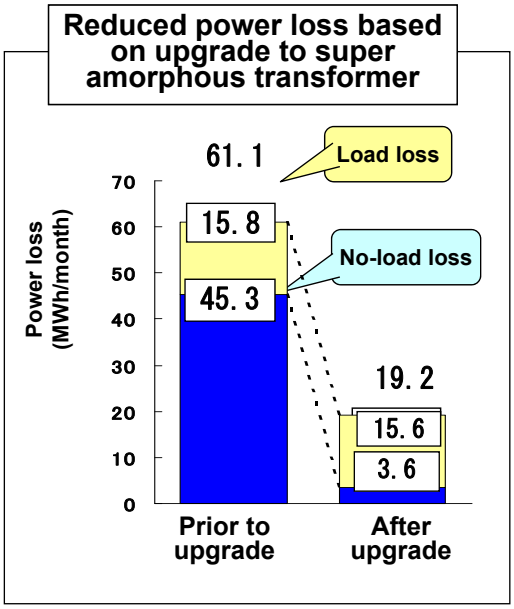
【Point】 1. Reduce power loss and contracted power based on review of transformer capacity according to present work load.
2. Minimize power loss with introduction of super amorphous transformer and proper arrangement.





2-6. (1st Generation) Example of H-NET Use II 【paint booth】-1/2

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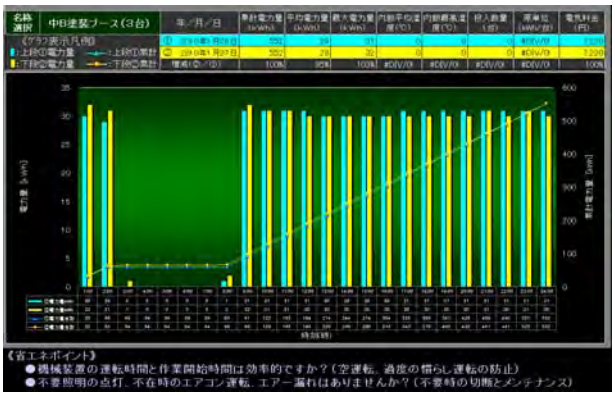
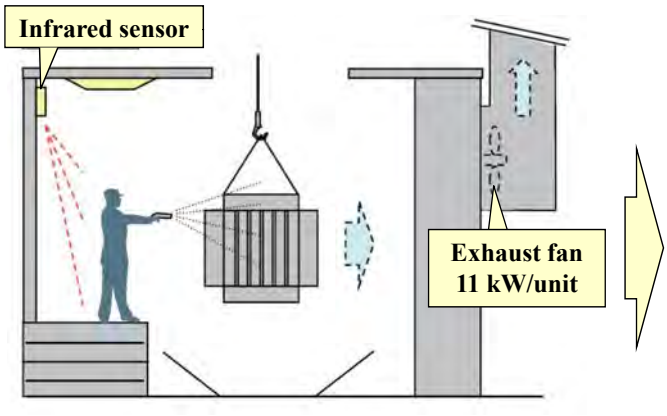


【Before improvements】
・Exhaust fan left on when not needed due to human-operation. Response required.
【After improvements】
・Automatic operation with sensor that starts exhaust fan when worker detected entering paint-spraying area and shuts it off when worker exits.



2-6. (1st Generation) Example of H-NET Use II 【paint booth】-2/2

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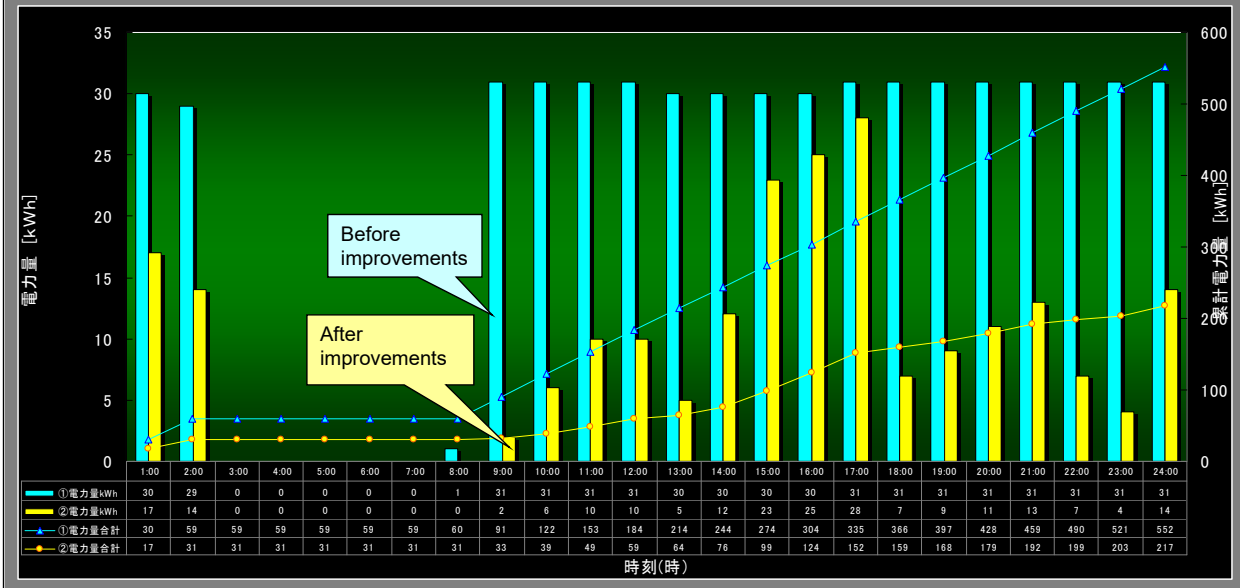
名称選択	中B塗装ブース(3台)	年／月／日	累計電力量(kWh)	平均電力量(kWh)	最大電力量(kWh)
《ｸﾞﾗﾌ表示凡例》		① 2010年1月26日	552	29	31
：上段①電力量	：上段①累計	② 2010年3月25日	217	12	28
：下段②電力量	：下段②累計	増減(②／①)	39%	41%	90%

【Results】
・Power :79.2 MWh/year
・Power costs :790,000 yen/year



	1:00	2:00	3:00	4:00	5:00	6:00	7:00	8:00	9:00	10:00	11:00	12:00	13:00	14:00	15:00	16:00	17:00	18:00	19:00	20:00	21:00	22:00	23:00	24:00
①電力量kWh	30	29	0	0	0	0	0	1	31	31	31	31	30	30	30	30	31	31	31	31	31	31	31	31
②電力量kWh	17	14	0	0	0	0	0	0	2	6	10	10	5	12	23	25	28	7	9	11	13	7	4	14
①電力量合計	30	59	59	59	59	59	59	60	91	122	153	184	214	244	274	304	335	366	397	428	459	490	521	552
②電力量合計	17	31	31	31	31	31	31	31	33	39	49	59	64	76	99	124	152	159	168	179	192	199	203	217

《省エネポイント》
●機械装置の運転時間と作業開始時間は効率的ですか？(空運転、過度の慣らし運転の防止)
●不要照明の点灯、不在時のエアコン運転、エアー漏れはありませんか？(不要時の切断とメンテナンス)

2-7. (1st Generation) Example of H-NET Use III 【power suppression】-1/3

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Adjusted operation during summer and winter

Suppress average demand value by over 500kW for contracted power between 9:00-21:00 during period designated by Tohoku Electric for summer and winter when power demand is high.

《Power suppression measures》

- ◆Monitoring with H-NET
- ◆ Limit on number of electric dryer furnaces in operation (10 units)
- ◆All-out shut-off of lighting and OA equipment when unused
- ◆Partial shut-off of vending machines
- ◆Temporary shut-off of snow-melting pipe
- ◆Permission system for operation of testing equipment (short-circuit generator)
- ◆Thorough review of management of air-conditioning equipment
- ◆Generator during peak times (total capacity: 37 kVA)
- ◆Exhaustive application on site and patrols to thank workers for cooperation

【Energy-saving points】 with H-NET

- ○ Ascertainment of power consumption of each piece of equipment
- ○ Monitoring/management during peak power

2-7. (1st Generation) Example of H-NET Use III 【power suppression】-2/3

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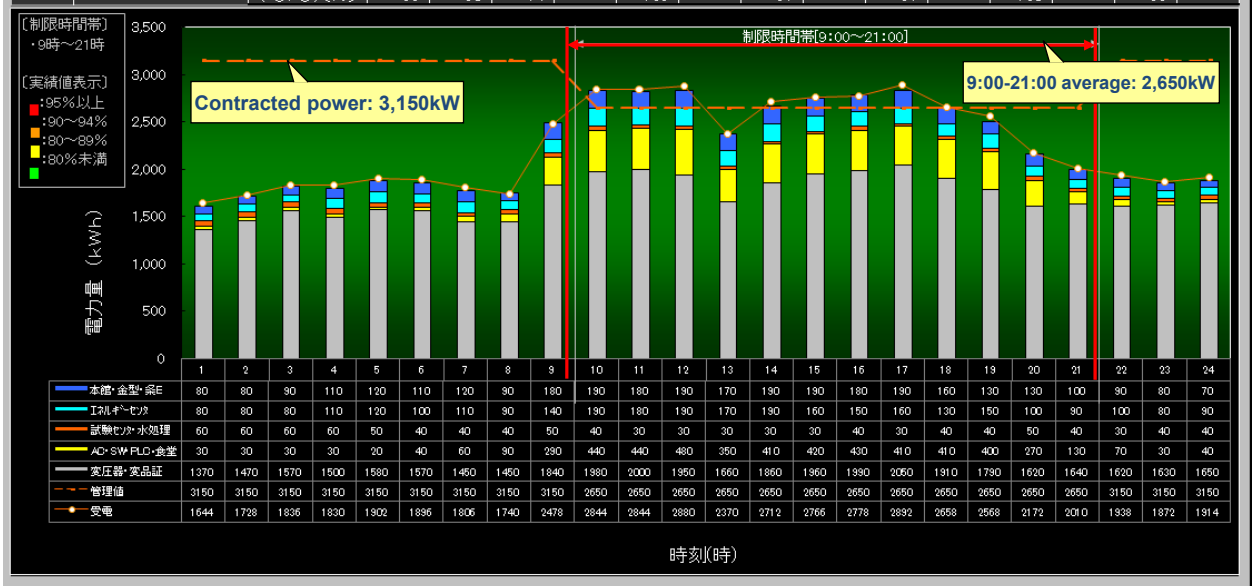
Hourly value management graph

データ年月日	2014/02/07(金)	項　目	受　電		本館・金型・他		ｴﾈﾙｷﾞｰｾﾝﾀ		試験C・水処理		AC・SW・PLC・食		変圧器・変品証		部門時間最大値	
			9~21	ピーク	9~21	ピーク	9~21	ピーク	9~21	ピーク	9~21	ピーク	9~21	ピーク	9~21	ピーク
名称	部門別電力使用量	① 管理値[kWh]	2,650	2,950	224	－	142	－	70	－	396	－	1,817	－	2,650	－
		② 実績値[kWh]	2,625	2,892	167	－	155	－	36	－	383	－	1,868	－	2,625	－
		(②/①)[%]	99	98	74	－	109	－	51	－	97	－	103	－	99	－



	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
本館・金型・採E	80	80	90	110	120	110	120	90	180	190	180	190	170	190	190	180	190	160	130	130	100	90	80	70
ｴﾈﾙｷﾞｰｾﾝﾀ	80	80	80	110	120	100	110	90	140	190	180	190	170	190	160	150	160	130	150	100	90	100	80	90
試験C・水処理	60	60	60	60	50	40	40	40	50	40	30	30	30	30	30	40	30	40	40	50	40	30	40	40
AC・SW・PLC・食堂	30	30	30	30	20	40	60	90	290	440	440	480	350	410	420	430	410	410	400	270	130	70	30	40
変圧器・変品証	1370	1470	1570	1500	1580	1570	1450	1450	1840	1980	2000	1950	1660	1860	1960	1990	2050	1910	1790	1620	1640	1620	1630	1650
管理値	3150	3150	3150	3150	3150	3150	3150	3150	3150	2650	2650	2650	2650	2650	2650	2650	2650	2650	2650	2650	2650	3150	3150	3150
受電	1644	1728	1836	1830	1902	1896	1806	1740	2478	2844	2844	2880	2370	2712	2766	2778	2892	2658	2568	2172	2010	1938	1872	1914

《省エネポイント》
- ●機械装置の運転時間と作業開始時間は効率的ですか？（空運転、過度の慣らし運転の防止）
- ●不要照明の点灯、不在時のエアコン運転、エアー漏れはありませんか？（設定温度：28℃、不要時の切断とメンテナンス）
- ●使用していないOA機器の電源が入っていませんか？（不要時のこまめな切断の習慣）

2-7. (1st Generation) Example of H-NET Use III 【power suppression】-3/3

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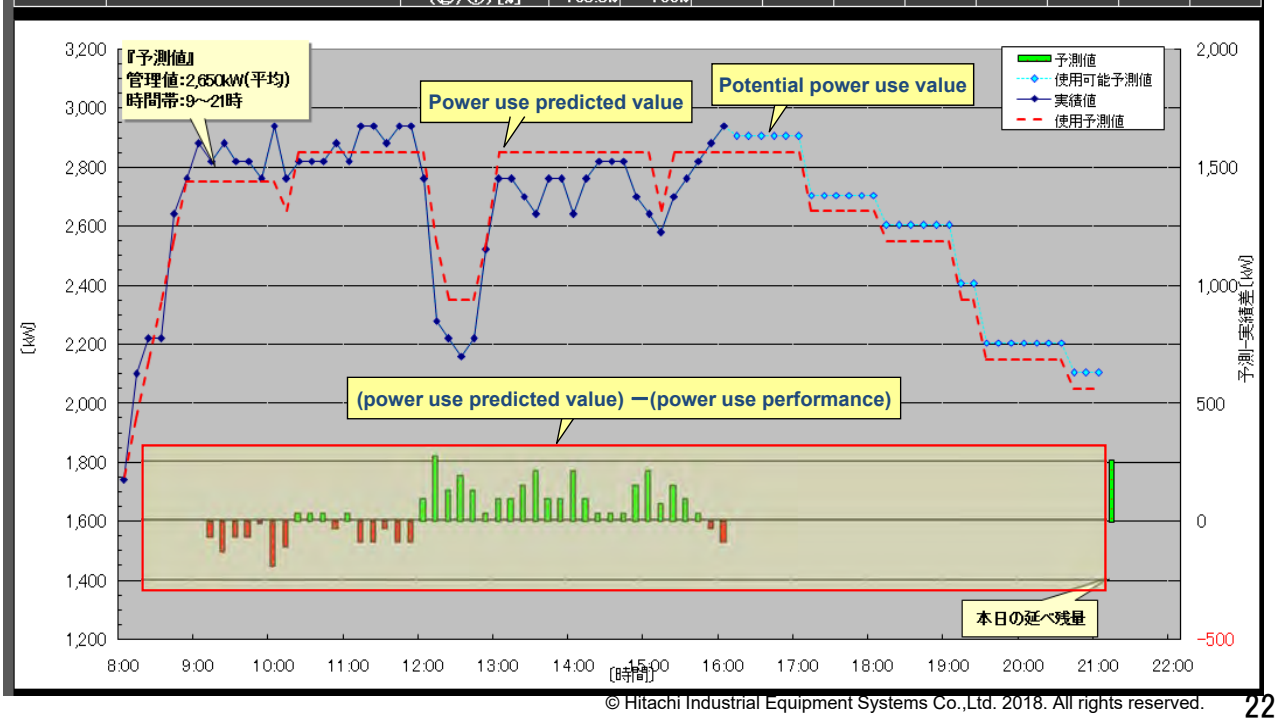
10 min. value management graph

データ 年月日	2014/02/07(金)	項 目	受電		本館・金型		試験C・廃水		AC・SW・PLC		変圧器・変品証	
			9～21	ピーク	9～21	ピーク	9～21	ピーク	9～21	ピーク	9～21	ピーク
名 称	部門別電力使用量	① 管理値[kWh]	2,650	2,950								
		② 実績値[kWh]	2,739	2,940								
		(②/①)[%]	103.3%	100%								



2-8. (2nd Generation) Configuration of factory energy management system (SANFEMS)

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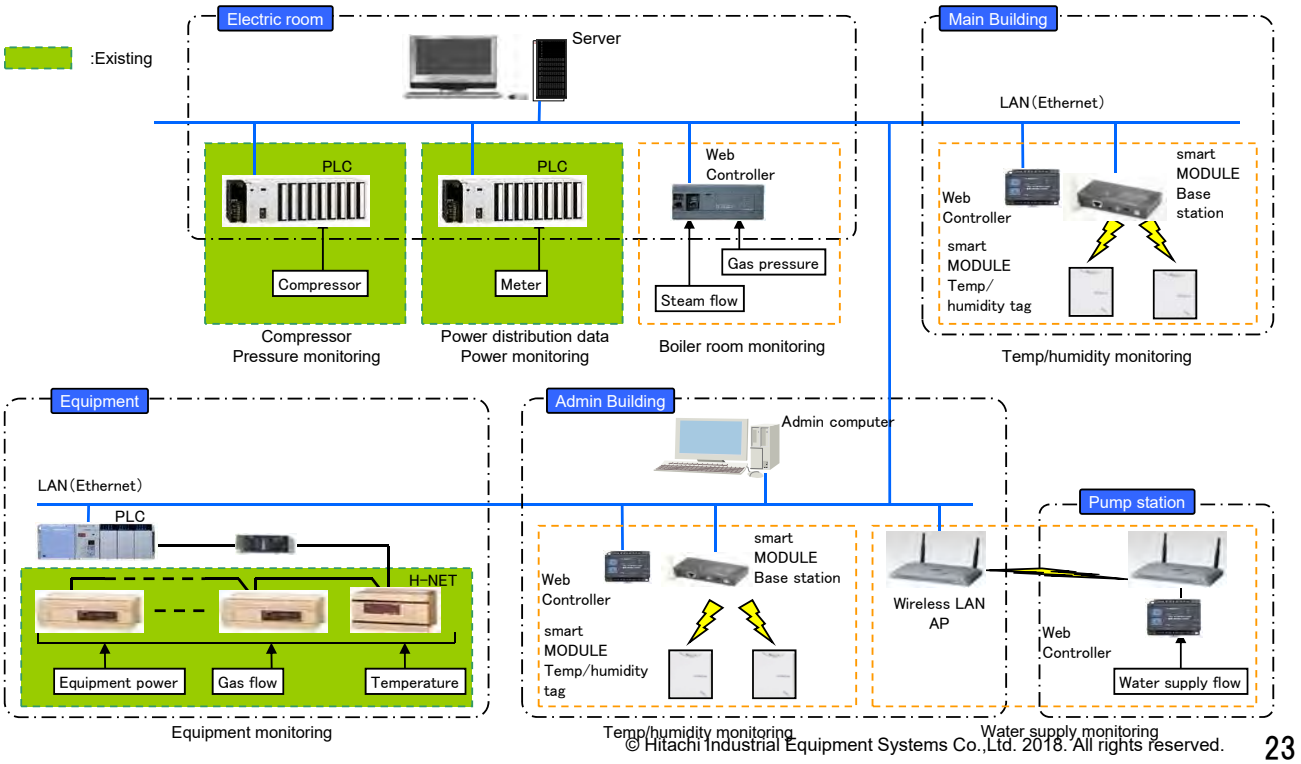
〈Monitoring〉: Power, steam, natural gas, water supply, temperature, humidity

【Advantages】
1. Expanded scope of monitoring (utility)
2. Expanded analysis of collected data



2-9. (2nd Generation) Example of SANFEMS Use I【air】-1/3

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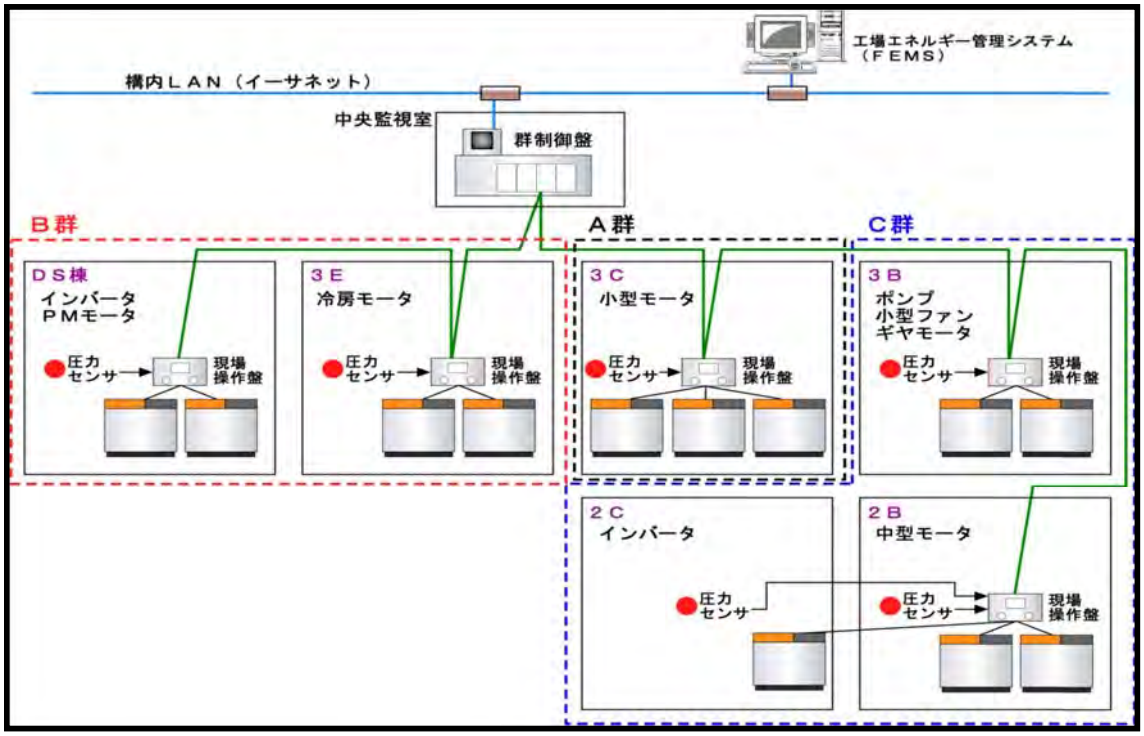

2-9. (2nd Generation) Example of SANFEMS Use I【air】-2/3

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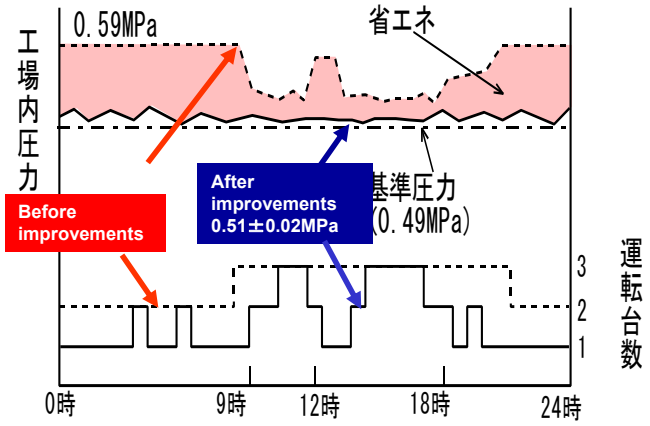
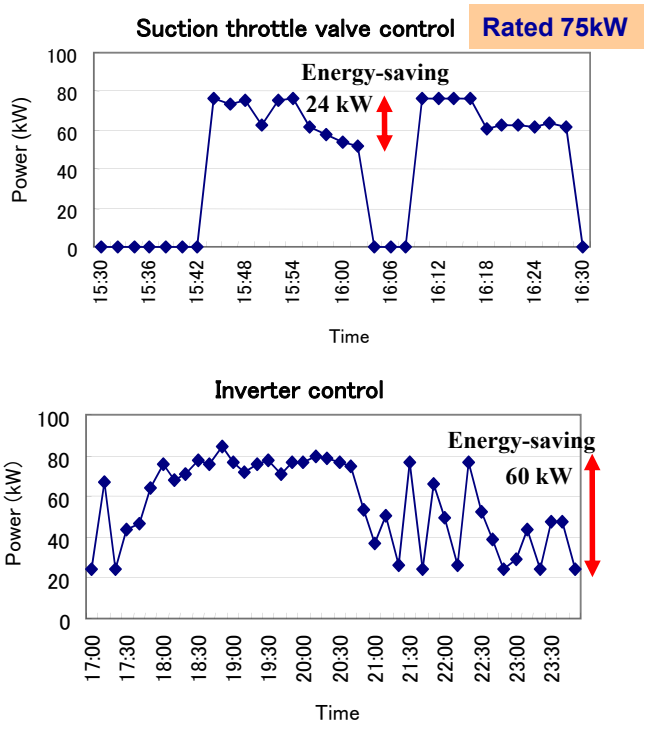
Control unit quantity/load pressure constant control



State of load pressure and units in operation (compact motor plant)

Energy-saving 1,260 (MWh/year)

Energy-saving with inverter control



2-9. (2nd Generation) Example of SANFEMS Use I【air】-3/3

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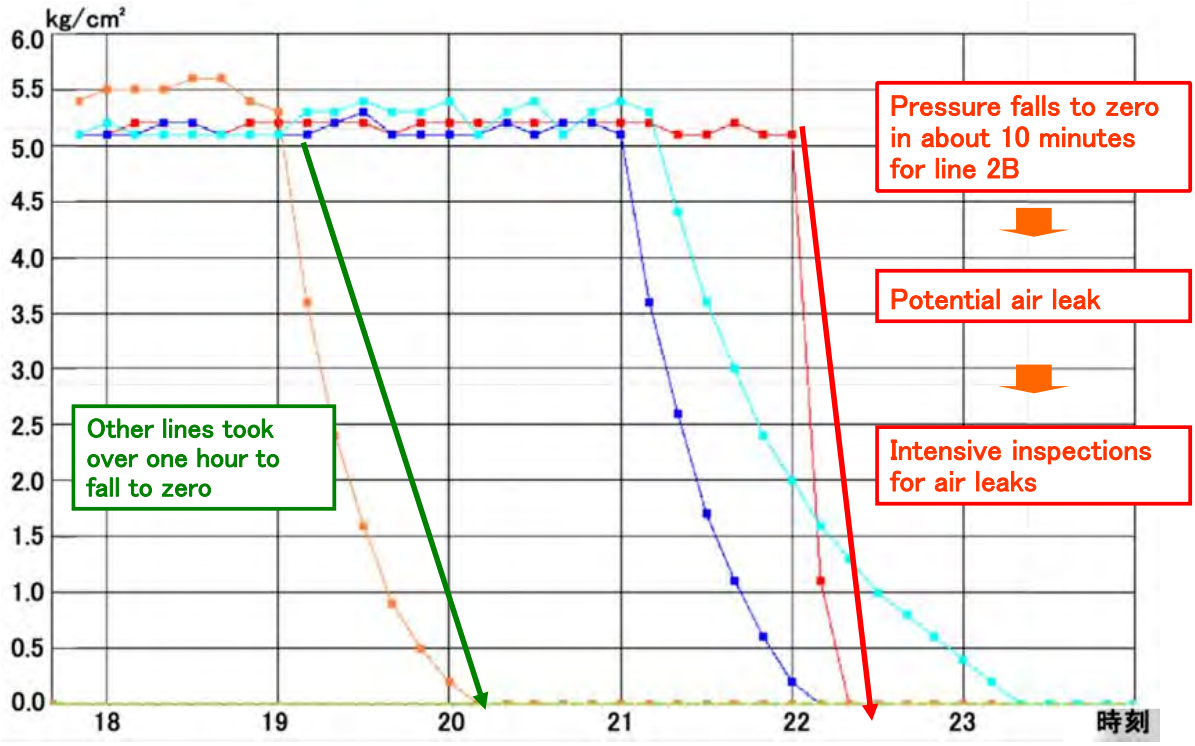
Shift in air pressure during Saturday compressor shutdown

Air pressure line 2B 2C 3C 3E



2-10. (2nd Generation) Example of SANFEMS Use II 【water supply】-1/3

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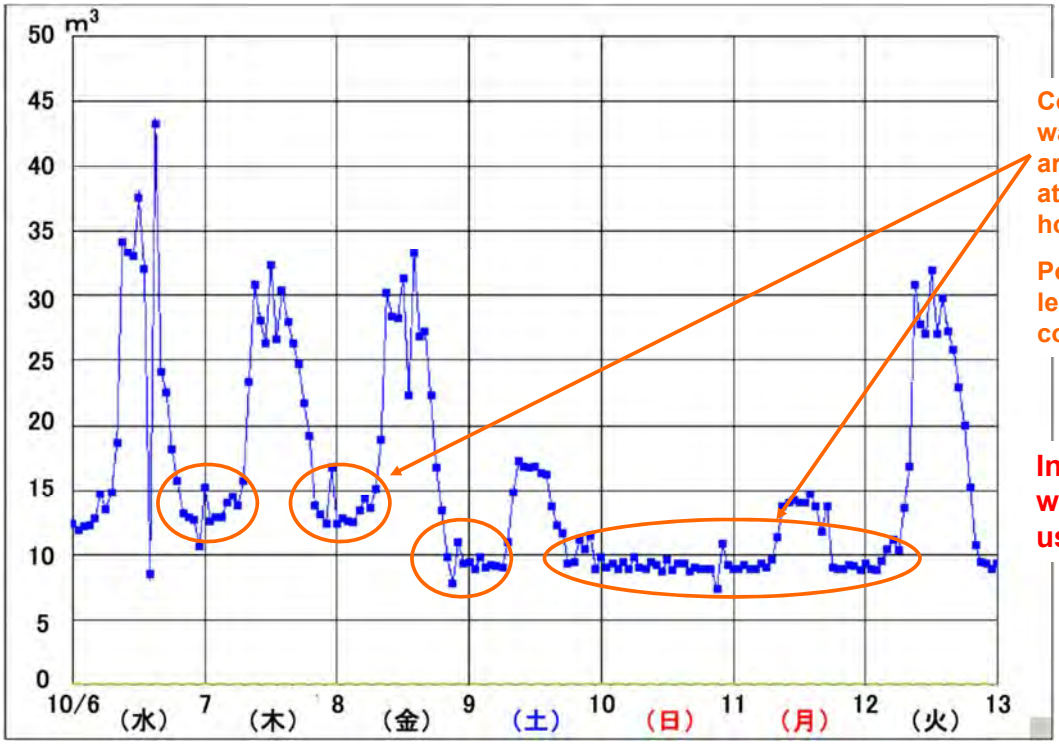
●Usage data on overall factory water supply (potable water)



Continuous flow of water supply around 10m³/h even at night and on holidays

Potential waste and leaks of equipment cooling water

Inspection of water supply usage required

2-10. (2nd Generation) Example of SANFEMS Use II 【water supply】-2/3

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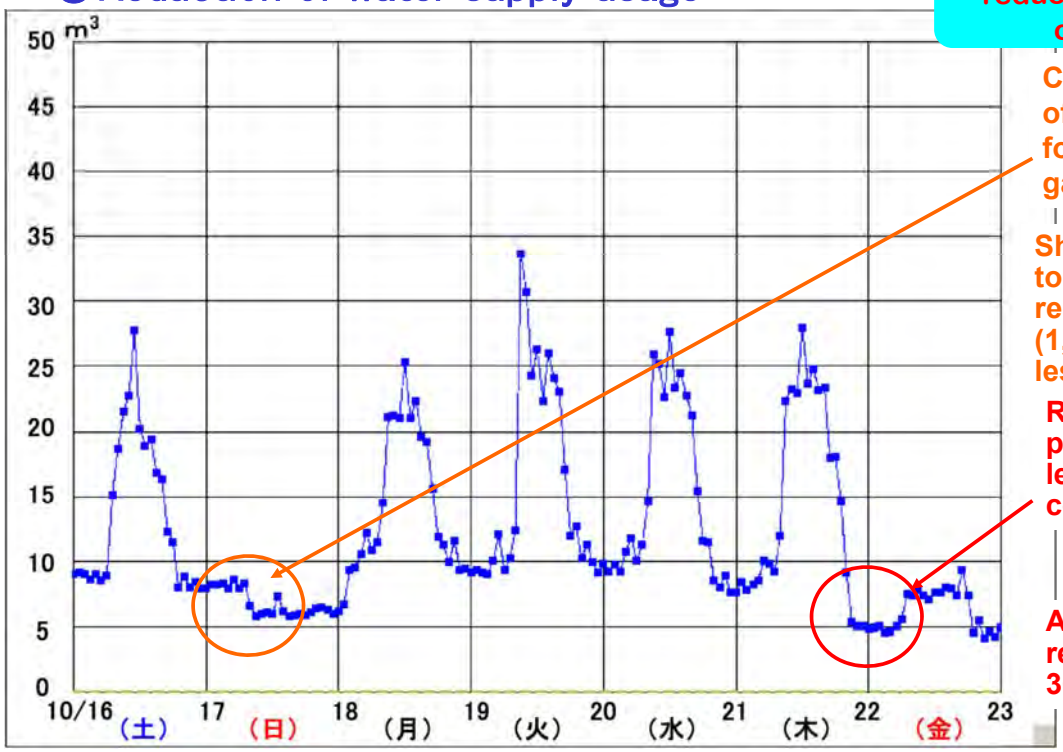
●Reduction of water supply usage



Annual 8 mil. Yen reduction in water charges

Continuous use of water by fountain at front gate

Shutting valve led to about 2.5m³/h reduction (1,800m³/month less)

Repairs to piping in leaking air-con cooling tower

About 0.5m³/h reduction (about 360m³/month)

2-10. (2nd Generation) Example of SANFEMS Use II 【water supply】-3/3

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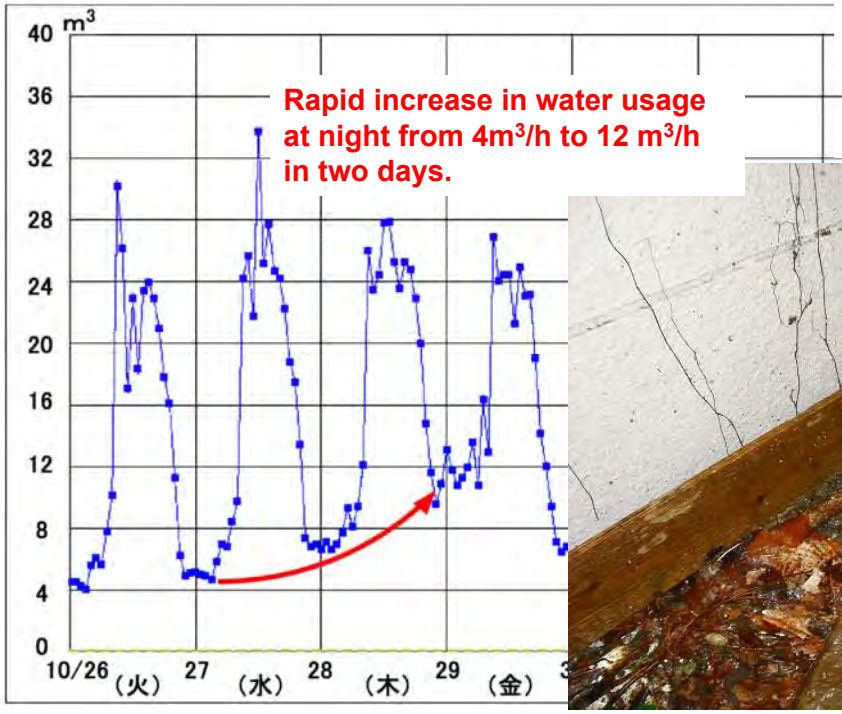
●Changes on graph due water leak



Rapid increase in water usage at night from 4m³/h to 12 m³/h in two days.

Leak found in deteriorated broken pipes on site

Early detection of leaks

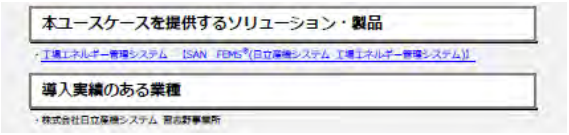
Registering as a use case on Hitachi's Lumada IoT Platform

Support for energy-saving based on energy management

《Major know-how》 ⇒ Potential to be Lumada solution core

(1) Realization of CAPD cycle concept
- ・(Check) Visualization of collected data with operation cycle
- ・(Analysis) Comparative analysis with past data. Support for multifaceted discoveries
- ・(Plan) Support for planning energy-saving operation and optimization of operation
- ・(Do) Demand monitoring air-conditioning function, energy-saving by manual operation
- ・(Check) Visualization of improvements, confirmation of outcomes to enhance motivation

(2) On-site compressed air (decreased pressure times), discovery of steam energy loss (pressure, temperature)
(3) On-site elimination/consolidation of transformers (ascertainment of actual state of load factor)
(4) Air compressor end-pressure feedback control
(5) Isolation of energy reduction locations based on comparative graph visualization
(6) Rescheduling of multiple production line operations based on ascertainment of energy data (future AI topic)



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Contents

3-1. (3rd Generation) Need for IoT in Manufacturing

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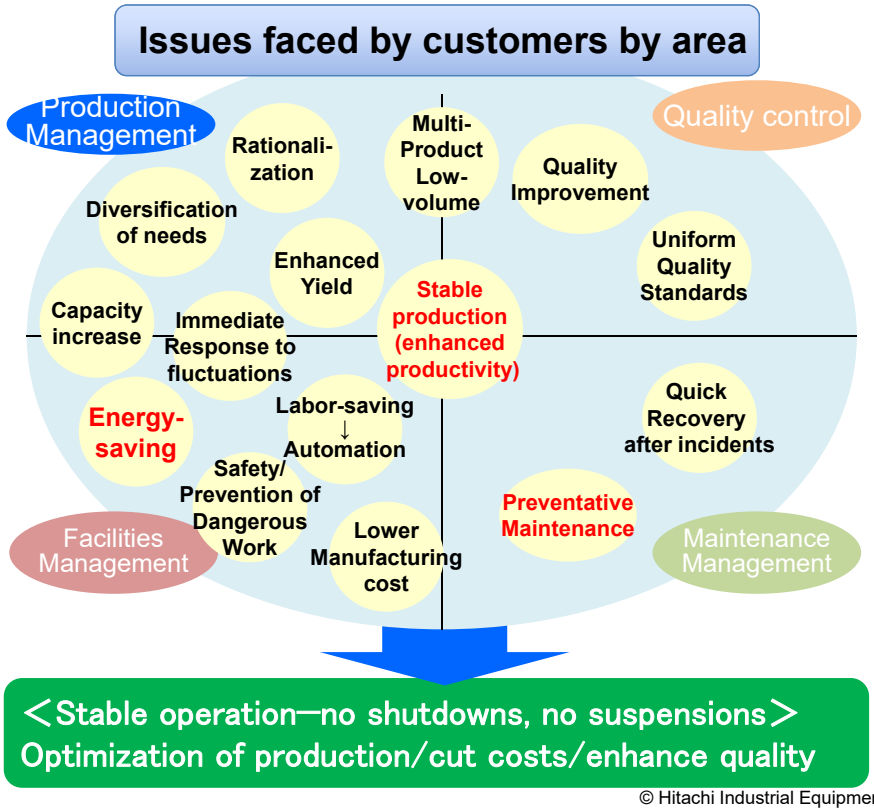

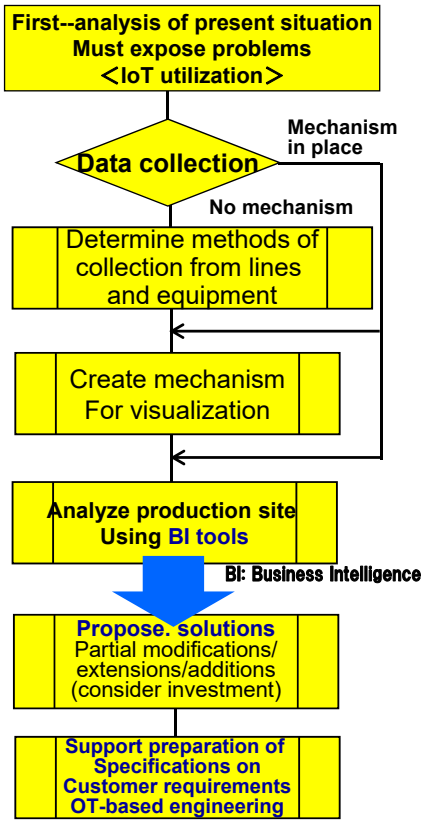

3-2. (3rd Generation) STEPS for IoT Introduction

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Step 5	**Total optimization** **•Total optimization based on central control of multiple positions** **•Selection of optimal production plant from capacity balance/operation, inventory balance**	**Total optimization (using the cloud)**
Step 4	**Smart factories** **•Realize efficient operation** **•Reduce total costs with energy information**	**On-site optimization**
Step 3	**Production automation** **•Automate process feasible for labor-saving**	**FA/Automation Robotization**
Step 2	Data analysis/analytics **•Analyze variance in state of operation, workers and products** **•Analysis of production plan and state of operation of all equipment**	Point of production Information management system
Step1	Information collection and visualization •Visualization of state of operation (operation rate, causes of non-operation, work efficiency)	Operation monitoring system Energy management system

3-3. (Example 1) Data utilization and application/ Productivity enhancement (preventative maintenance) 1/5

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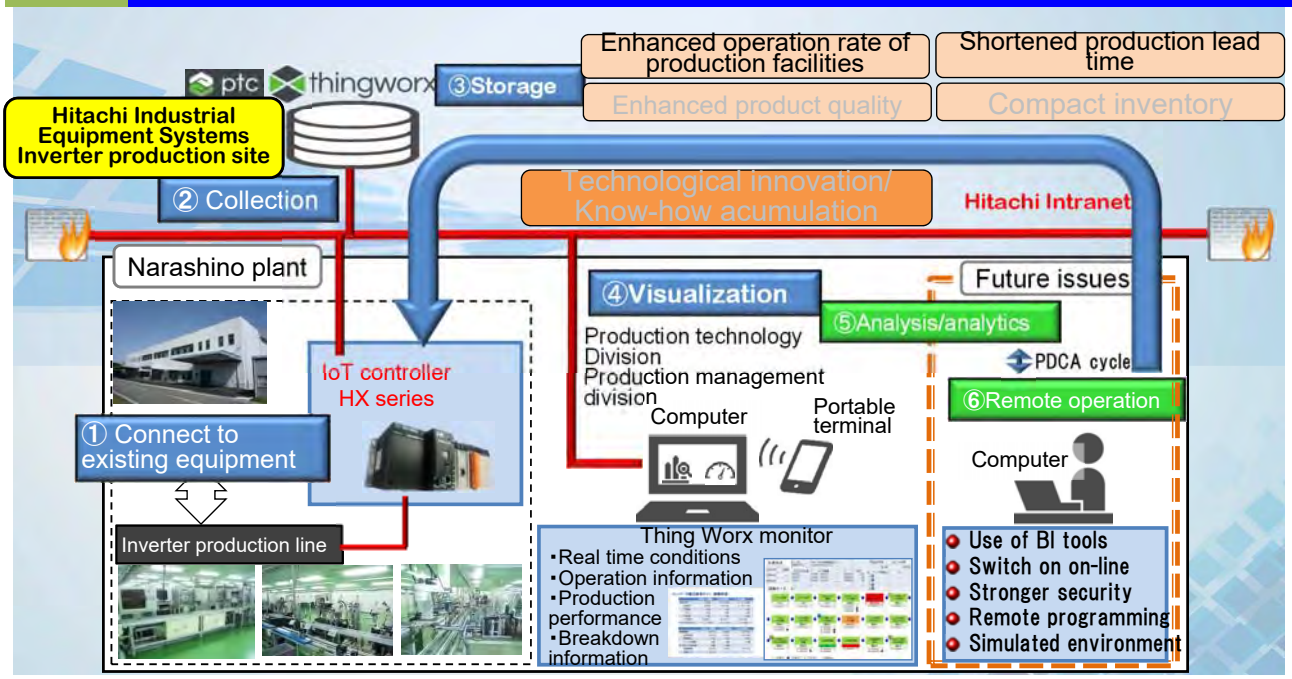
Test details

COLLECT, STORE and VISUALIZE production line real time operation data in safe intranet environment, then reveal production issues based on ANALYSIS/ANALYTICS to test our “Smart Factory” that unites OT and IT.



3-3. (Example 1) Data utilization and application/ Productivity enhancement (preventative maintenance) 2/5

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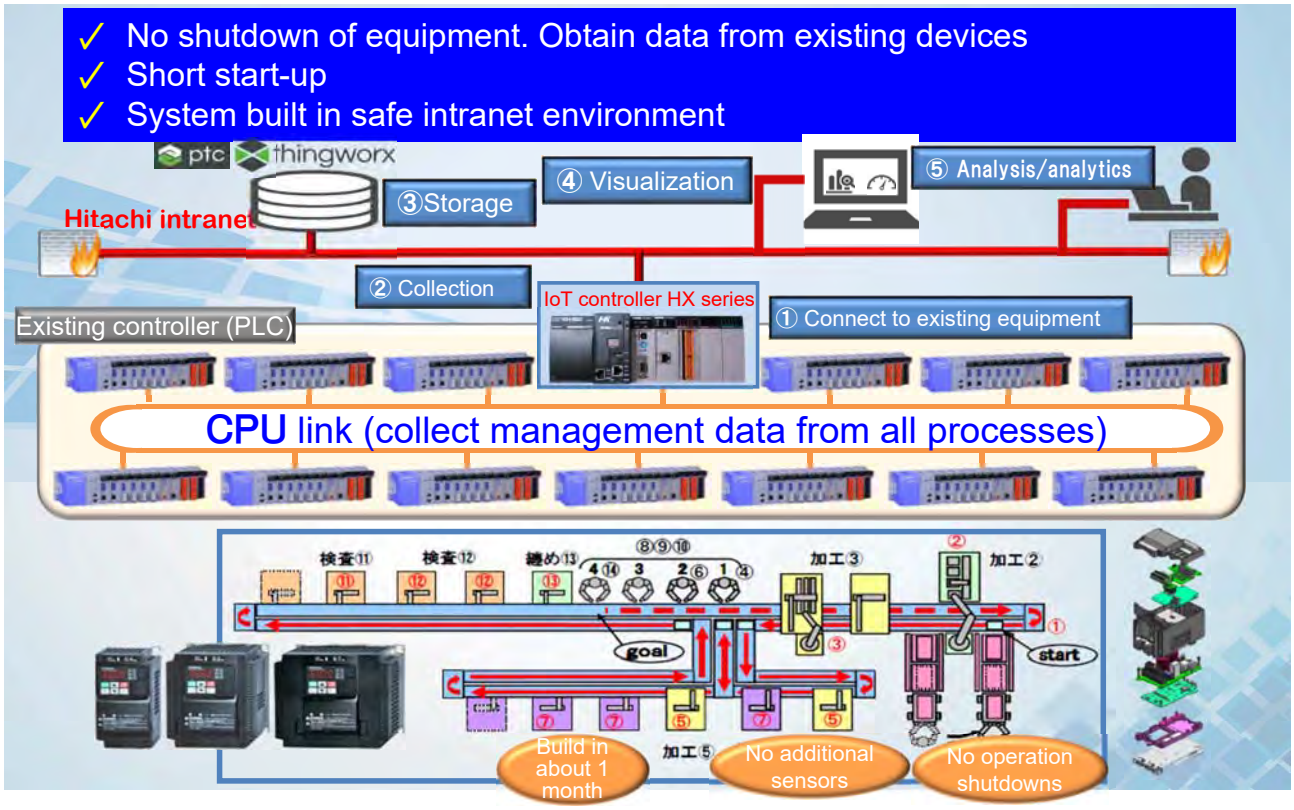

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Monitor screen

Inverter assembly inspection line State of production monitor

	現在（1時間）	当日累積	当月累積（前日）
生産状況	35台	325台	5,100台
正常品	35台	325台	5,096台
不良品	0台	0台	4台
リカバー	0台	0台	4台
不良品	0台	0台	0台
(不良率)	(0.00%)	(0.00%)	(0.00%)
サイクルタイム	1．6分	1．6分	1．6分

Inverter assembly inspection line State of operation monitor

	現在（1時間）	当日累積	当月累積（前日）
稼働時間	48分	96分	8,370分
正常状態	44分	90分	8,328分
異常停止	4分	6分	42分
チョコ停回数	0回	1回	8回
はんだコテ先交換	0回	0回	1回
装着時間	48分	96分	7,800分
交換まで	－	－	2,200分

Inverter assembly inspection line Production plan progress monitor

Inverter assembly inspection line Real time operation monitor

【Reference】Ten Maxims

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1. Seeing is believing⇒ Check out other companies!
2. Take pride in second place
   ⇒ Imitate other companies with proven results
3. Two heads are better than one
   ⇒ Learn from other companies!
4. Look at all sides
   ⇒ Why steam? Air?
5. Five W’ s and one H
   ⇒ Energy-saving during hard times
6. Use six senses
   ⇒ Live by energy-saving and write down ideas
7. Use tools and technologies
   ⇒ All experience is good
8. Be a jack of all trades
   ⇒ Diversify, electricians should study heat
9. Don’ t give up
   ⇒ Keep searching for a way
10. Don’ t be a perfectionist
    ⇒ Can you prove you’ re #1?