Industrial Big Data Practice for Power Plant Energy Efficiency Optimization

Industrial submission to CSD&M2017

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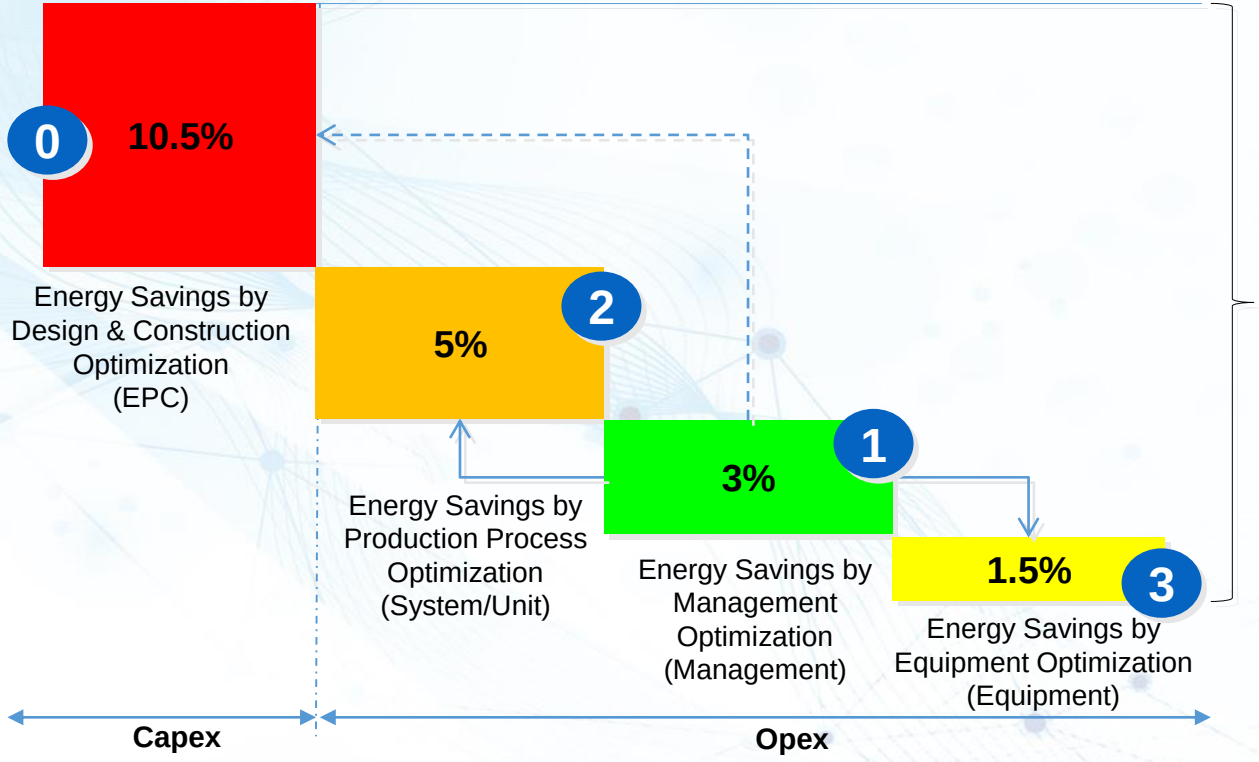
1. Background & Value proposition
Energy savings potential of energy production/transformation companies

Energy savings potential for energy production/transformation companies through Energy Efficiency Optimization could be 20% in total. *

- Capex (EPC phase) optimization could contribute the most portion of Energy Savings - 10.5%. But since it is always not under control of plant operators, it will not be discussed in this paper.
- Opex (Operation phase) optimization, which is the focus in this paper, could be categorized as three portions - 1.5% for Equipment, 3% for Management, 5% for System/Unit.
- Even though Management Optimization is the least technical driven, it is the base to trigger other optimization.
- The end to end metering and visualization for energy consumptions and related impacting factors are fundamental to achieve higher energy efficiency.



Energy Savings Potential thru. Energy Efficiency Optimization*

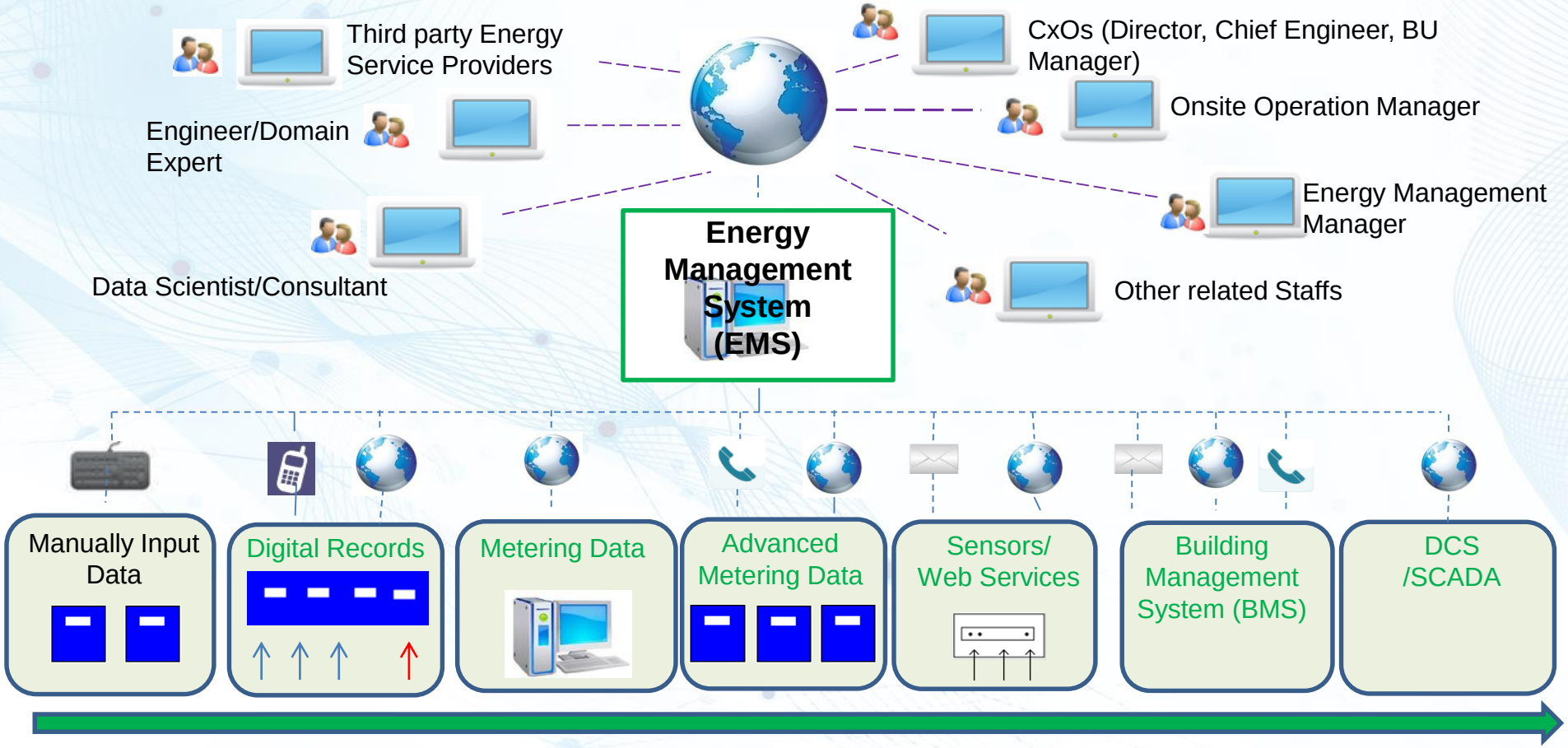
This statistics refers to the generic energy enterprises. The corresponding numbers might be different for power generation industry, but the ratios are similar (Capex : Opex = 10.5% : 9.5%, System/Unit : Management : Equipment = 5% : 3% : 1.5%)

* by SIEMENS research

1. Background & Value proposition
EMS and big data analysis are key enablers to realize energy savings target

Energy Management System (EMS) and big data analysis are key enablers to realize energy savings target. *

- The main function of EMS is to collect, process and configure applications with all kinds of data related to energy consumptions.
- It acts as a data aggregator to do analytics.
- The future of Energy Efficiency Optimization relies on big data analysis.

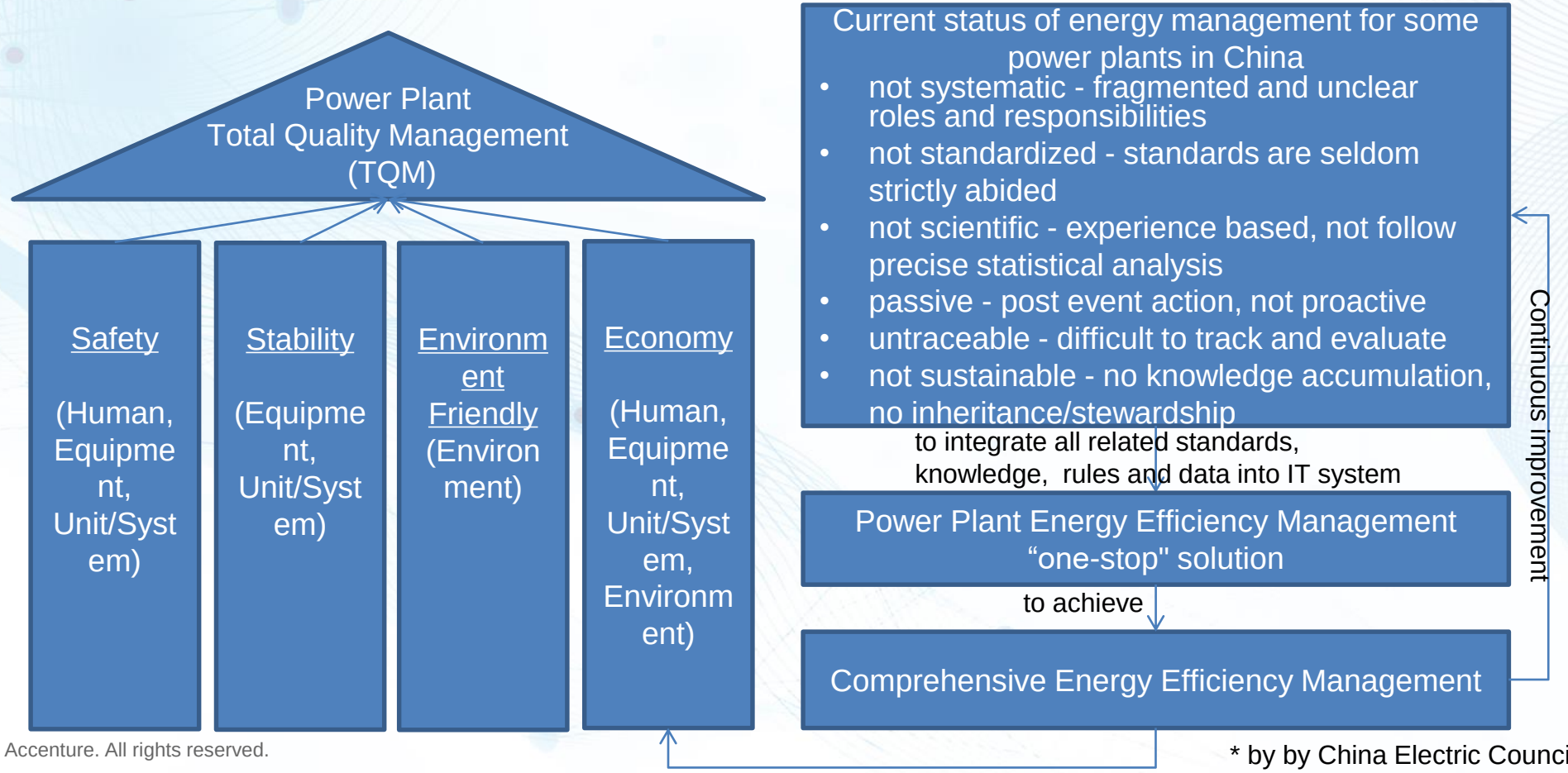


* by Schneider Electric

1. Background & Value proposition
Current Status of energy management in power generation industry

Current status of energy management in China power generation industry are far from expectation. *

- Power Plant Total Quality Management (TQM) is consisted of four pillars - Safety, Stability, Environment & Economy, among which Economy is the most difficult, which need to put all factors into consideration.
- Energy Management is a comprehensive program which plays an important role and acts as the most complex and comprehensive topic of Economy pillar.
- Successful energy management could not only help on only one pillar of TQM, but also greatly enhance the overall competitive capability of a power plant.

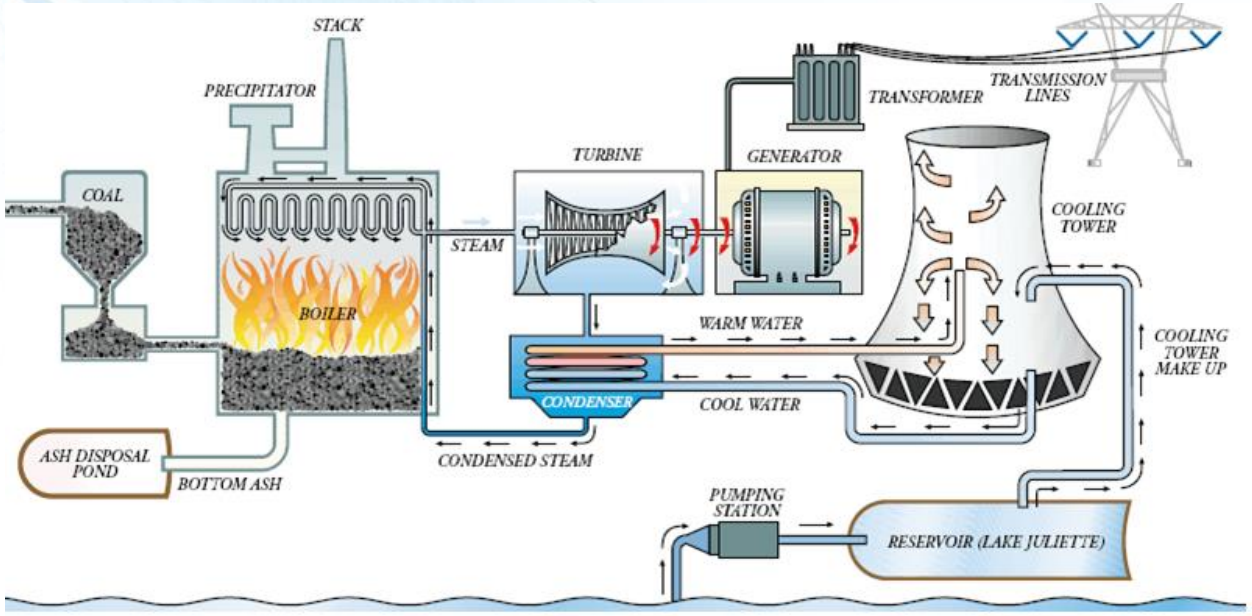


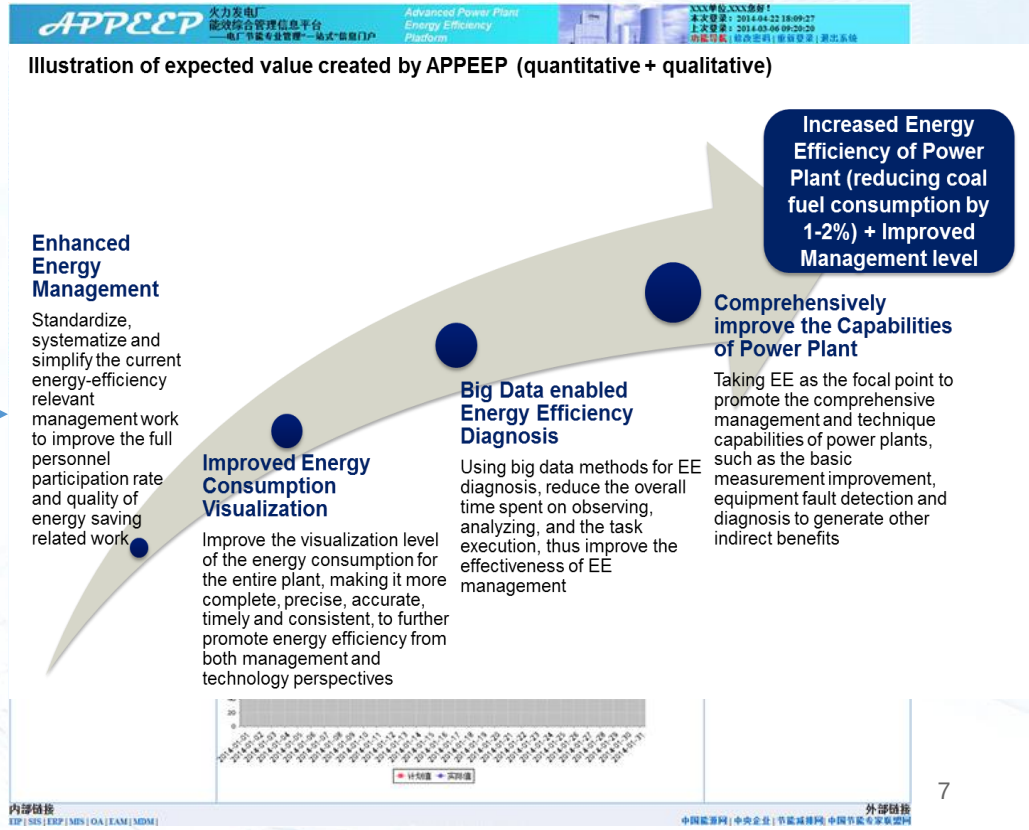
* by by China Electric Council

1. Background & Value proposition
Development of APPEEP and its expected value propositions

To build and implement Advanced Power Plant Energy Efficiency Platform (APPEEP) following PDCAE (Plan-Do-Check-Action-post-Evaluation) cycle, empowered by industrial big data analysis, could maximize the business value for thermal power generation plants (especially coal-fired power plants).

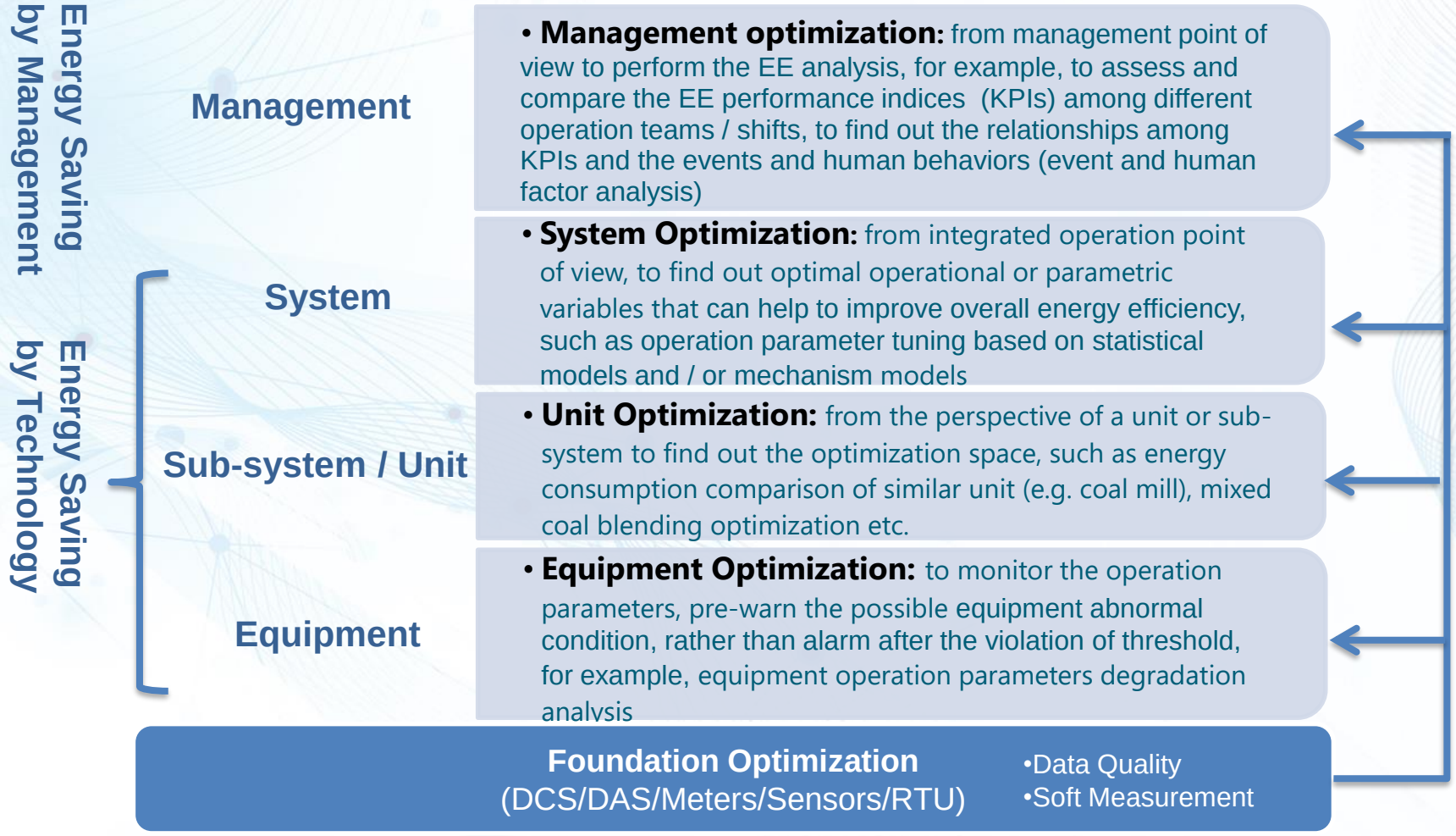
- **Plan (forecasting)**: Energy consumption forecasting and threshold value setting - to set the baseline for energy consumption and energy efficiency
- **Do (monitoring and statistics)**: Statistical analysis and visualization of actual energy consumption and energy efficiency - to identify issues that require further analysis
- **Check (diagnosis)**: Diagnosis of the identified issues - to analyze issues and make corresponding solutions
- **Action (execution)**: Task planning, fulfillment and tracing - to implement the solutions
- **post-Evaluation (effectiveness assessment)**: Post evaluation after the action taken - to evaluate the implementation results and effectiveness of solutions (completeness & effectiveness)





2. Systematic Framework for power plant energy efficiency analytics
5-layer framework of power plant energy efficiency optimization

A systematic framework for power plant energy efficiency analytics is consisted of 5 layers optimization - Foundation, Equipment, Unit, System, Management. This framework could also be applied in other industries.

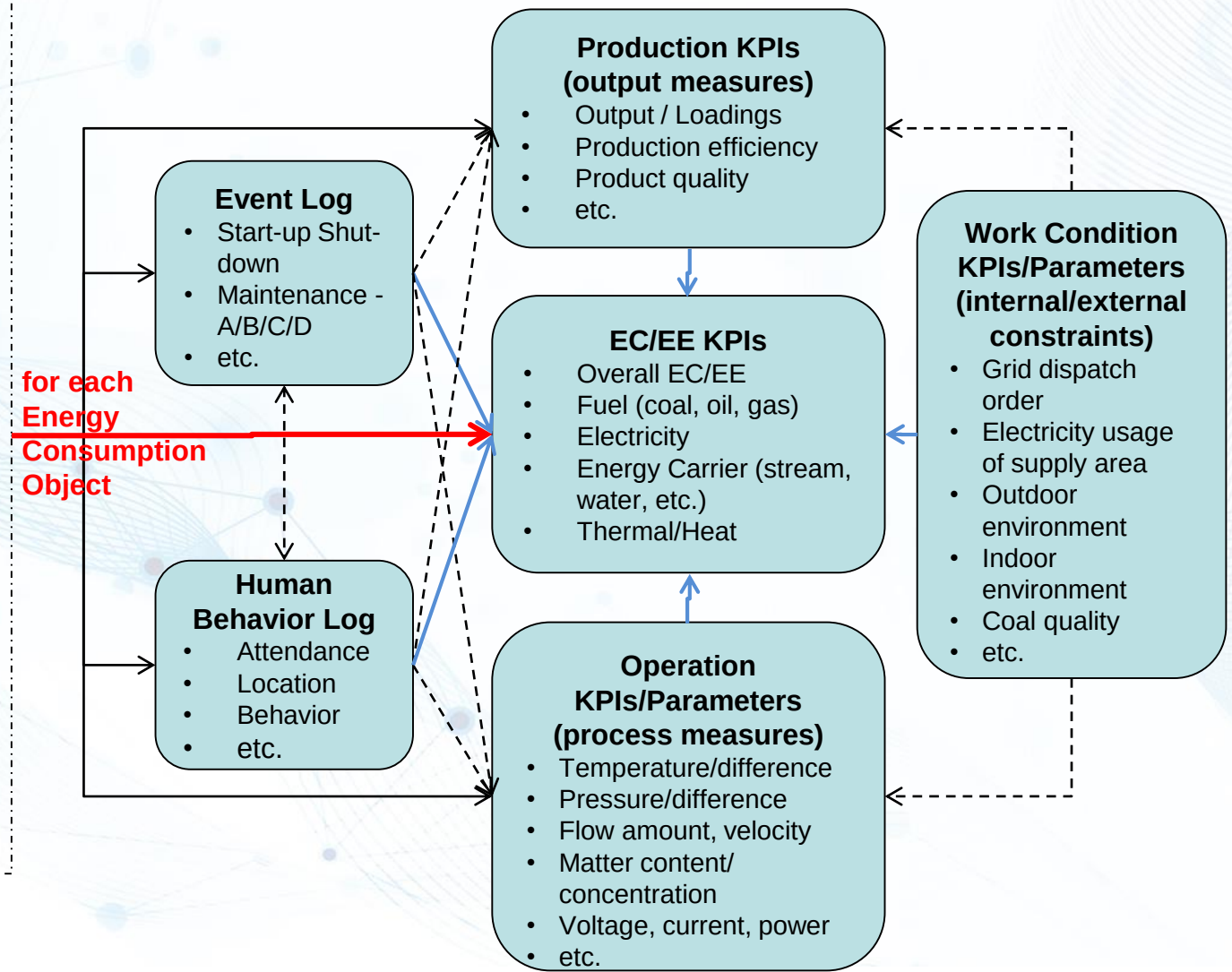


2. Systematic Framework for power plant energy efficiency analytics
Extended data capturing framework for energy efficiency related big data analysis

In order to do power plant energy efficiency analytics, an extended data capturing framework was proposed, which lists data sets required to collect for EE related big data analysis.

Object Tree （Energy Consumption Objects）

- **Power Plant / Fleet X**
  - #1 Generation Unit
  - #2 Generation Unit
  - #3 Generation Unit
    - Boiler
    - Steam Turbine
    - Electricity
    - Desulfurization
    - Denitrification
    - Others
  - Shared Production Units
    - Fuel
    - Chemical
    - Desulfurization
    - Denitrification
    - Soot blow & Ash Removal
    - Sewage treatment
    - Heat supply
    - Auxiliary devices
    - Others
  - Logistics and Facilities
    - Office
    - Logistics/livings
    - Others
  - Others



3. Pilot case example as Proof-of-Concepts
Pilot case overview - Coal-fired, 2*300MW Units (#1, #2) + 1*600MW Unit (#3)

An aged Coal-fired Power Plant with 2*300MW Subcritical Units (#1, #2) + 1*600MW Supercritical Unit (#3)

- **Analytic topic selection** - (1) Energy consumption prediction considering all kinds of impacting factors, (2) Operational variables optimization based on historical data statistics, (3) In-depth discovery of human behavior factors based on shift energy efficiency KPI benchmarking analysis
- **Data capturing & pre-processing**
- **Analytic results**

3. Pilot case example as Proof-of-Concepts
Analytic topic selection

Analytic topic selection - Overall rating by both doable and valuable

Category		Analytic Topic	Matching Technologies	Overall Rating
Energy saving by management		Energy consumption / EE statistics & visualization	BI, Visualization	5
		Energy consumption prediction considering all kinds of impacting factors (heat rate baseline setting for EE action effects post-evaluation)	Time series analysis, Regression analysis	5
		In-depth discovery of human behavior factors based on shift Energy Efficiency KPI benchmarking analysis (correlation analysis between events and human factors)	Association analysis, Text mining, Feature extraction	5
Energy saving by technology	System	Operational variables optimization based on historical data statistics	CFA (Critical Factor Analysis), Statistics	5
		Mechanism model based operational performance simulation	Simulation - using the third party professional tools/software	4
	Sub-system / Unit	Coal blending optimization	Linear programming	3
		Coal grinding mill commitment	Linear programming	3
		Cold end system EE optimization	Simulation - using the third party professional tools/software	3
	Equipment	Equipment performance monitoring and parameter degradation analysis	Pattern recognition, Trend analysis	3
Foundation		•Data quality •Soft measurement		4

3. Pilot case example as Proof-of-Concepts
Data capturing & pre-processing

Data capturing & pre-processing - Extended full set data need to collect for EE related big data analysis

Object Tree （Energy Consumption Objects）

- **Power Plant / Fleet X**
  - #1 Generation Unit
  - #2 Generation Unit
  - #3 Generation Unit
    - Boiler
    - Steam Turbine
    - Electricity
    - Desulfurization
    - Denitrification
    - Others
  - Shared Production Units
    - Fuel
    - Chemical
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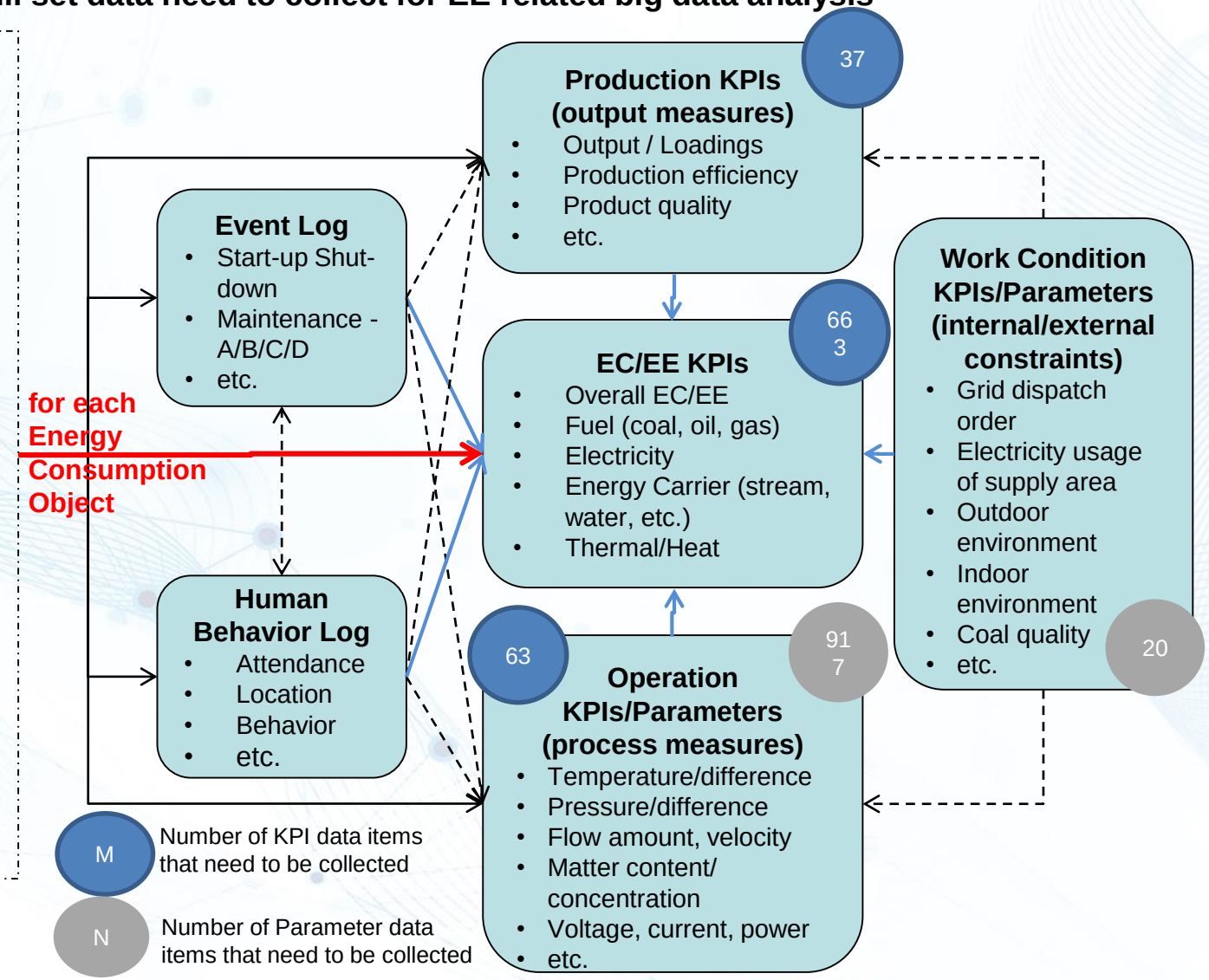
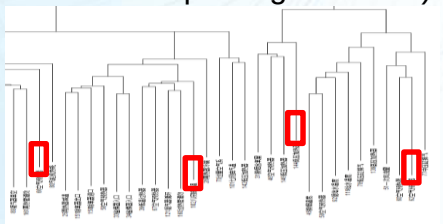
    - Denitrification
    - Soot blow & Ash Removal
    - Sewage treatment
    - Heat supply
    - Auxiliary devices
    - Others
  - Logistics and Facilities
    - Office
    - Logistics/livings
    - Others
  - Others



3. Pilot case example as Proof-of-Concepts
Analytic results by applying innovative big data methods

- **Energy consumption prediction considering all kinds of impacting factors (heat rate baseline)**

1.Key factors selection (which impacting heat rate)

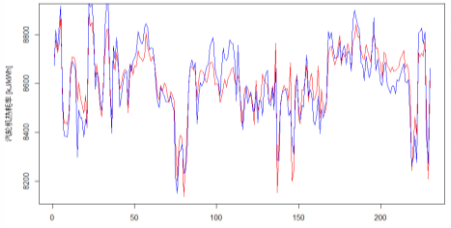


2. Regression analysis

$$\eta = f(x_1, x_2, \ldots, x_n)$$

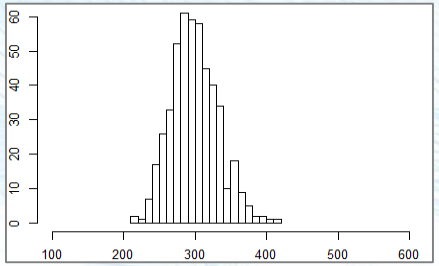
Under different work conditions

3. Energy consumption prediction (heat rate baseline)

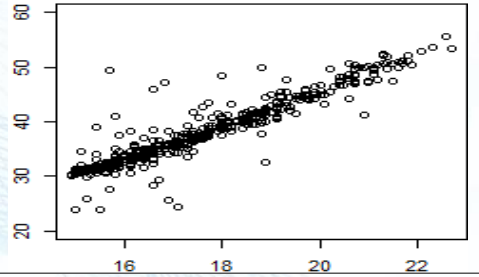


- **Operational variables optimization based on historical data statistics**

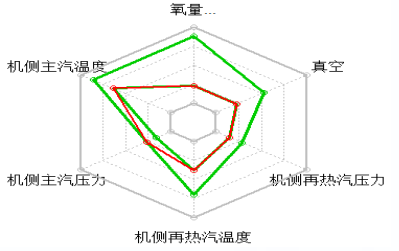
1.Parameter profiling



2. correlation analysis

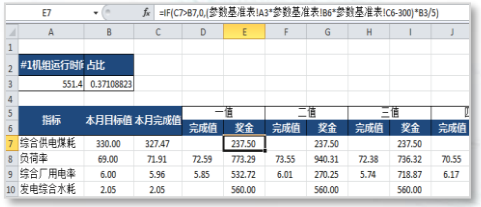


3. Optimal variables value setting recommendation



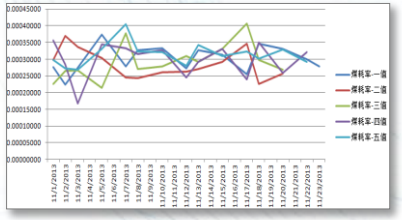
- **In-depth discovery of human behavior factors based on shift Energy Efficiency KPI benchmarking analysis**

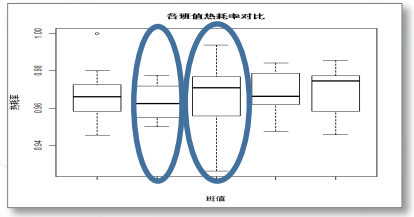
EE KPI benchmarking (5 shifts)



指标	本月目标值	本月完成值	一值		二值		三值	
			完成值	奖金	完成值	奖金	完成值	奖金
综合供电煤耗	330.00	327.47		237.50		237.50		237.50
负荷率	69.00	71.91	72.59	773.29	73.55	940.31	72.38	736.32
综合厂用电率	6.00	5.96	5.85	532.72	6.01	270.25	5.74	718.87
发电综合水耗	2.05	2.05		560.00		560.00		560.00

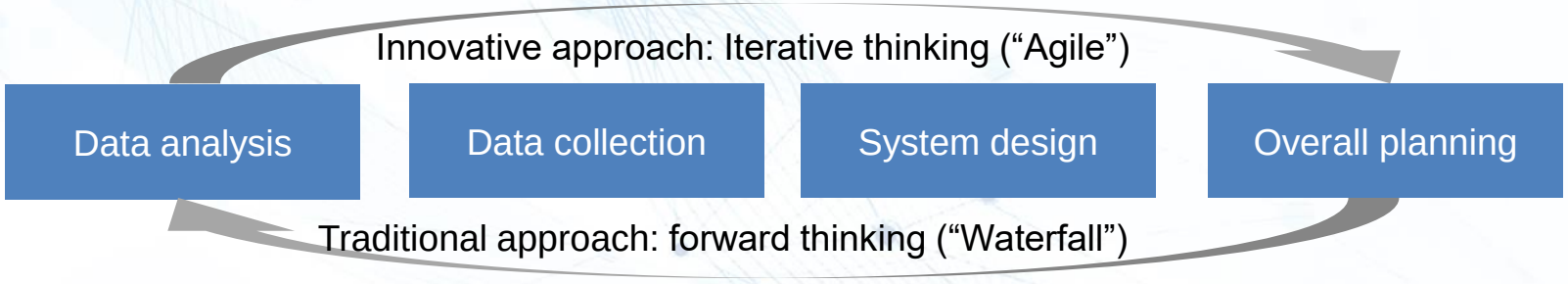
Energy Efficiency comparison (Shift 2 vs. Shift 3)





4. Summary of key findings & Outlook of future To-Dos
Summary of key findings

- The applying of big data analysis technologies could effectively enable the analysis of high volume industrial data. For example, historical records of multiple parameters in the production process could be fully analyzed and compared based on statistical analysis, so as to propose a new optimization model, considering the complex production process as a "black box“ and searching for optimal variable values under different work conditions according to the most optimal records happened in history.
- Under critical challenges for energy savings, such as development of renewable energy, convergence of OT and IT etc., industrial companies need to leverage industrial big data innovation to help them gain competitive advantages from multiple aspects, including extended data collection, storage, processing, analysis and visualization, to achieve Intelligent business decision-making and operation excellence.
- Besides energy savings, industrial big data could realize extensive business value. With full set and high volume data collection with big data analysis, enterprises can achieve stronger capabilities on production optimization, cost savings, emission reduction etc.
- The success of industrial big data analysis is not such easy. High quality and comprehensive data collection is among the top of key success factors. And it is much better to apply big data not only for one certain enterprise, but across the entire industry.
- Except for data issue, other barriers for implementing industrial big data analysis lies on traditional management manner and approach. Traditional forward thinking (“Waterfall”) approach need to be replaced by innovative iterative thinking (“Agile”) approach, so that business results could be rapidly achieved.

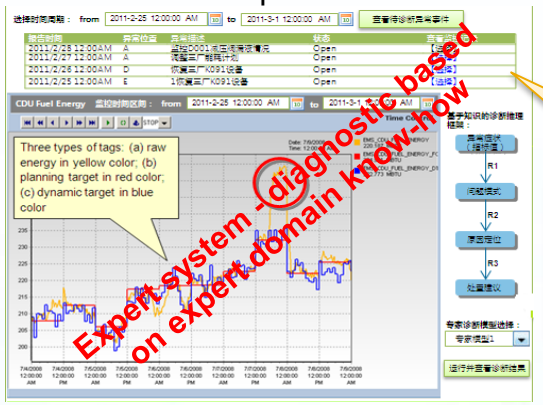


4. Summary of key findings & Outlook of future To-Dos
Outlook of future To-Dos

- Applying of a result-driven based “agile” approach
- Establishment of a service-oriented platform economy business model
- Combination/Convergence of traditional and big data analytics methods

Big Data methods (qualitative analysis) - Statistics model or/and Expert domain know-how model

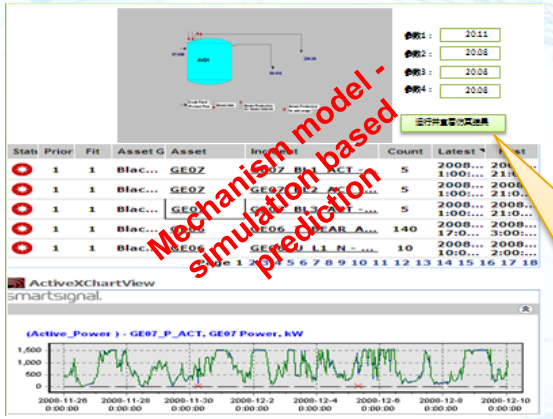
Patterns & abnormities recognition



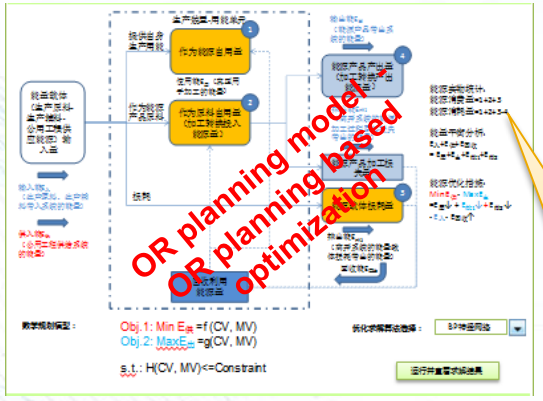
Illustration

Rely on expert knowledge to analyze problems and find matching solutions

Traditional Mechanism methods (quantitative analysis) - Mechanism model or/and OR (Operating Research) planning model



Identify potential risks and help to find out preventative solutions



Solve OR planning model and search the optimal variable values

Thanks for your attention!

Q&A

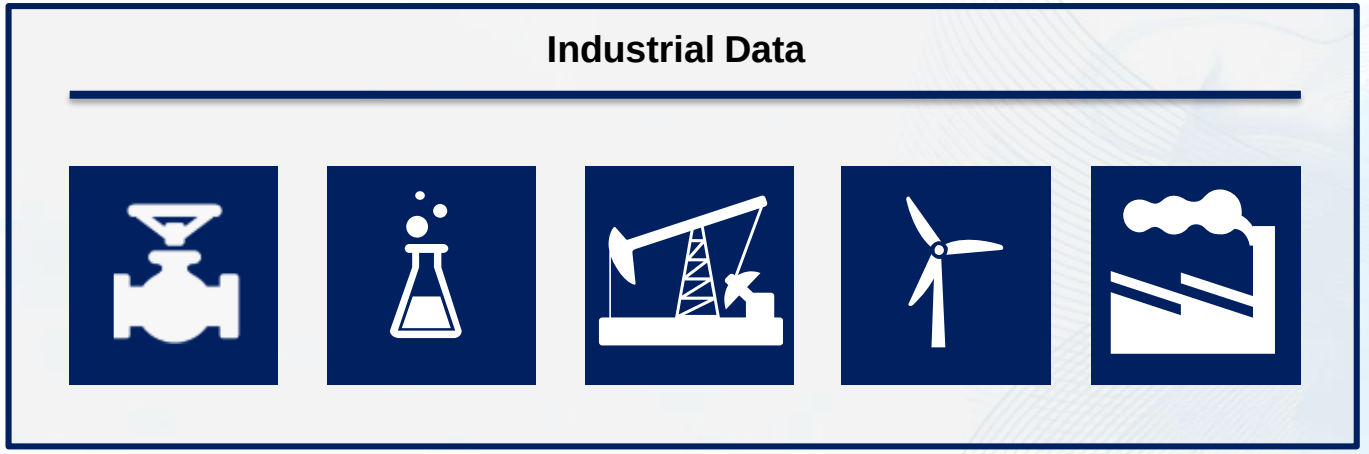
Appendix: Industrial Data and Opportunities

Industrial Data

Data created by industrial process and equipment such as chemical reaction, jet engines, and MRI machines, holds more potential business value on a size-adjusted basis than other types of Big Data associated with the social web, consumer Internet and other sources.

Industrial Data's Top Opportunity

95% of executives surveyed worldwide expect their company to use the Big Data Technology within 3 years, another 63% believe the industrial big data offers them competitive advantage



The IoT & Industrial Data Value will add **$737B** to the global economy in 2019*

Operational Efficiency

Automation, more flexible production techniques and predictive maintenance

Top-Line Growth

New digital products and services generate entirely new sources of revenue

* Ruiz Albert, Haughton Allan, Salama Ben - The Connected Industrial Worker – Stage 0 Deck, https://kxdocuments.accenture.com/contribution/4be33a8f-e03b-4d7b-814f-e7d79df9b92f?referrer=https://kxdocuments.accenture.com