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Sterilizer Energy Consumption Monitoring and Energy-Saving Optimization Based on an Electronic Quality Traceability System

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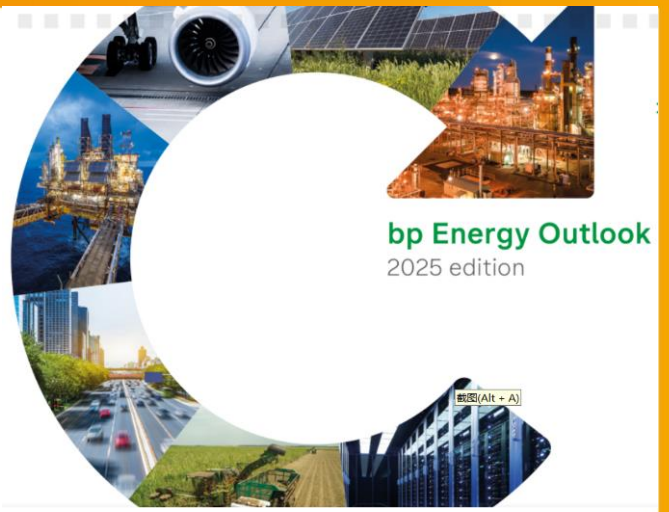
Energy Challenges and Hospital Responsibility



➢Sustainable development

Economic considerations

While pursuing excellent medical services, economic benefits should also be considered

Operational efficiency

Medical institutions are major energy consumers

Social responsibility

As an important part of society, we have a responsibility to contribute to this

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B. Transformation of Tracking and Tracing System into Decision Intelligence

C. Validation by Result

D. Intelligence Enhancement for Future Development

E. Conclusion

A. Background

➢Peking University School of Stomatology

- ✓ 4 International Collaborating Centers
- ✓ National Clinical Research Center for Oral Diseases
- ✓ National Engineering Laboratory for Digital and Material Technology of Stomatology

A. Background

- Founded in 1941, it integrates a college, a hospital, and a dental research institute
- The hospital currently has 807 dental treatment units and 173 beds
- It performs 9,000 inpatient surgeries and handles 2.09 million outpatient and emergency visits annually

The typical "large outpatient clinic, small inpatient ward" model concentrates the workload within a given time period, and the working efficiency decreases when outpatient services are interrupted or suspended

A. Background

CSSD： Unique challenges under high-load operation

Sterilizer (No.）（1500L）	Washer Disinfector（No.）（PG8528）	Key equipment operating time	Daily processing instrument（No.）
4	7	07:00——20:00	22000

Rugged management style

During periods of low workload, the equipment remains idle until the end of the workday when it is shut down

A. Background

Attempted to rely on personnel to shutdown, but the outcomes varied due to differences individual

Can energy waste be reduced during predictable equipment idle times?

- **Patient safety**
- **Clinical emergency response capability**

B. Transformation of Tracking and Tracing System into Decision intelligence

Traditional way: Recording system

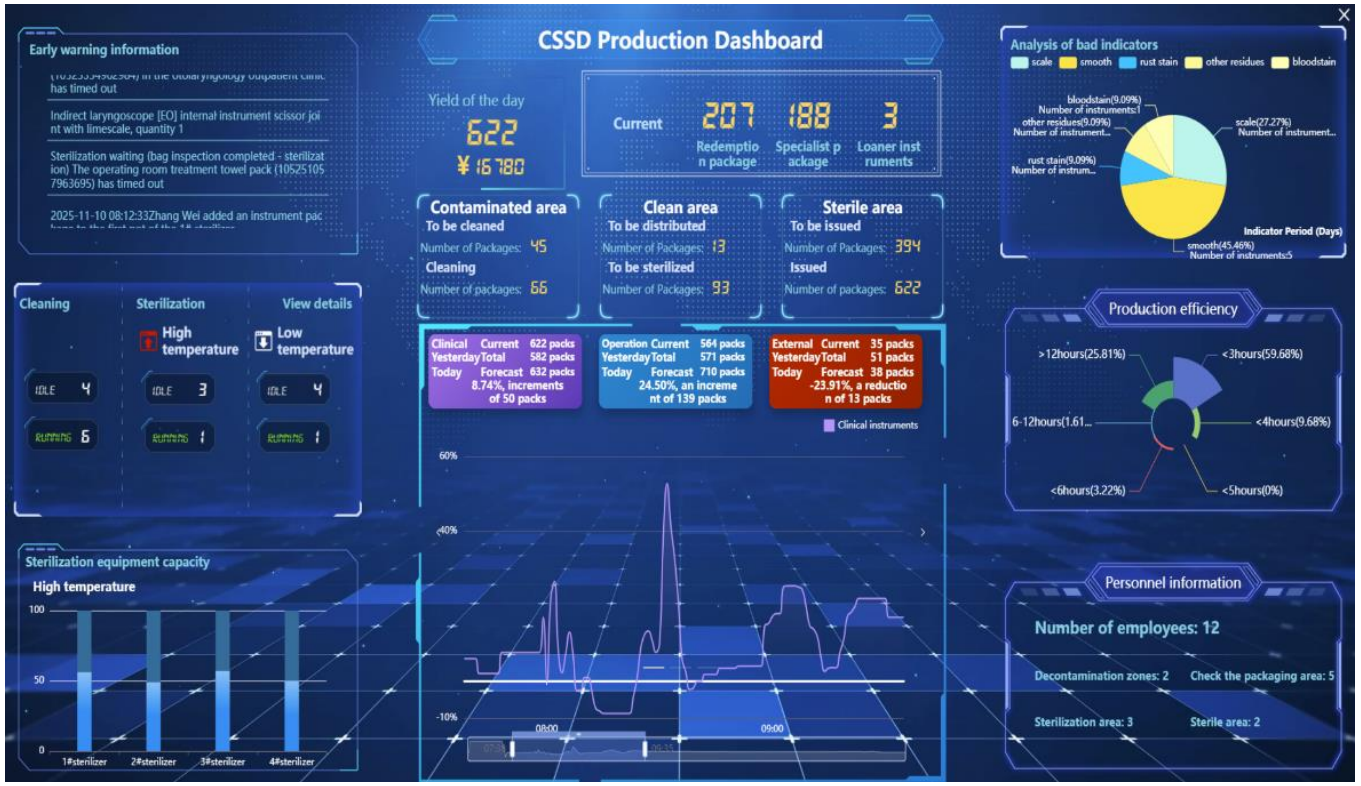
Designed to meet the mandatory documentation requirements of EN ISO 13485 and ensure patient safety

New Paradigm: The Decision intelligence

Record power on/off times accurately and operation logs to serve as data for energy consumption prediction

The paradigm shift from "recording systems" to "decision support systems" enables the secondary development through valuable data

B. Transformation of Tracking and Tracing System into Decision intelligence

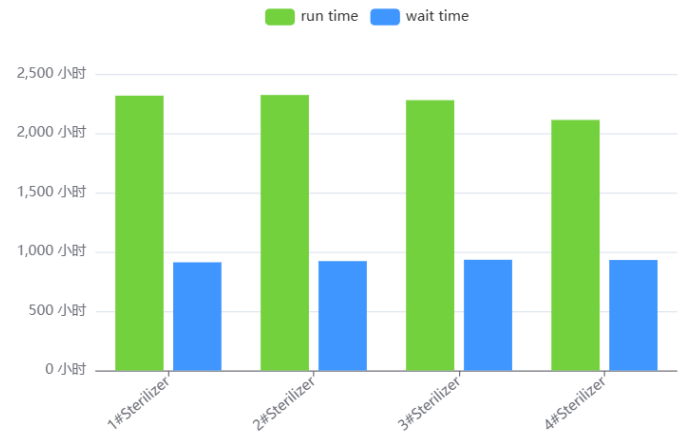


- CSSD Electronic Quality Tracking and Tracing System – A Data gold mine awaiting Discovery
- Extending the data used for quality assurance to energy management will make the system our "smart brain"

B. Transformation of Tracking and Tracing System into Decision intelligence

➢ Step 1: Quantify the Problem Precisely – Where are the energy consumption "Loopholes"?

analyze



Equipment Name	Total power-on time (h)	Running time (h)	Standby time (h)	Standby time percentage	Standby power consumption (kWh)	Standby steam consumption (kg)
Sterilizer #1	3228.89	2317.02	911.87	28.24%	300.92	13860.37
Sterilizer #2	3244.45	2322.54	921.91	28.42%	304.23	14013.05
Sterilizer #3	3212.09	2278.72	933.37	29.06%	308.01	14187.29
Sterilizer #4	3043.84	2112.37	931.46	30.60%	307.38	14158.23

Sterilizer Operation - Energy Consumption Summary

#	sterilization time	Equipment Name	Run batch	Sterilization batch	Instrument Num	Equip standby time (h)	Standby power(kWh)	Standby steam(kg)
1	2024	Sterilizer #1	631	499	62659	243.03	80.20	3694.03
2	2024	Sterilizer #2	645	513	75309	241.16	79.58	3665.63
3	2024	Sterilizer #3	623	491	68873	230.34	76.01	3501.22
4	2024	Sterilizer #4	598	468	56652	220.87	72.89	3357.29
total			2497	1971	263493	935.41	308.68	14218.18

B. Transformation of Tracking and Tracing System into Decision intelligence

Quantitative vulnerability: 925h of runtime is consumed by standby

29%

Standby time percentage

The average daily standby time is 4.5 hours, which is defined as reducible pure waste.

Electricity consumption

Waste per sterilizer per year 305 kWh

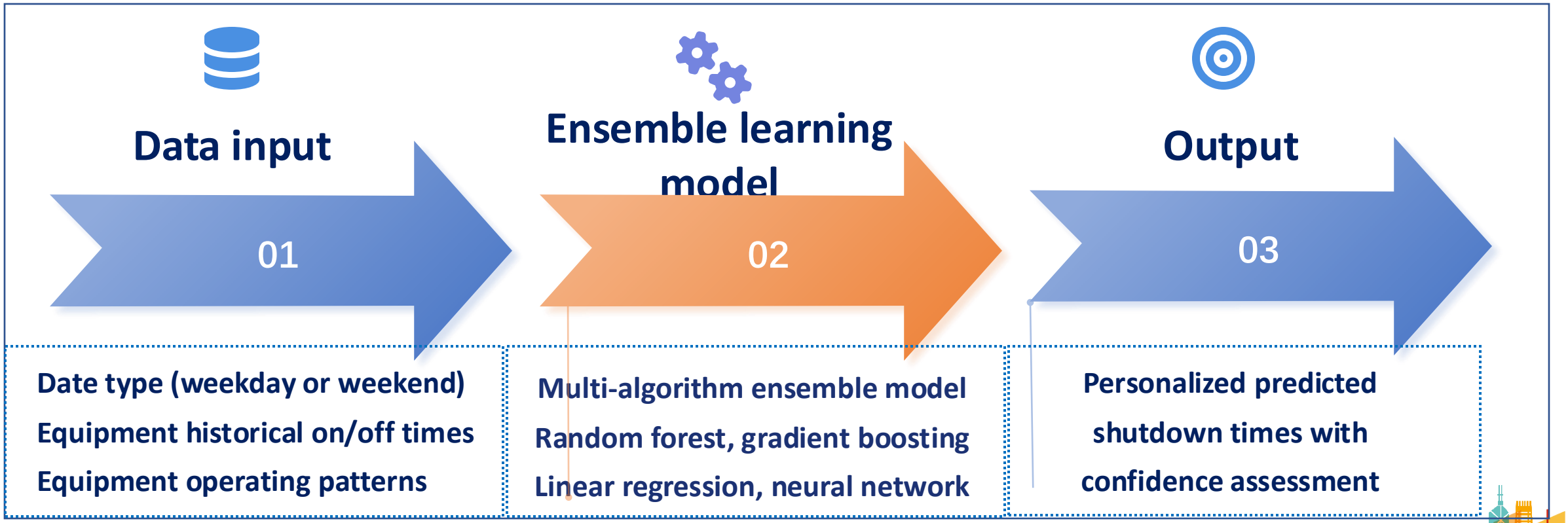
Steam consumption

Waste per sterilizer per year 14,145 kg

By analyzing data from 1 year and all sterilization cycles, calculated a significant "loophole" in standby power consumption

B. Transformation of Tracking and Tracing System into Decision intelligence

➢Step 2: Algorithm Intervention -- Predicting Safe Shutdown Window



By employing an ensemble learning model that combines the advantages of multiple algorithms, the end time of the daily "last task" can be accurately predicted

B. Transformation of Tracking and Tracing System into Decision intelligence

➢Step 3: Human-machine collaborative judgment closed loop

System Recommendations

Smart shutdown suggestion

Nurse confirmation

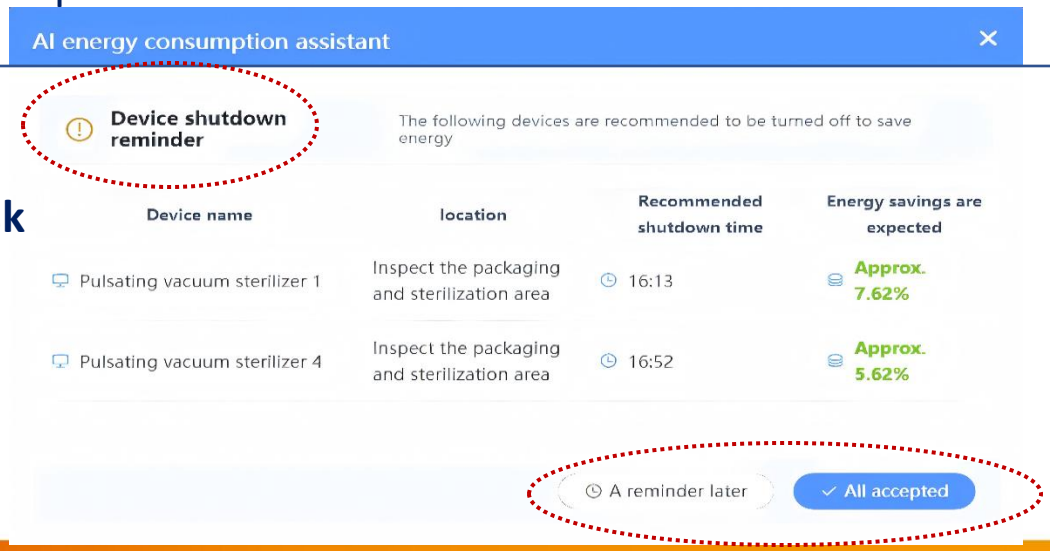
Veto power

Safe preheating

45-min guarantee

Green Channel

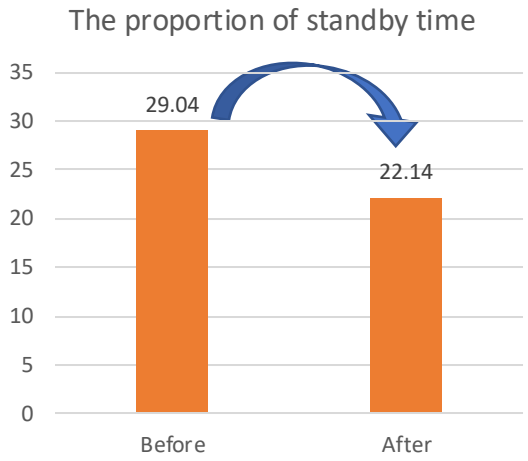
Backup machine for emergency



The closed-loop process reduces the risk of accidental shutdown by 92% and improves nurse participation and satisfaction

C. Validation by Result

➢Standby time and energy consumption decreased



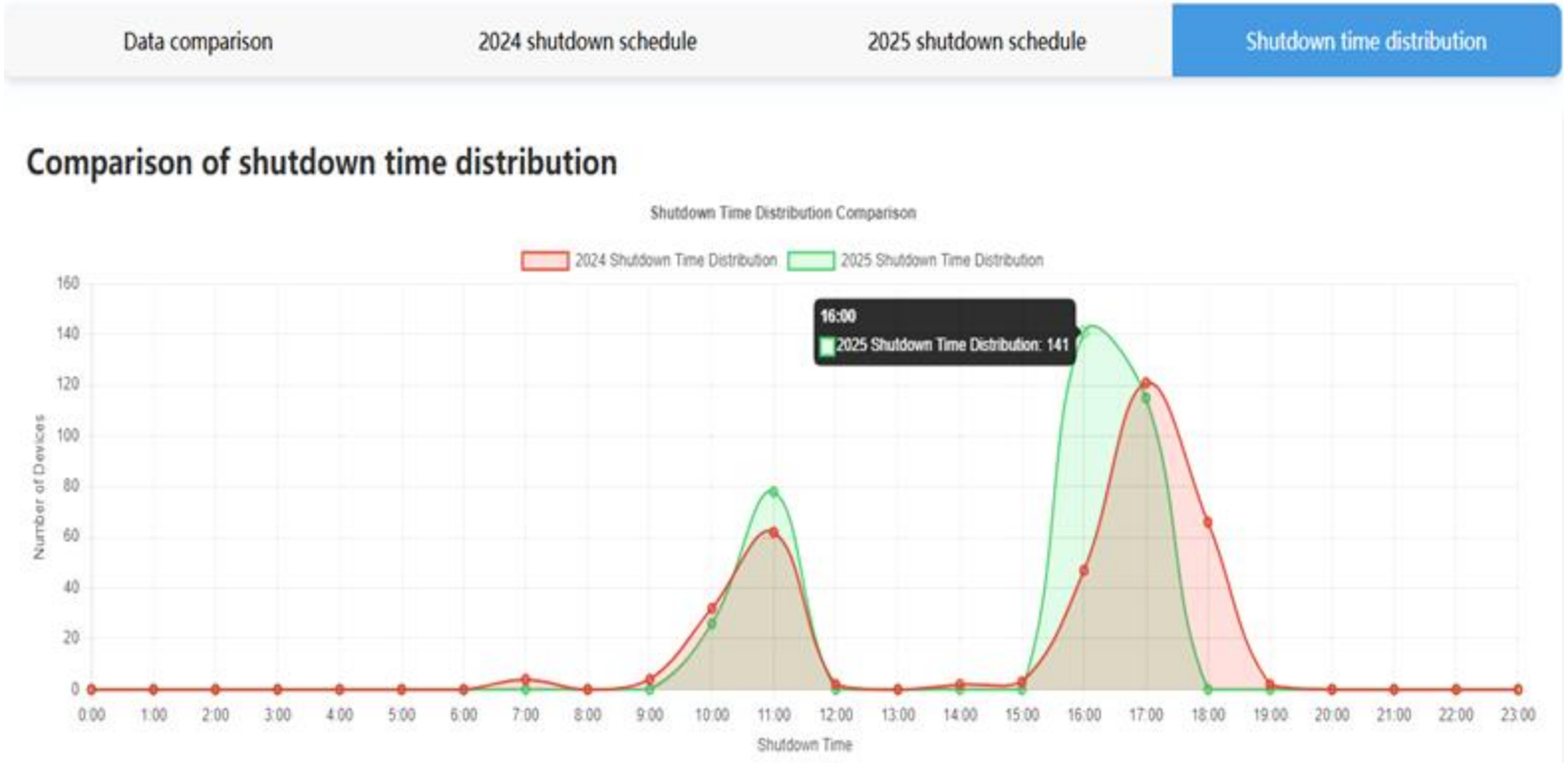
The average standby time percentage has decreased, with nearly a quarter of the ineffective standby time being converted into tangible energy savings

Detailed data comparison

index	January-March 2024 (unpredicted)	January-March 2025 (Forecast)	variation
Total standby energy consumption (kWh)	400.05	305.00	-95.05
Steam Consumption (kg)	13916.76	10608.75	-3308.01
Average shutdown time (hours)	3.31	2.53	-0.78

C. Validation by Result

➢Implementation of early shutdown



A total of 141 early shutdowns in the first 3 quarters of 2025

Sequential Shutdown

On workdays, the first sterilizer can be shut down as early as 3:00 PM

C. Validation by Result

➢Matching and error between actual shutdown and predicted shutdown

Device 1(mean error) 20.93 minutes Advanced Model Improvements:39.0%		Device 2(mean error) 18.14 minutes Advanced Model Improvements:39.4%		Device 3(mean error) 38.21 minutes Advanced Model Improvement:34.1%		Device 4(mean error) 21.48 minutes Advanced Model Improvement:38.0%
date	week	Date type	equipment	Actual shutdown time	Predict shutdown times	error
2025/09/01	Monday	weekday	Device 1	17:54	17:45	9.0
2025/09/01	Monday	weekday	Device 2	17:36	17:59	23.0
2025/09/01	Monday	weekday	Device 3	19:05	18:00	65.0
2025/09/01	Monday	weekday	Device 4	18:14	17:51	23.0
2025/09/02	Tuesday	weekday	Device1	17:19	17:29	10.0
2025/09/02	Tuesday	weekday	Device 2	18:40	18:26	14.0
2025/09/02	Tuesday	weekday	Device 3	19:12	17:36	96.0
2025/09/02	Tuesday	weekday	Device 4	17:19	17:32	13.0
2025/09/03	Wednesday	weekday	Device 1	16:38	17:10	32.0
2025/09/03	Wednesday	weekday	Device 2	18:57	18:36	21.0

The actual shutdown time deviated from the forecast by an average of 25 minutes—less than a full sterilization cycle

C. Validation by Result

➢Zero decline in quality and emergency response indicators

Accuracy of sterilization cycle

100%

Same as control period

Questionnaire Satisfaction Ratings

93%

process does not add to the workload

Equipment restart rate

2 times

All were completed within 45 minutes

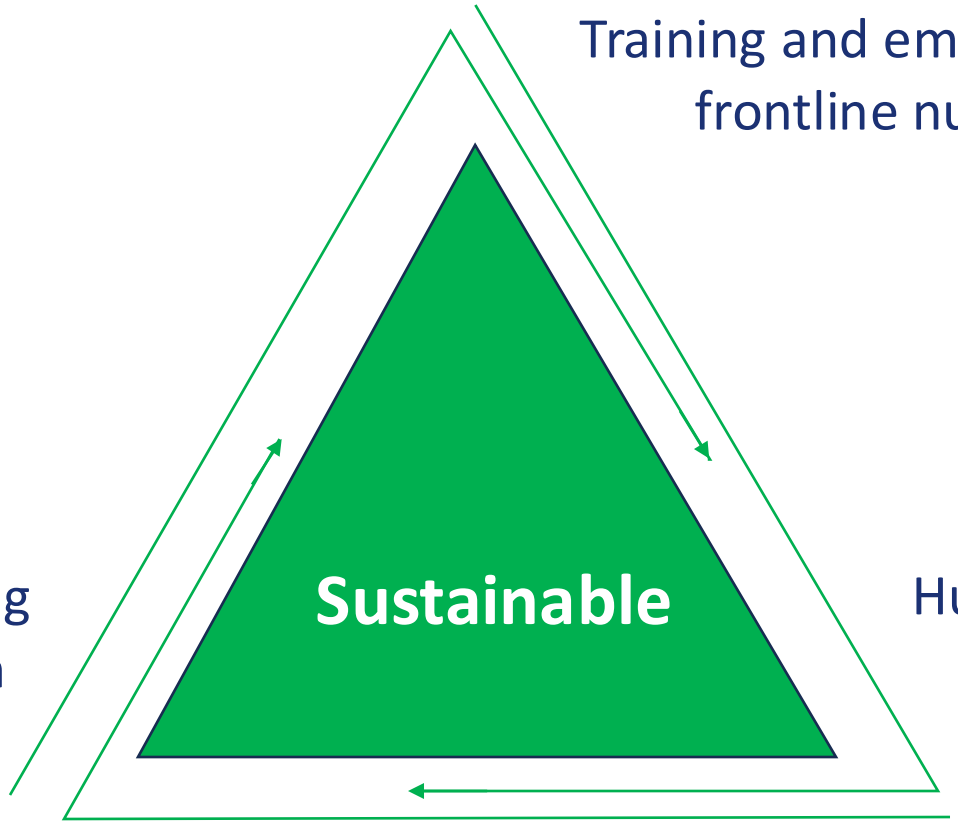
All key quality and emergency response indicators remained unaffected

Indication : From One Hospital's Experience to a Replicable Paradigm

Crucial Factors & Replicability Analysis

Personnel

Training and empowering frontline nurses



Technology

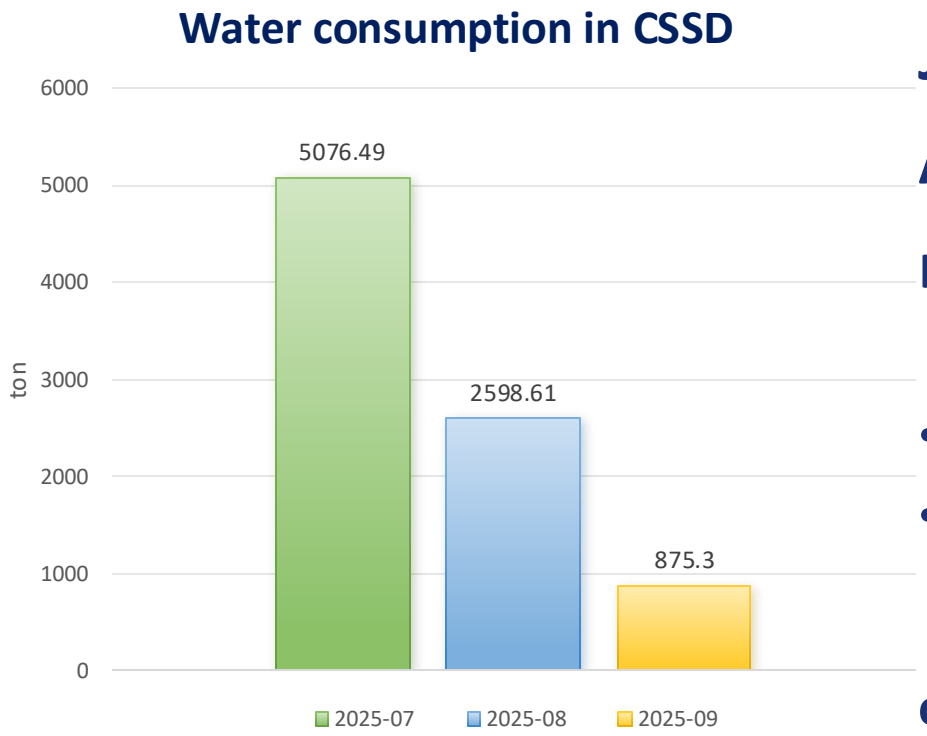
Popularization of tracking and tracing system trim down the cost

Process

Human machine co-judgement prevent interference
Clinical safety assurance

More suitable for hospital with multiple sterilizers operating 24 hours a day, the scale effect will be more significant, and it is a highly replicable paradigm

D. Intelligence Enhancement for Future Development



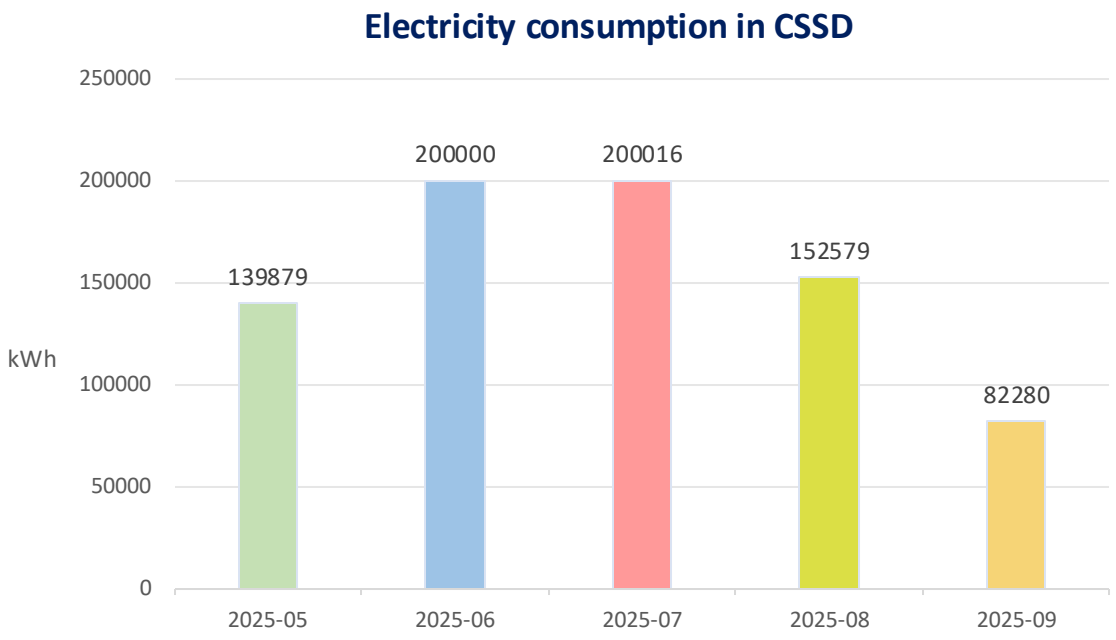
Jul： Use the system to collect and analyze data

Aug-Sep： compared with IFU's parameters, revealed discrepancies

- **identified and adjusted sterilizer piping connection**
- **Increased drainage temperature from 30 ℃ to 45 ℃**

consumption reduced by 82% , equals to 32670 RMB

D. Intelligence Enhancement for Future Development



May - Jul： Use the system to collect data

Aug - Sep： compare, and analyze data

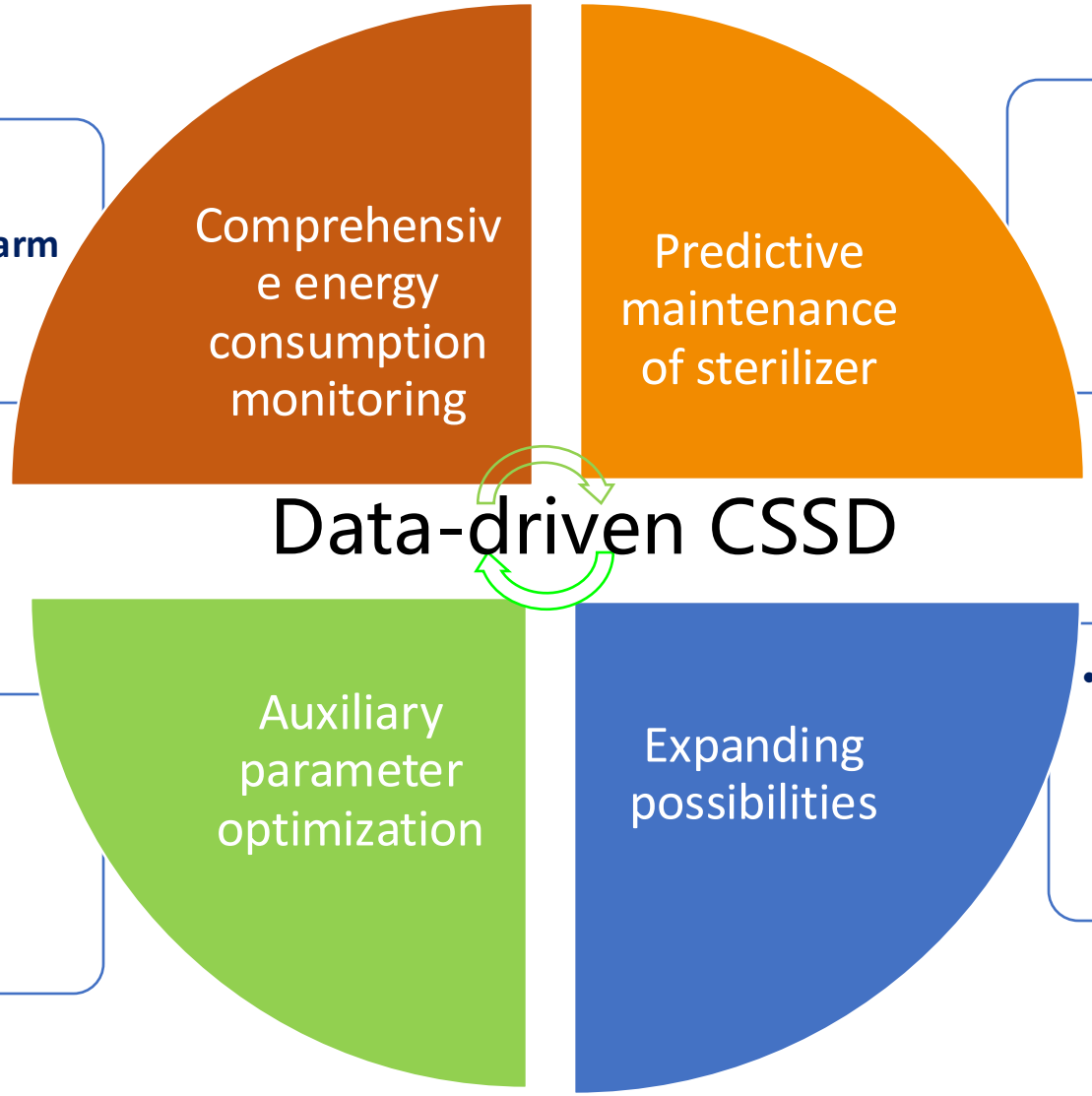
- **Reduce unproductive Idling**
- **Optimize procedures to minimize low-load operation**

electricity consumption decreased by 58% in September, 94800RMB

Data-driven refined management

Smart CSSD Green CSSD

D. Intelligence Enhancement for Future Development



- Set energy-saving targets
- Energy consumption anomaly alarm
- Optimize environmental energy consumption

- Build and maintain models
- Record runtime anomalies
- Track component lifespan

- Wash disinfector A_0 value
- Adjust the sterilizer program according to the type of items

- Exploring the utilization of renewable energy and integrating Internet of Things (IoT) technology

E. Conclusion

- Effective prediction of shutdown time window by the upgraded traceability system
- Significant energy savings achieved through early shutdowns
- No impact on work efficiency or daily operations
- A replicable management model for other hospitals

Quality Tracking & Tracing System + Prediction algorithm + Human-machine collaboration

Safe, efficient, and sustainable CSSD operations

Thanks to every member of the team for their outstanding work and dedication:
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Thank you for your attention