



GE燃机电厂数字化方案



燃机电厂的发展环境

挑战

燃料与能源价格波动

动态多变的能源需求

专业人才的短缺

政策的不断调整变化

环保标准和碳排放交易

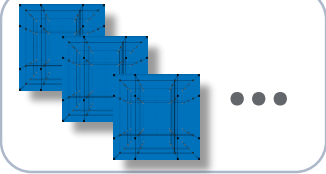
大数据技术的快速扩展

机遇



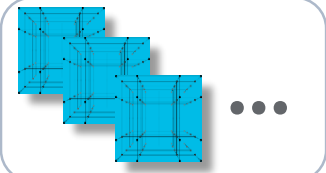
GE数字双胞胎模型和智慧

性能模型



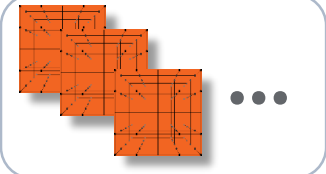
- 启动燃料指导
- 余热锅炉性能
- 热耗和效率预测
- ...

异常模型

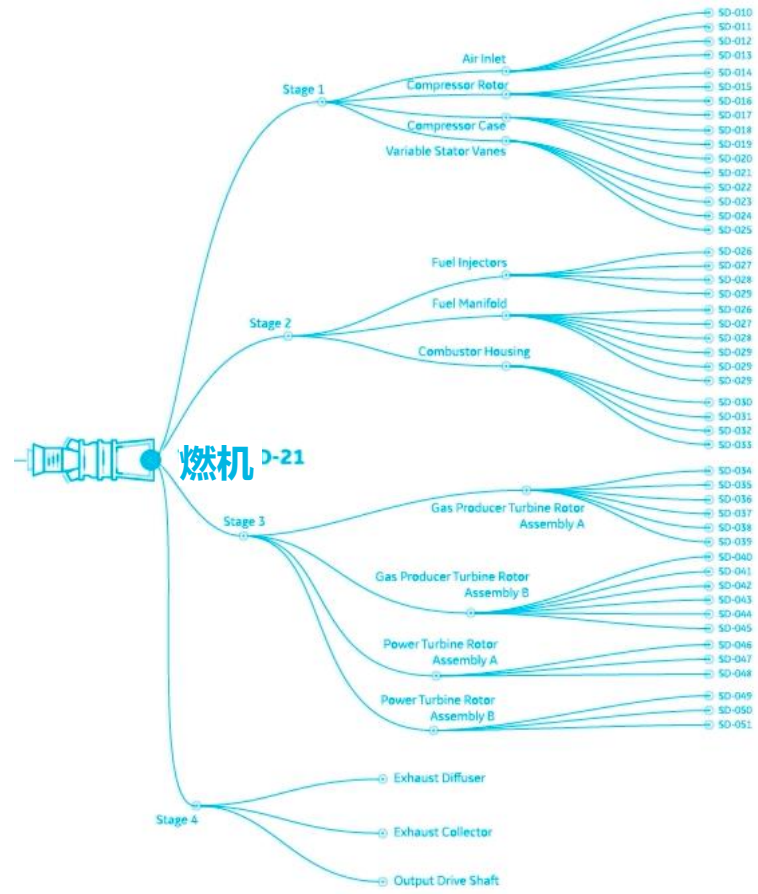
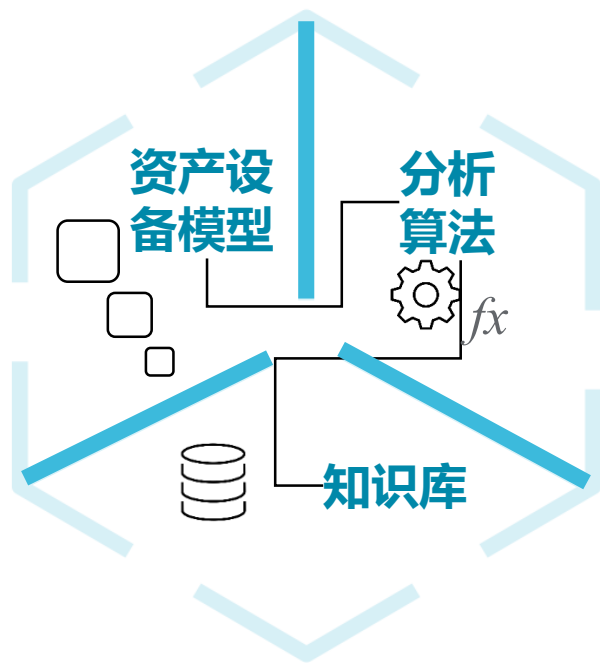


- 燃烧监测, 动压
- 压气机出口, 压力偏差
- 异常的启动振动
- ...

寿命模型



- 寿命里程表
- 失效风险
- 使用率和基于状态的模型
- ...



❖ 设备设计制造参数 ❖ 经受试验确定的极限 ❖ 机群运行历史经验



数字化助力燃机电厂朝智慧迈进

安全、高效、灵活、可扩展、集成与分布

设备监测

实时



阶段 0:
设备和仪表

设备控制

实时



阶段 1:
机组控制系统

机组先进控制和优化

实时和近实时



阶段 2:
边缘计算服务器

电厂和机群优化

秒到分钟的分辨率



阶段 3:
上层决策服务

智慧

将电厂设备连通实现适应性控制、诊断和决策支持的贯通





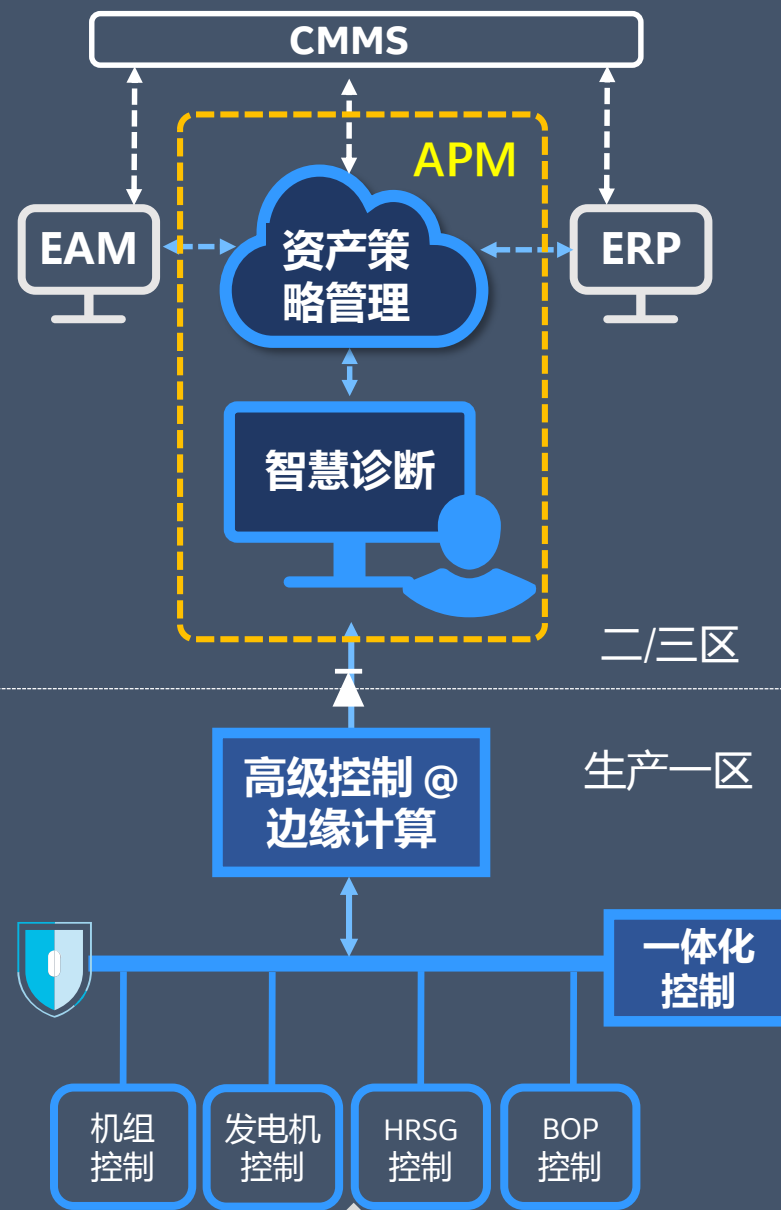
生产到管理的整体数字化

GE赋予了从边缘到大树据的整体方案



工业互联网

工业以太网控制系统



燃机电厂数字化



1. 边缘计算



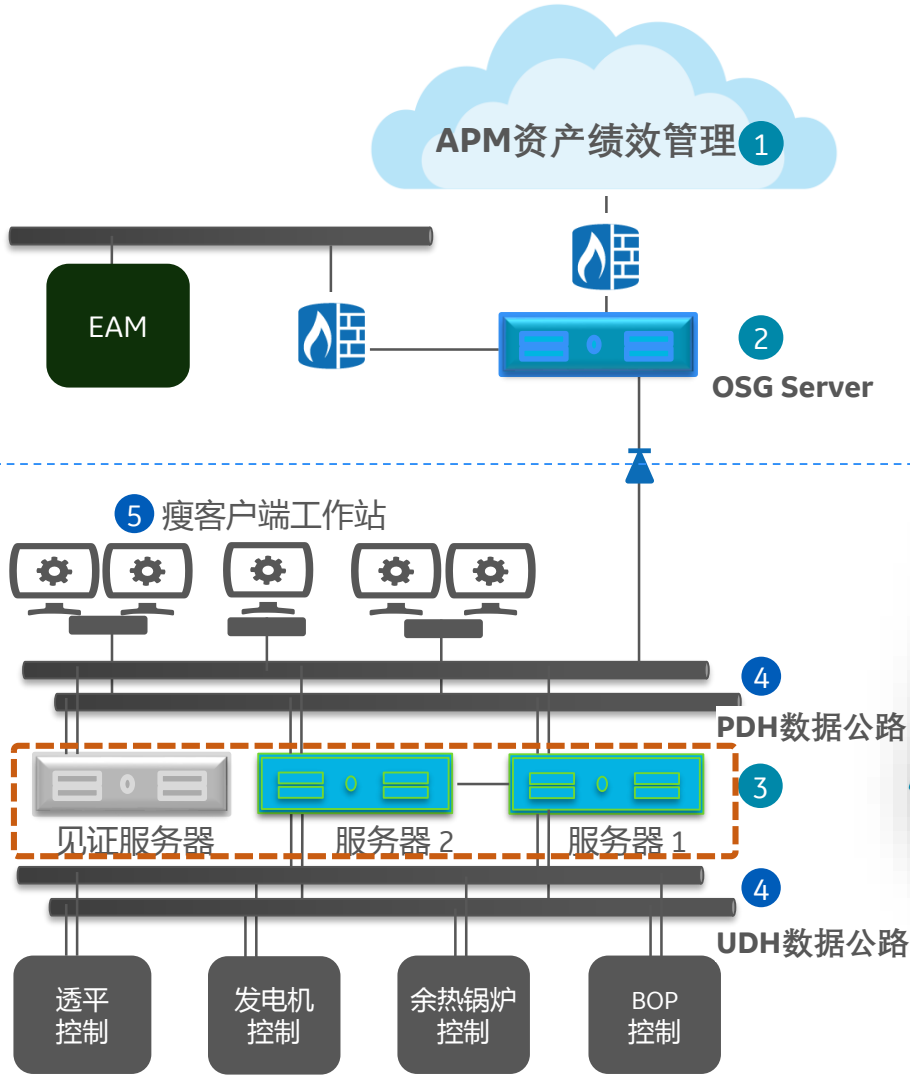
边缘计算赋予控制系统新的能力

生产二区/三区

大数据平台

生产一区:

控制系统



嵌入式数字双胞胎



See tutorial regarding confidentiality disclosures. Delete if not needed.





GROSS OUTPUT

0 2000 **1115** MW

HEAT RATE

9021
Btu/kWh

GENERATOR

MVAR PF
25 0.897
MVARStatus
Ext SetpointSpeed
3600
RPM

TURBINE

Control
RemoteTTXM
1066
°FCTR Max Vib
60 0.82
%FUEL
75.0 Gas
%

GT ALARMS

1 2 3
16 15 1

GT ALERTS

28

Marin County
Power Station04:57 PM
10/03

PLANT



GT



HRSG



ST



GEN



BOP



ELEC



TASKS



ALARMS



Home :: GT

GT OVERVIEW

CONTROLS

+ FUEL GAS SYSTEM

+ COMPRESSOR

+ ROTOR

+ COMBUSTION

+ AUXILIARIES

FREQ. CONTROL

MASTER CONTROL

Prestart Test Control

ENABLE

DISABLE

Turbine CTRL Mode

Remote

Synch CTRL

Synch On

Start Control

START

STOP

Cooldown Control

ON

OFF

Start Control

ENABLE

DISABLE

CRANK

FAULT RESET

RESET

MASTER RESET

DIAGNOSTIC RESET

Prestart Test Status

Completed

Control State

Remote

Status

Pre-Select

Start Permissive

Ready

Shutdown Condition

Normal

Trip

No Trip

Purge Credit Perm.

OK

Purge Credit Fault

None

Purge Time Remaining

None

Temp Match Status

Active

Temp Match Ref

700.0 degF

Temp Match Ref Rate

2.0 degF/sec

SPEED CONTROL

Speed
■ Current 3600 RPM
■ Reference 3500 RPM
▼ Target 3600 RPM

LOAD CONTROL

Current
310 MW

Target

312 MW

+ -

Mode

Base Load

FUEL CONTROL

FSR
75.0%

FSR CTRL

Fuel Mode

Gas

Manual FSR

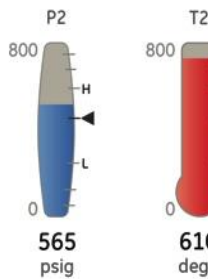
DLN Mode

Premix

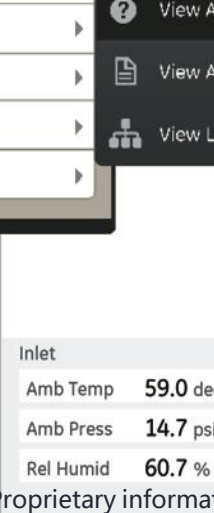
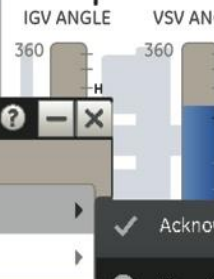
AutoTune Status

Active

Combustion



Compressor

燃机运行受益...
提升操作体验，降低操作成本

- ✓79% 更少的翻阅时间
- ✓68% 更少的翻阅步骤
- ✓42% 更少的任务完成时间



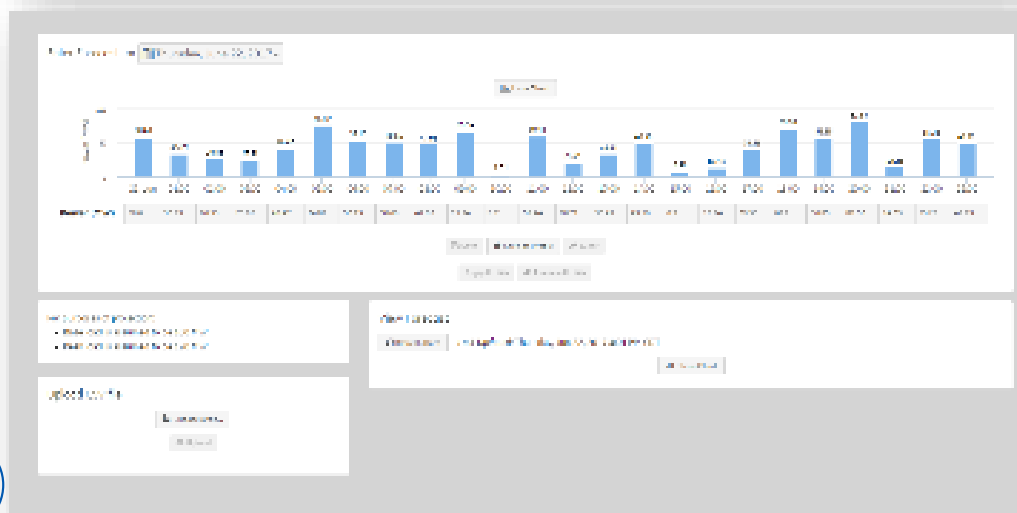
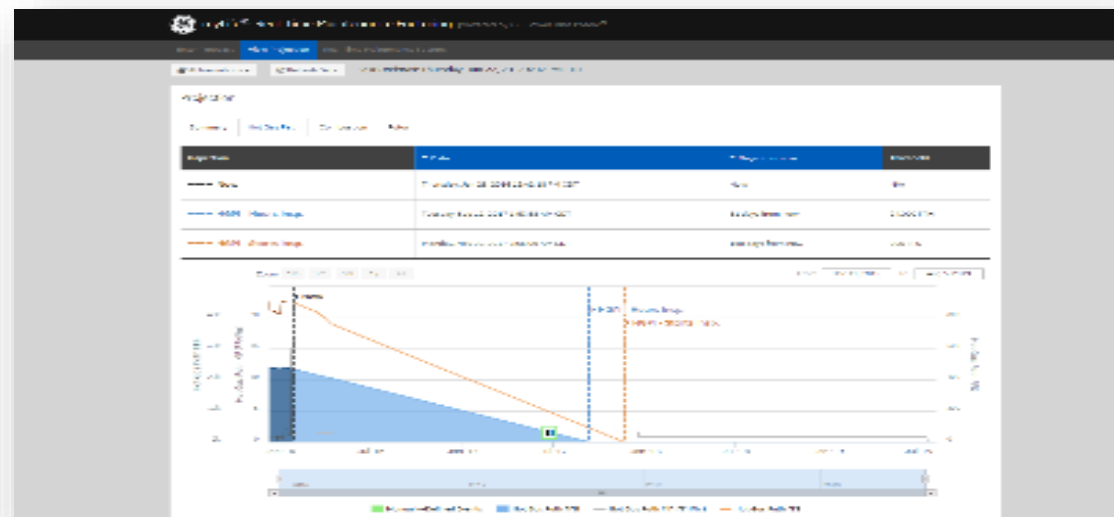
- ✓61% 更好的舒适度
- ✓58% 更高的系统使用率
- ✓38% 更好的用户体验评分



- ✓80% 更少的报警 (合理化)
- ✓72% 更少的时间用于阅读报警信息 (帮助功能)
- ✓40% 更少的许可条件(合理化)

燃机运行里程表

设备等效运行时间和启动次数实时跟踪，动态计算检修周期



- 实时反馈运行情况对检修计划的影响
- “假设”场景是一个预测工具用于降低风险
- 自动跟踪运行数据，计算检修因子，等效启动次数和等效运行小时，提高工作效率



Performance Recovery Advisor powered by Predix

Compressor Advisor Heat Exchanger Advisor Turbine Advisor

Control Historical View Scheduling

Recommended Action

Impact of All Actions

Projected Effects if Water is Performed Now

345.2 MW

314.3 MW

Power (MW)

Time (h)

345.2 MW

314.3 MW

- Predict
- Performance gain
- Plan outage



Case	Power	Compressor	Inlet Filter	Overall
G1	152.33 MW	 Compressor 7.23 MW Inlet Filter 4.34 MW	 Compressor 5.84 MW Inlet Filter 4.34 MW	Compressor 81 % Inlet Filter 100 % Overall 88 %
G2	148.24 MW	 Compressor 6.93 MW Inlet Filter 4.33 MW	 Compressor 5.43 MW Inlet Filter 4.38 MW	Compressor 78 % Inlet Filter 101 % Overall 87 %
G3	154.96 MW	 Compressor 8.34 MW Inlet Filter 4.36 MW	 Compressor 6.14 MW Inlet Filter 4.34 MW	Compressor 74 % Inlet Filter 99 % Overall 82 %

- 水洗和进气滤网更换建议
- 将预测的检修成本与提升的性能和收益进行平衡
- 当更低成本可以提升生产力时就执行检修维护工作

燃机电厂数字化

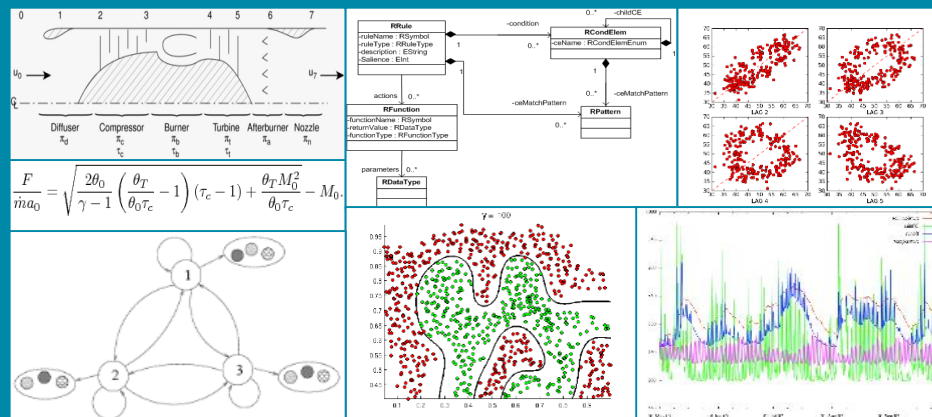


2. 智慧诊断



故障预测与诊断

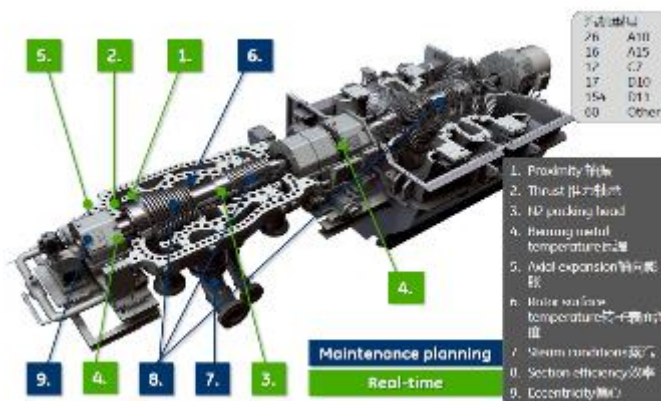
基于GE亚特兰大监控中心20多年经验及数据的专家分析系统。提供预测性的建议、专家诊断和故障排查，进而能够预测、预防并解决客户机组在运转时的风险。



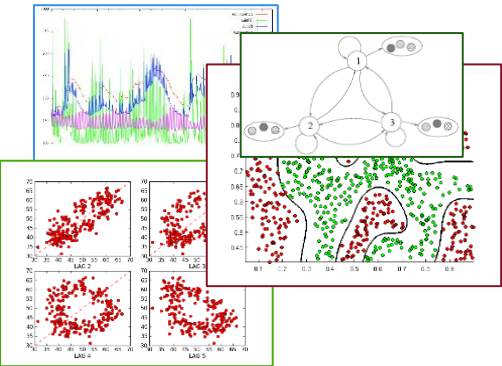
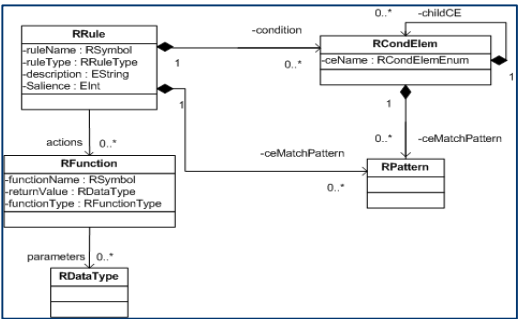
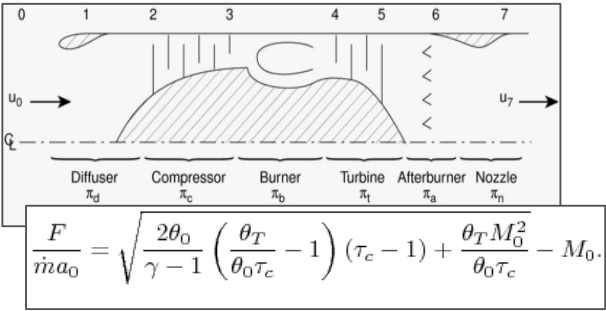
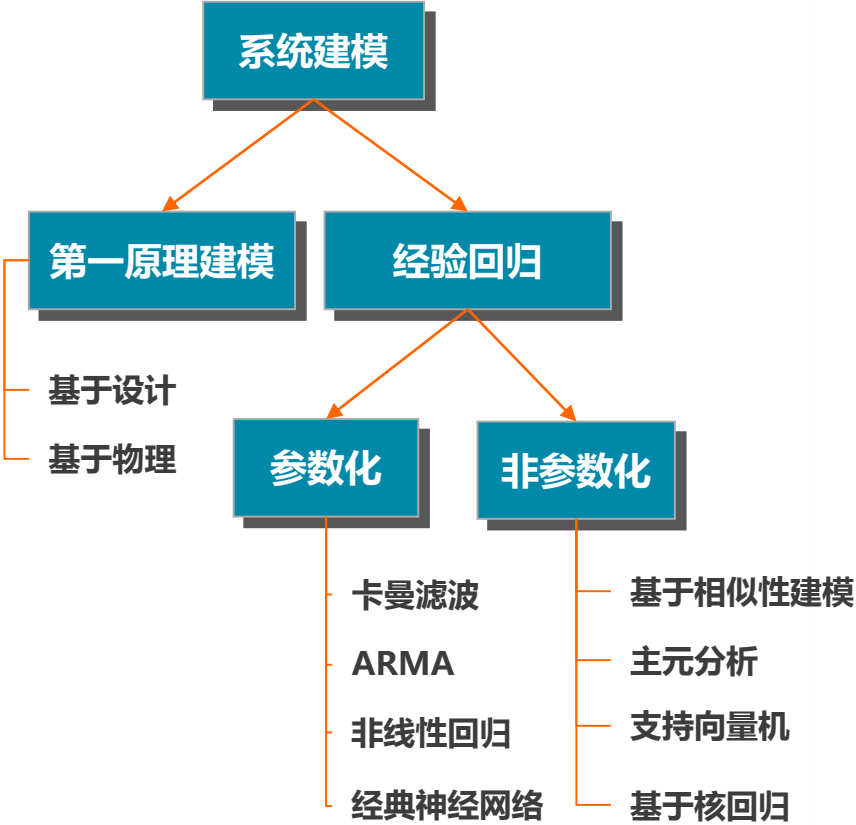
20+年燃机运行经验

物理模型+统计模型

主设备 { 可靠性 ↑
可用率 ↑
安全风险 ↓



模型覆盖GE或非GE的全厂主设备



物理模型

- 基本原理和行业知识
- 数据需求少
- 效果随时间推移下降

经验规则

- 直觉
- 专家知识的积累
- 来自领域专家的更新

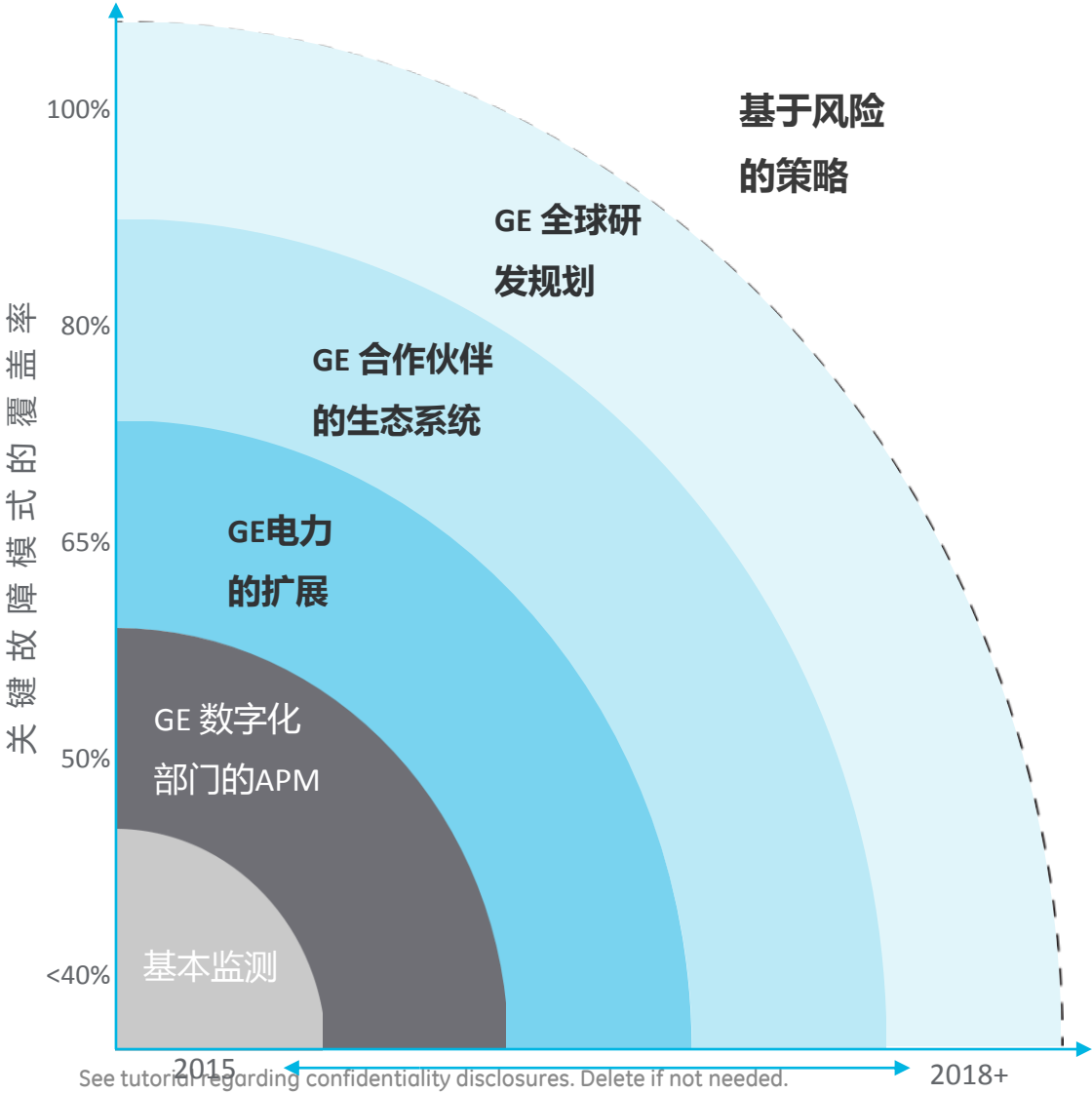
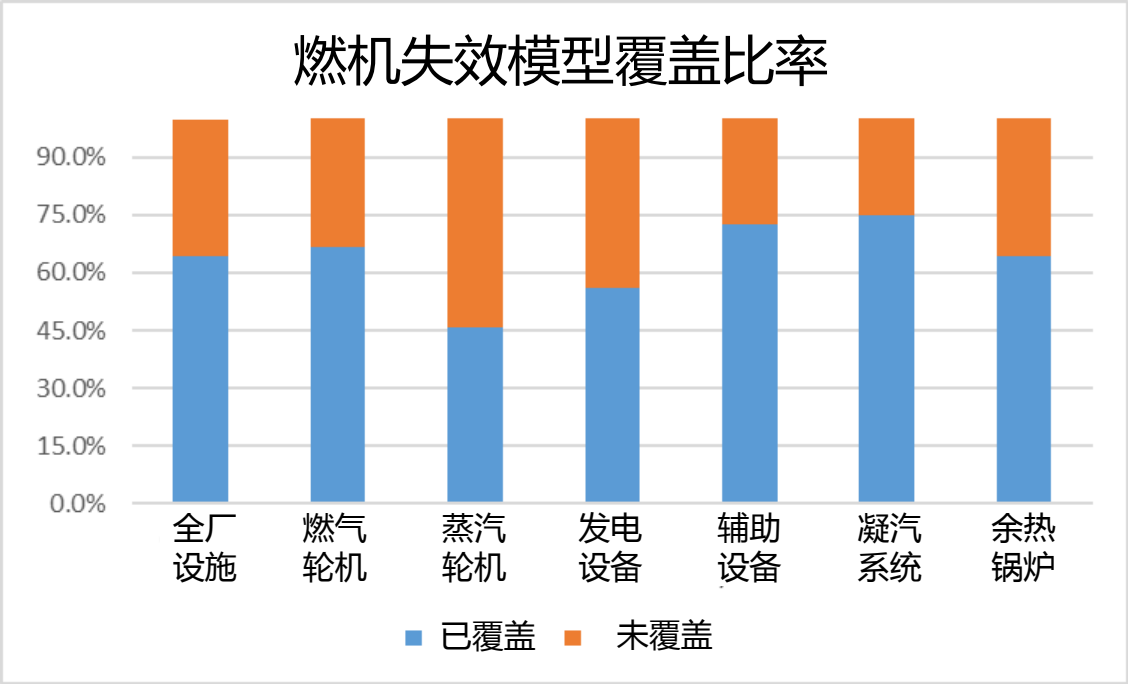
数字抽象

- 易于量化和维护
- 利用工业领域的有限信息
- 预测基于历史事件



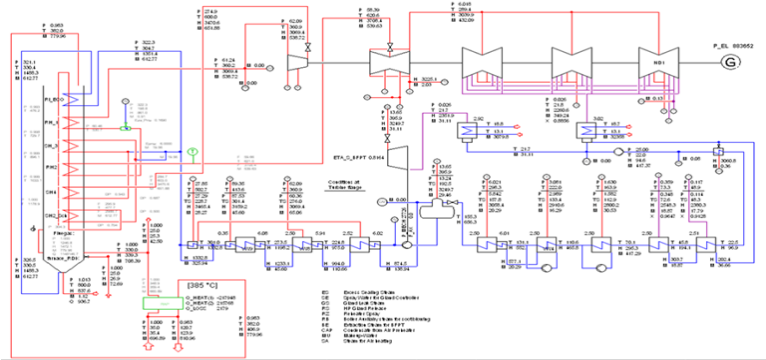
数字双胞胎（失效模型）

超过**64%**的失效得到覆盖



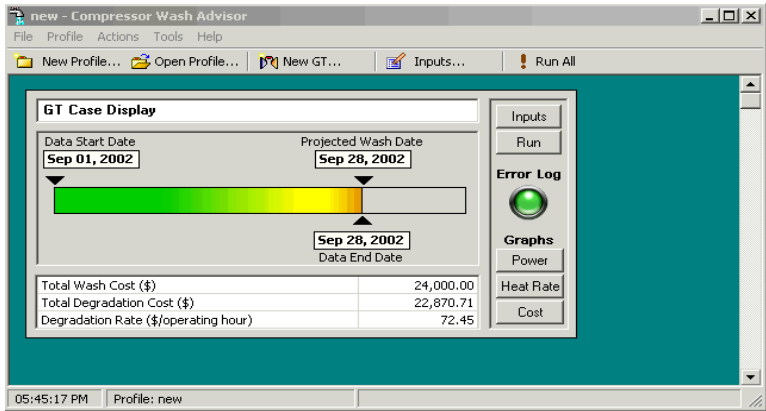
数字双胞胎（热效率模型）

在线热平衡模型



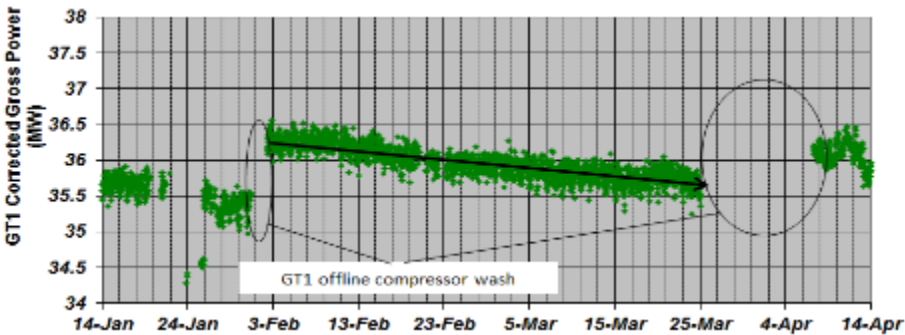
热平衡模型

运行建议：自动计算平衡成本



压气机水洗时间建议界面展示

性能分析：跟踪性能劣化或提升



软件计算出的修正值，剔除了环境因素、不同负荷的影响

What-if：离线假设分析预测效率

Run Description	Description
Inputs	
Ambient Conditions	
Ambient Temperature	15.0 °C
Ambient Pressure	1.013 bar
Ambient Relative Humidity	60.0 %
Operating Conditions	
Maximum Capacity yes / no	yes
Control Plant Power yes / no	
Target Plant Net Power	
Block MW Difference (BL1-BL2)	
Auxiliary Power	0.0 MW
Generator Power Factor	0.80 -
Gas Turbine	
Baseload Flag GT1 on / off	
Baseload Flag GT2 on / off	
Block 1 Desired Net Power	
Block 2 Desired Net Power	
Block 1 Shutdown yes / no	
Block 2 Shutdown yes / no	
HRSG	
Maximum HP Steam Temp.	520.0 °C
Maximum HR Steam Temp.	510.0 °C
Condenser	
Condenser Cooling Water Inlet Temp.	29.5 °C
± Economic Calculation	
Fuel Cost	11.0 \$/sm³
Electricity Price	90.0 \$/MWh

Results	
Calculation Status	
Date/Time of What-if run	12/1/16 4:15 PM
Status	ok
Plant output & Projected Plant Net Heat Rate	
Net Cycle Power	121.3 MW
Gross Cycle Power	121.3 MW
Net Cycle LHV Heat Rate	7,683 kJ/kWh
Net Cycle LHV Efficiency	46.86 %
Block output & Projected Block Heat Rate	
Block 1 Gross Power	121.3 MW
Block 1 Gross LHV Heat Rate	7,683 kJ/kWh
Block 1 Gross LHV Efficiency	46.86 %
Block 2 Gross Power	121.3 MW
Block 2 Gross LHV Heat Rate	7,683 kJ/kWh
Block 2 Gross LHV Efficiency	46.86 %
Power Output	
GT1 Net Power	41.7 MW
GT2 Net Power	41.7 MW
Steam Turbine 1 Net Power	38.2 MW
Steam Turbine 2 Net Power	38.2 MW
Fuel & Heat Rate	
GT1 Net LHV Heat Rate	11,180 kJ/kWh
GT2 Net LHV Heat Rate	11,180 kJ/kWh
Steam Turbine 1 Efficiency	28.12 %
Steam Turbine 2 Efficiency	28.12 %
GT1 Fuel Flow	10.0 ton/hr
GT2 Fuel Flow	10.0 ton/hr
Plant Fuel Flow	17.0 sm³/sec
Fuel Gas LHV	46,754 kJ/kg
Fuel Gas HHV	51,946 kJ/kg

What-if输入界面 What-if输出结果

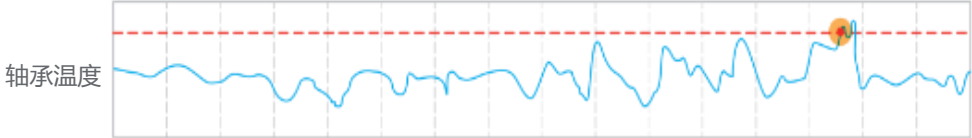


智慧诊断结合专业分析服务

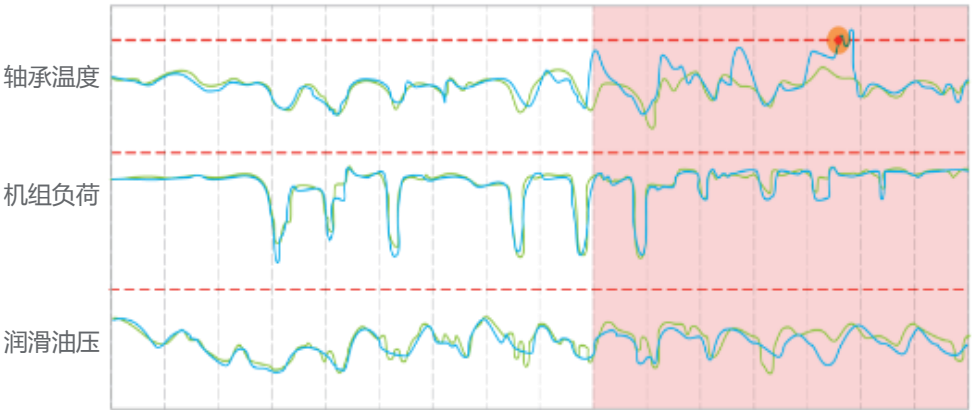


可靠性管理					
交付	4* 级	3 级	2 级	1 级	
机器设备健康基本服务			✓	✓	
预警咨询单和预警案例管理				✓	
简单模型维护				✓	
每周主动报告和咨询，以便更好地规划			✓	✓	
复杂的模型维护			✓	✓	
月度运营评估与咨询		✓	✓	✓	
6周过程监控和记分卡报告	✓	✓	✓	✓	

传统方法：单个传感器分析通过使用传统的定值或者规则来报警



机器学习：实时多变量分析，基于学习规则的预警模式



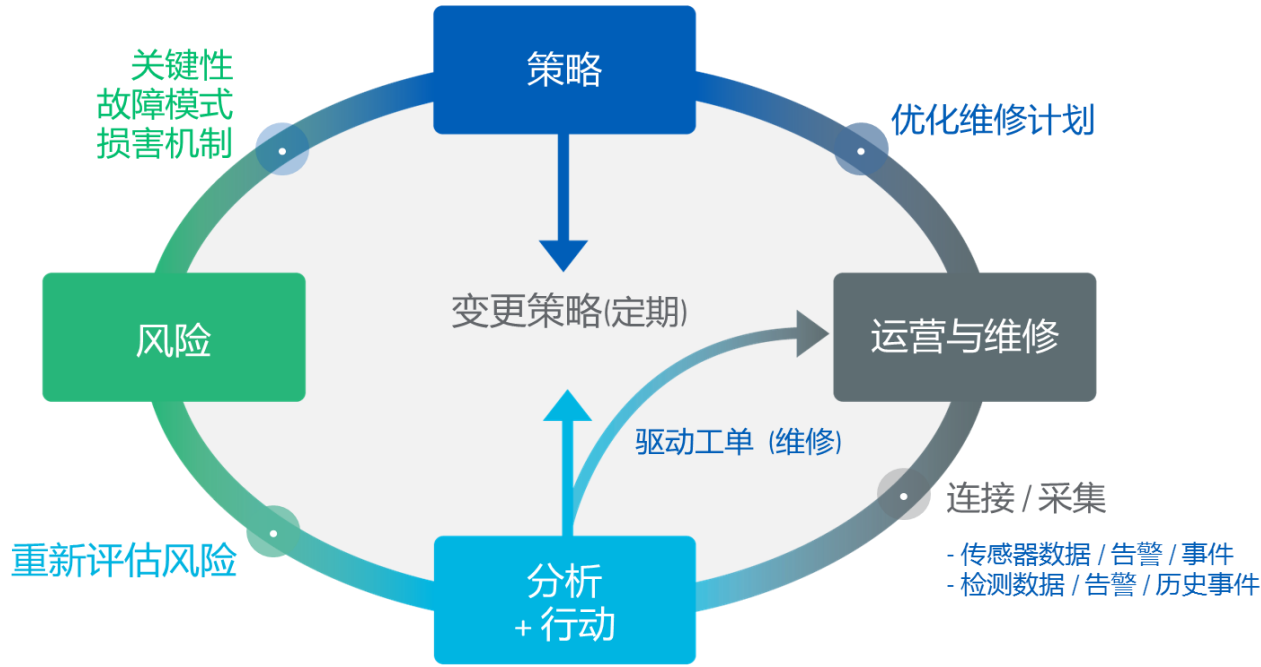
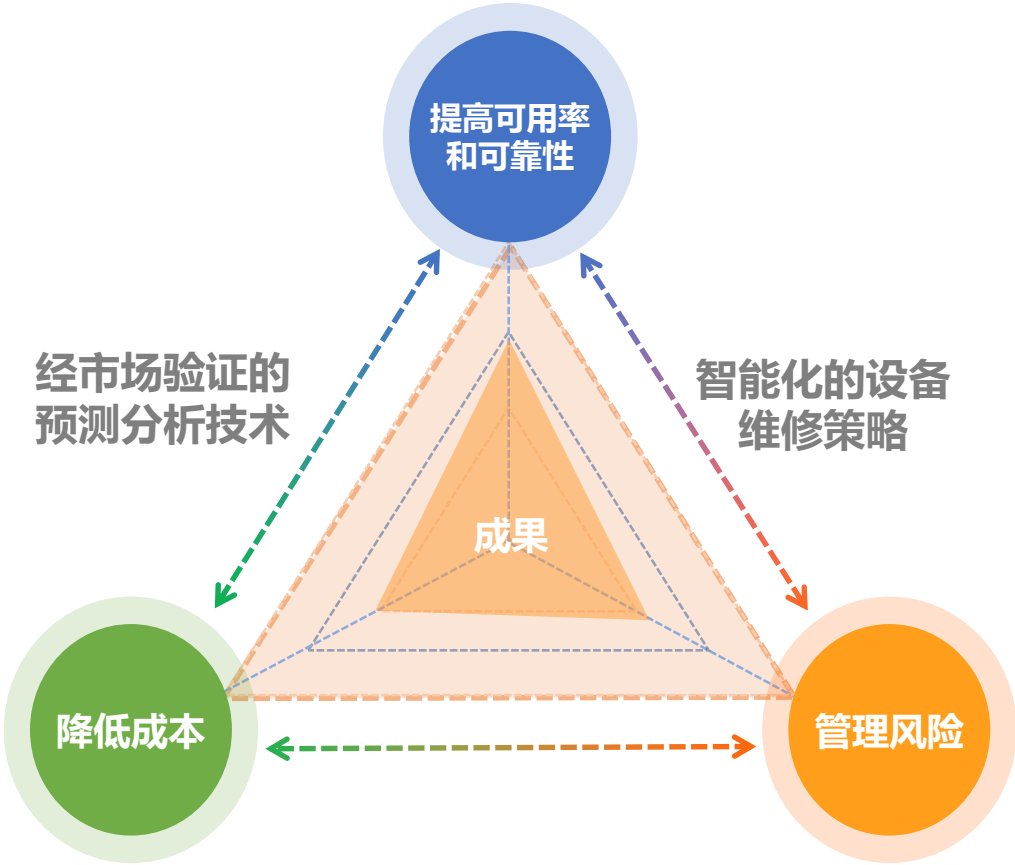
燃机电厂数字化



3. 资产策略管理



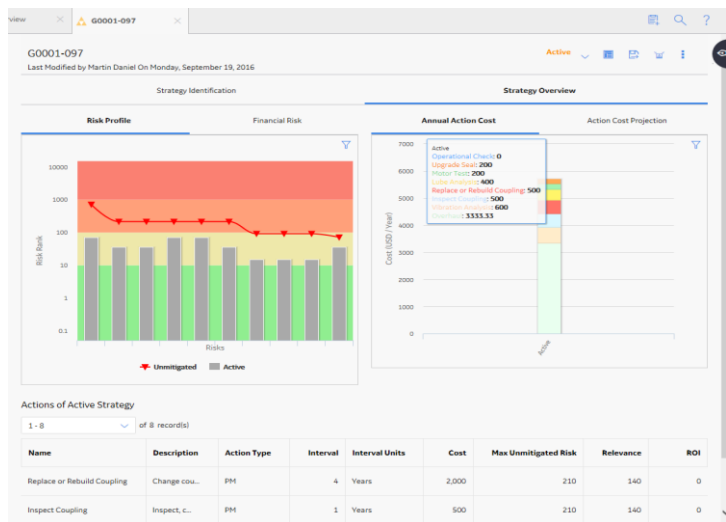
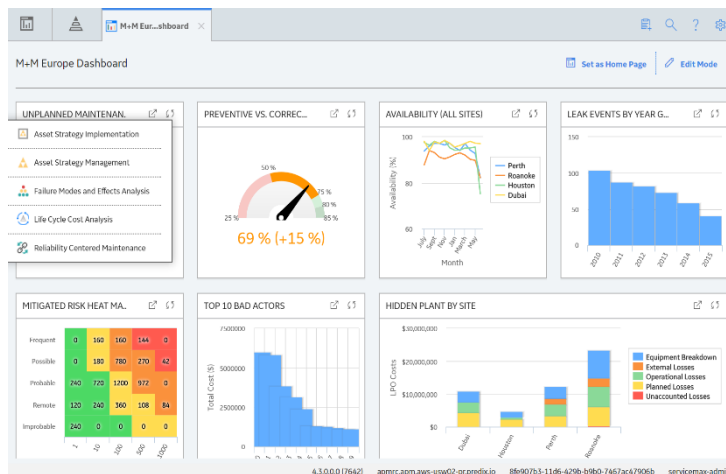
资产策略管理



跨越系统的数据整合，数字化的智慧指导设备的状态检修



资产策略管理



生产数据和管理数据

融合

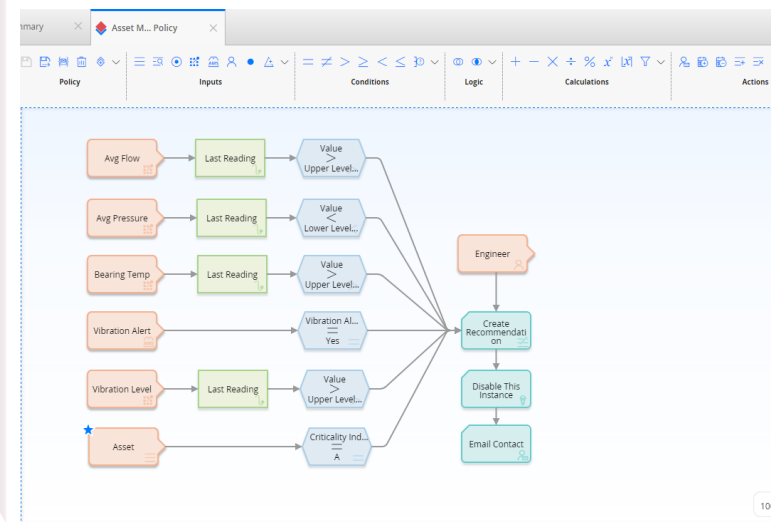
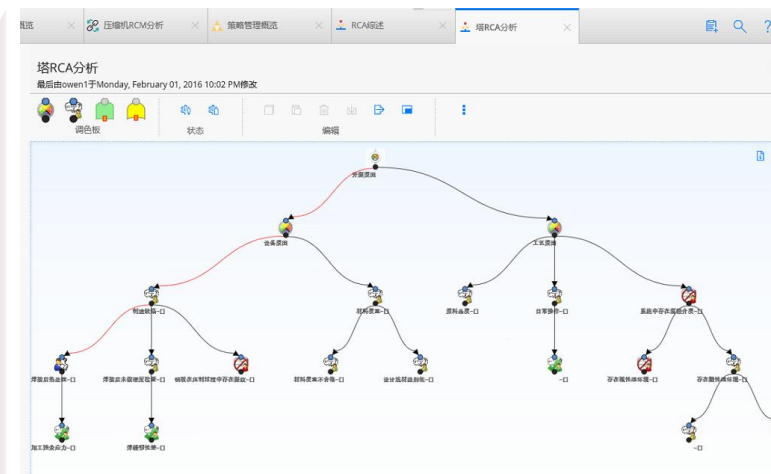
设备风险评估和后果量化

内置的维护策略工具
(RCM/FMEA)

策略知识库 (ASL)

汇聚设备系统相关的
“全寿命”成本数据

编制措施和策略逻辑
闭环追踪



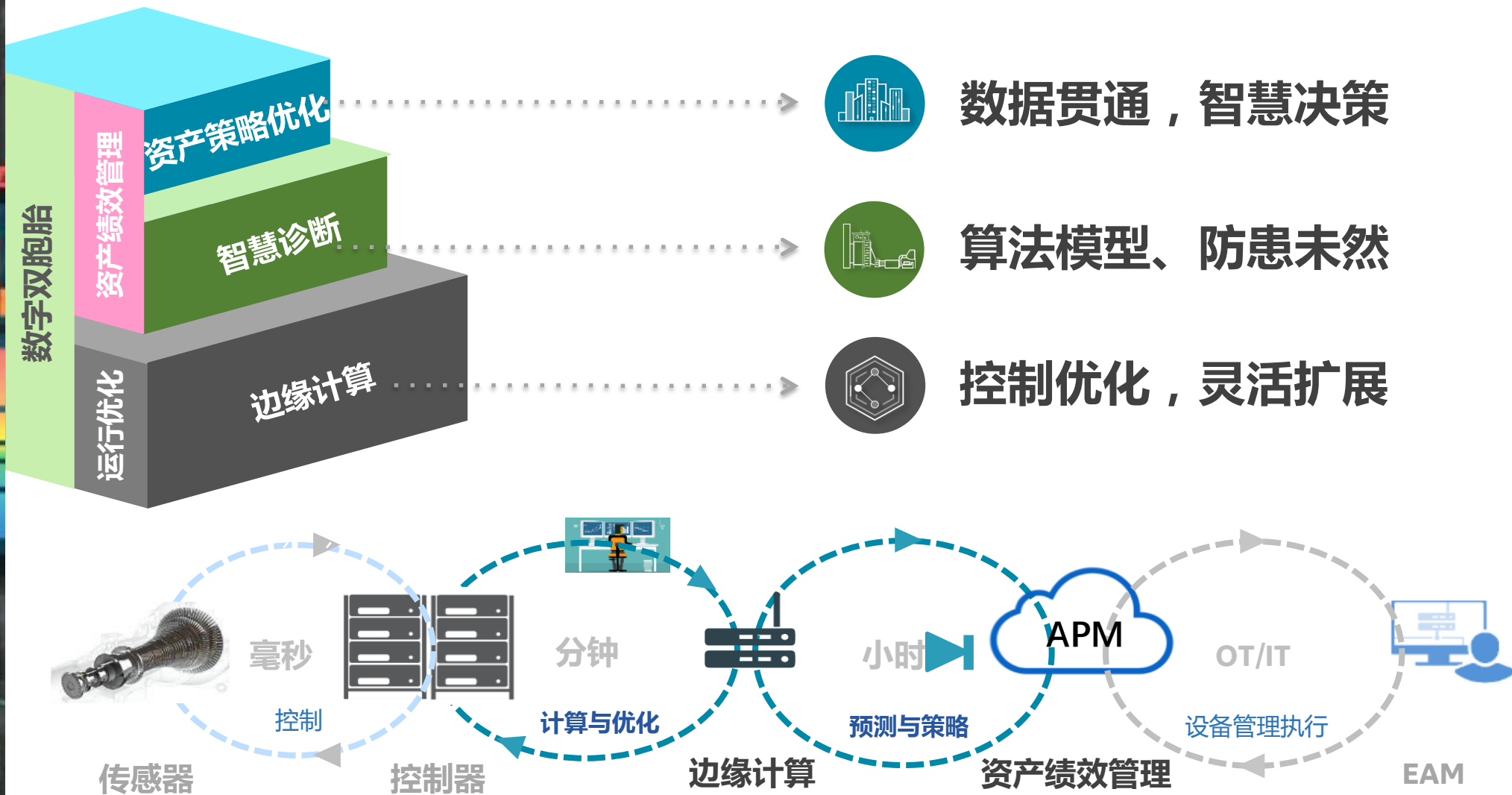
燃机电厂数字化



4. 总结



数字企业，智慧能源



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