

# Exploration and Practice of Smart Hydroelectric power Plant 智能水电厂发展实践及探索

NARI GROUP CORPORATION  
南瑞集团有限公司



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1	Background	<b>发展背景</b>
2	Definition	<b>内涵定义</b>
3	Architecture	<b>技术体系</b>
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# Background

- **Rapid development and wide applications of latest technologies**

**最新技术的快速发展和广泛应用**

- **Many countries are constructing Smart Grid**

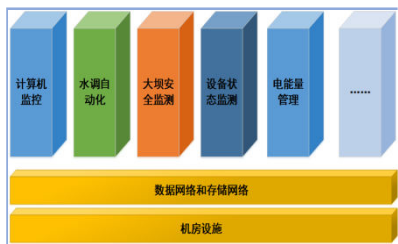
**许多国家在推进智能电网建设**

- **China has mentioned the intellectualization of power generation in relevant documents such as**

**“Building Novel Power System”, “Energy Technology Innovation”, and “Enterprise Digital Transformation “**

**中国在“建设新型电力系统”、“能源技术创新”、“企业数字化转型”等相关文件中都提到了发电智能化**

# Background - Business Problem



**Business information sharing**  
业务信息共享



**equipment condition measurement**  
设备状态感知



**Safety management and risk control**  
安全风险管控



**Multi-energy regulation**  
多元能源调控



**Intelligent analysis and disposal**  
智能分析处置



**Source network coordination ability**  
源网协调能力



**Electricity transaction optimization**  
电力交易优化

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## Definition of “Smart Hydroelectric Power Plant”

### “智能水电站”术语定义

Chinese National Standard 《Guide for Smart Hydropower Plant》 (GB/T 40222-2021)

中国国家标准《智能水电厂技术导则》(GB/T 40222-2021)

On the basis of **automation, digitalization and informatization**, with the application of **cloud computing, big data, Internet of Things, mobile internet, artificial intelligence** and other technologies, it has the ability of **self-sensing, self-learning, self-decision-making, self-execution and self-adaptation**, and realizes **safe, stable and efficient** operation of hydropower plants.

以**自动化、数字化、信息化**为基础，利用**云计算、大数据、物联网、移动互联、人工智能**等技术，具有**自感知、自学习、自决策、自执行、自适应能力**，实现**安全、稳定、高效**运行的水电厂。

# Definition-Term



## Definition of “Smart Hydroelectric Power Plant” “智能水电站” 术语定义

BS IEC/IEEE 63198-2775:2023 《 Technical guidelines for smart hydroelectric power plant 》

IEC、IEEE、英国BS标准《智能水电厂技术导则》 63198-2775:2023

Hydroelectric power plant or group of plants which is featuring **digitalized information, networked communication, standardized integration, interactive applications, optimized operation,** and **intelligent decision**

具有**信息数据化、通信网络化、集成标准化、能够进行交互应用、优化运行、智能决策**等特点的水电站或水电厂群。

# Definition-Characteristics

- Smart hydropower plant is a **new generation** of technical support system adaptive to **refined management**.  
智能水电厂是适应**精细化、集约化生产运行管理**的**新一代**技术支撑**体系**
- Smart hydropower plant achieves the improvement of **all business capabilities** within the whole plant.  
智能水电厂是**全局视角**下的水电站运行管理**全业务能力提升**。
- Smart hydropower plant is a self-adaptive system with **high coordination, high flexibility and high autonomy** capabilities.  
智能水电厂是**高度协同、高度灵活、高度自治**的自适应系统。
- Smart hydropower plant is a **dynamic self-optimization system** to accomplish repetitive and dangerous work in the plant.  
智能水电厂是**机器人、自主演进**的动态自优化系统。



# Definition-Construction Goal



Eliminate application system islands  
消除应用系统孤岛



Reduce the cost of system construction  
降低系统建设成本



Realize business cooperation  
实现业务协同互动



Improve decision-making capabilities  
提升优化决策能力



Promote operation and management  
优化生产管理水平

- Unattended operation  
“关门运行”
- Condition-based maintenance  
“状态检修”
- Hydraulic and electricity cooperation dispatching  
“水电协同调度”
- Integration of operation and inspection  
“运检一体”
- Centralized maintenance  
“统一运维”
- Expert knowledge  
“专家知识”
- Data-driven business  
“数据驱动”
- Intelligent enterprise  
“智慧企业”

# Definition-Intelligent Grading

## General characteristics (primary) 总体特征 (初级)

Improve the ability of automatic monitoring and control, realize the information interaction between different business, improve the system decision support ability, realize the operation control and system optimization based on man-machine cooperation, and improve the safe operation level and work efficiency of hydropower plants.

提高自动化监控能力, 实现不同业务之间的信息交互, 提高系统决策支持能力, 实现基于人机协同的运行控制和系统优化, 提高水电站的安全运行水平和工作效率。

## General characteristics (medium) 总体特征 (中级)

Intelligent electronic devices and unified information model are adopted to realize equipment intelligence, improve the abilities of intelligent monitoring and fault diagnosis, realize machine-based operation control and system optimization, boast technical conditions of closed operation, and intervene manually in extreme cases.

采用智能电子设备和统一的信息模型, 实现设备智能化, 提高智能监控和故障诊断能力, 实现基于机器的运行控制和系统优化, 具备封闭运行的技术条件, 在极端情况下可手动干预。

## Overall characteristics (advanced) 总体特征 (高级)

By means of intelligent equipment, digital simulation model, industry expert knowledge base and artificial intelligence, the self-learning, self-decision, self-execution and self-adaptation abilities of equipment and systems are realized, and the optimal operation of production and system maintenance are completely completed automatically by the system.

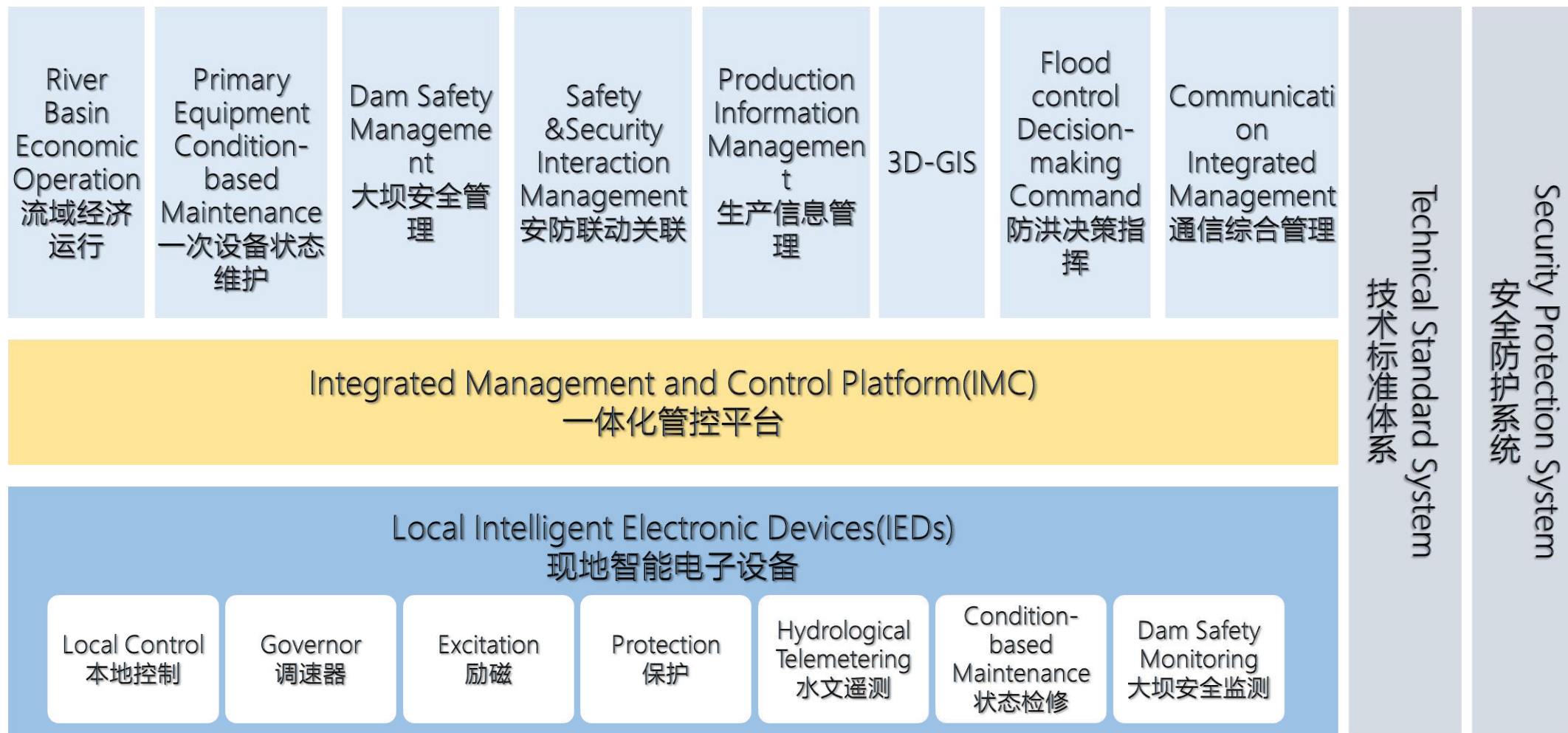
通过智能设备、数字仿真模型、行业专家知识库和人工智能, 实现设备和系统的自学习、自决策、自执行和自适应能力, 系统自动完成生产的优化运行和系统维护。

Current stage of  
development  
当前发展阶段

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# Architecture



# Business Applications

## 1 Intelligent Engineering 智能工程

- ◆ **3D visual design**  
三维可视化设计
- ◆ **Smart site management**  
智慧工地管理
- ◆ **Project safety monitoring**  
工程安全监测
- ◆ **Dynamic monitoring of strong earthquakes**  
强震动态监测
- ◆ **Geological hazard monitoring**  
地质灾害监测
- ◆ **Personnel positioning system**  
人员定位系统
- ◆ **Emergency broadcasting system**  
应急广播系统

## 2 Intelligent operation 智能运行

- ◆ **Smart sensor**  
智能传感器
- ◆ **Intelligent electronic device**  
智能电子装置
- ◆ **Multi-system interaction**  
多系统联动
- ◆ **Intelligent alarm**  
智能报警
- ◆ **Smart Reports**  
智能报表
- ◆ **Intelligent patrol (RFID, robot patrol, UAV)**  
智能巡检 (RFID、机器人巡检、无人机)
- ◆ **Operation safety and environment monitoring**  
作业安全环境监测
- ◆ **Intelligent lighting and ventilation**  
智能照明、通风
- ◆ **Personnel and vehicle positioning**  
人员、车辆定位
- ◆ **Monitoring of environment and water quality in reservoir area**  
库区环境与水质监测
- ◆ **Access control system**  
门禁系统
- ◆ **Credit guarantee management**  
保信管理
- ◆ **Industrial TV**  
工业电视
- ◆ **Fire fighting system**  
消防系统

# Business Applications

## 3 Intelligent scheduling 智能调度

- ◆ **Water inflow forecast**  
来水预测
- ◆ **Optimized scheduling**  
优化调度
- ◆ **Trend prediction and self adjustment**  
趋势预测与自调整
- ◆ **Dispatching risk analysis**  
调度风险分析
- ◆ **Bidding in electricity market**  
电力市场竞报价

## 4 Intelligent maintenance 智能检修

- ◆ **Equipment status monitoring**  
设备状态监测
- ◆ **Equipment condition maintenance**  
设备状态检修
- ◆ **Spare parts management**  
备品备件管理
- ◆ **asset management**  
资产管理
- ◆ **Tools and instruments management**  
工器具管理
- ◆ **Maintenance training simulation**  
检修培训仿真

## 5 Intelligent management 智能管理

- ◆ **Panoramic display**  
全景展示
- ◆ **Big data analysis**  
数据分析
- ◆ **Emergency command**  
应急指挥
- ◆ **Centralized operation and maintenance platform**  
集中运维平台
- ◆ **Mobile office and public interaction**  
移动办公、公众互动
- ◆ **Production management system**  
生产管理系统

# Key Technologies

## ◆ Uniform equipment code 统一设备编码

- Realize friendly interaction between different business

KKS、RDS-PS、OPC-UA

- 实现不同业务友好互动
- KKS、RDS-PS、OPC-UA

## ◆ Business information modeling 业务信息建模

- Realize data fusion and semantic understanding

IEC 61850, IEC 61970 (CIM)

- 实现数据融合与语义理解
- IEC 61850, IEC 61970 (CIM)

## ◆ Operation risk identification and assessment 运行风险识别与评估

- Realize independent risk pre-control

Risk identification, risk quantification and preference analysis

- 实现风险自主预控
- 风险识别、风险量化、偏好分析

## ◆ Equipment condition evaluation and fault diagnosis 设备状态评价与故障诊断

- Strengthen equipment safety management

Fault case library and normal sample library

- 强化设备安全管理
- 故障案例库、正常样本库

## ◆ Big data analysis and business knowledge base 人工智能及数字孪生

- Improve business insight

Distributed processing, data mining, business model

- 提升业务洞察能力
- 业务模型、数据挖掘、知识图谱

## ◆ Application of IoT technology 物联网技术应用

- Improve information measurement

RFID, Lora, NB-IoT, 5G.....

- 提升信息自感知能力
- RFID、Lora、NB-IoT, 5G

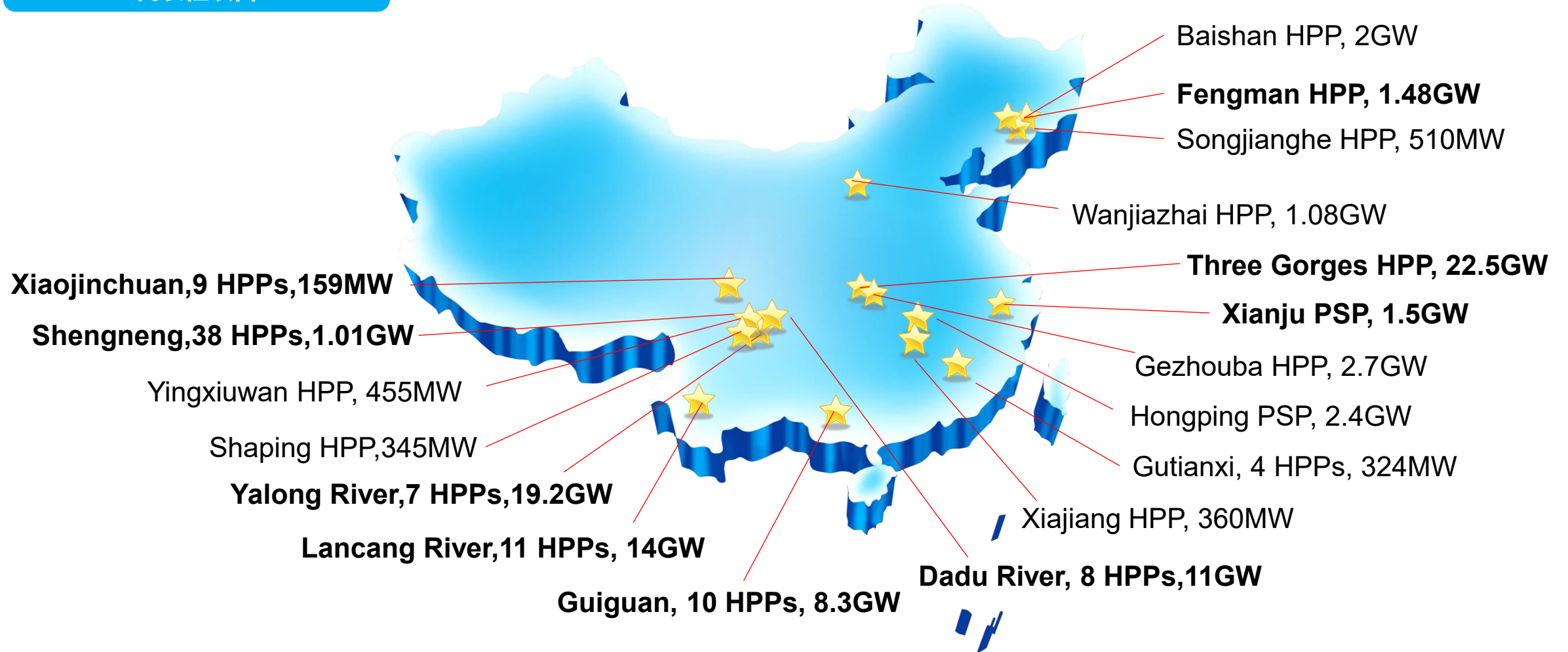
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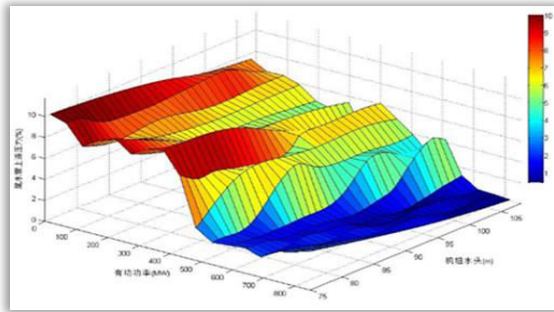


# Project Case – Overview

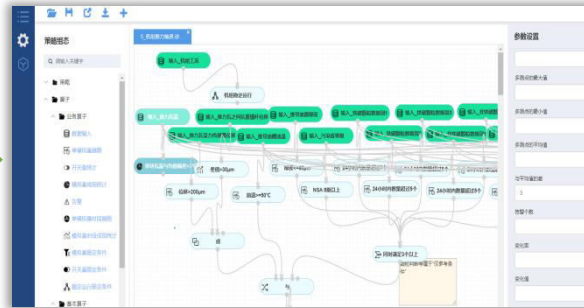
## Representative Projects 代表性项目



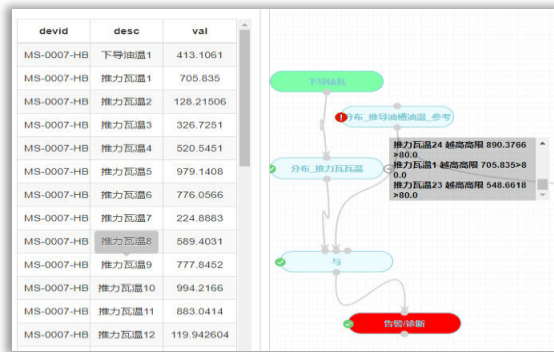
# Project Case - Three Gorges Power Plant Smart maintenance (22.5GW)



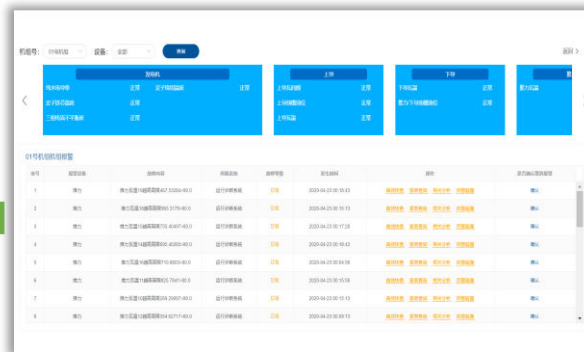
Full working condition health model of the unit and equipment  
机组及设备全工况健康模型



Key threshold learning and updating mechanism  
关键阈值学习更新机制



Abnormity tracing  
异常追溯



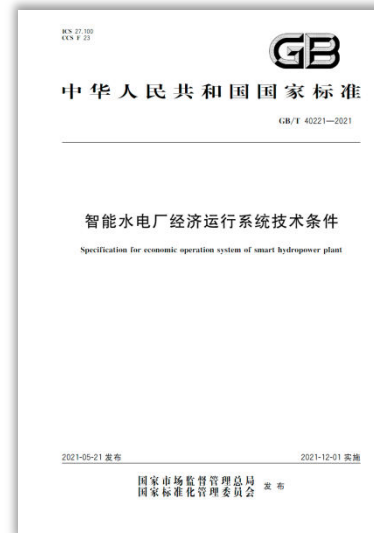
Fault diagnosis and alarm  
故障诊断及告警

By summarizing various basic data, the Three Gorges power plant smart maintenance project proposes an algorithm which effectively identifies equipment performance characteristics, and establishes diagnosis models for **unit stability, unit water guiding mechanism, unit thrust bearing, unit governor hydraulic system, and top cover**. Besides, a **process-based visual configuration nor software** has been developed. Users can easily modify and add various diagnosis models. The innovation project improves the equipment safety management level of the Three Gorges power plant. 该项目在汇总清洗各类基础数据的基础上, 提出了一种**设备性能特征指标提取算法**, 建立了**机组稳定性、机组导水机构、机组推力轴承、机组调速器液压系统、顶盖排水系统等分析诊断模型**, 研制了流程化可视组态界面, 用户可以便捷地修改和增加各类分析诊断模型, 提升了三峡电厂设备安全保障能力。

# Chinese National Standards

No.	Type	Standard Name
1	National Standard 国家标准	《Specification for economic operation system of smart hydropower plant》 《智能水电站经济运行系统规范》
2	National Standard 国家标准	《Technical specification for dam safety analysis and evaluation system of smart hydropower plant 》 《智能水电站大坝安全分析与评价系统技术规范》
3	National Standard 国家标准	《Technical requirements of common information models for smart hydropower plant》 《智能水电站通用信息模型技术要求》
4	National Standard 国家标准	《Technical specification for unified management and control platform of smart hydropower plant》 《智能水电站统一管控平台技术规范》
5	National Standard 国家标准	《Technical requirements of security and protection system linkage for smart hydropower plant》 《智能水电厂安防系统联动技术要求》
6	National Standard 国家标准	《Guide for smart hydro power plant 》 《智能水电站导则》
7	National Standard 国家标准	《 Technical specification of flood control emergency command system for smart hydropower plant》 《智能水电站防洪应急指挥系统技术规范》
8	National Standard 国家标准	《Technical specification of intelligent measurement and control devices for smart hydropower plant》 《智能水电站智能测控装置技术规范》
9	National Standard 国家标准	《Technical guide for main equipment condition based maintenance decision support system of smart hydroelectric power plant》 《智能水电站主要设备状态检修决策支持系统技术指南》

# Chinese National Standards



# International Standards -

## IEC/IEEE 63198-2775 "Technical Guidelines for Smart Hydroelectric Power Plants"

□ In February 2017, IEEE approved the standard project, led by China and **8 countries** participate in the standard, including the United States and Canada, etc.

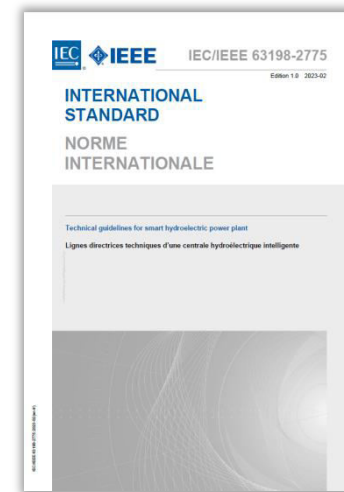
2017年2月, IEEE批准标准立项, 项目号P2775, 中国牵头, 美国、加拿大等**8国**参编。

□ In February 2018, IEC approved the standard project, led by China and Austria, **12 countries** participate in the standard, including the United States, Canada, France, Germany, and Sweden, etc.

2018年2月, IEC投票15个国家**100%**通过, 美国、加拿大、法国、德国、瑞典等**12国**参与标准编写。

□ On February 17, 2023, the standard are released as IEC/IEEE 63198-2775 both **in English and French**. It was the **first international standard for smart power generation** in the world.

2023年2月17日, IEC/IEEE 63198-2775 《智能水电厂技术导则》以**英法双语**正式发布, 是全球首次制定**发电领域智能化国际标准**。2023年2月28日, 英国BS标准全文引用该标准。



Standard Release Version  
标准发布版

### Work statistics

Whole process duration: **6 years**

Meeting frequency: **60+**

Handling opinions: **900+**

Full text pages: **150+**

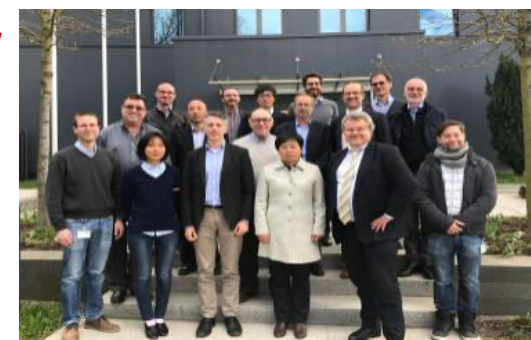
### 工作情况统计

全程历时: **6年**

会议次数: **60+**

处理意见: **900+**

全文页数: **150+**



Kick-off meeting of the working group in Lafenburg, Germany  
工作组德国拉芬斯堡启动会

**Thanks!**