# AI-Driven Real-Time "Prediction of Paper Stiffness and Moisture"

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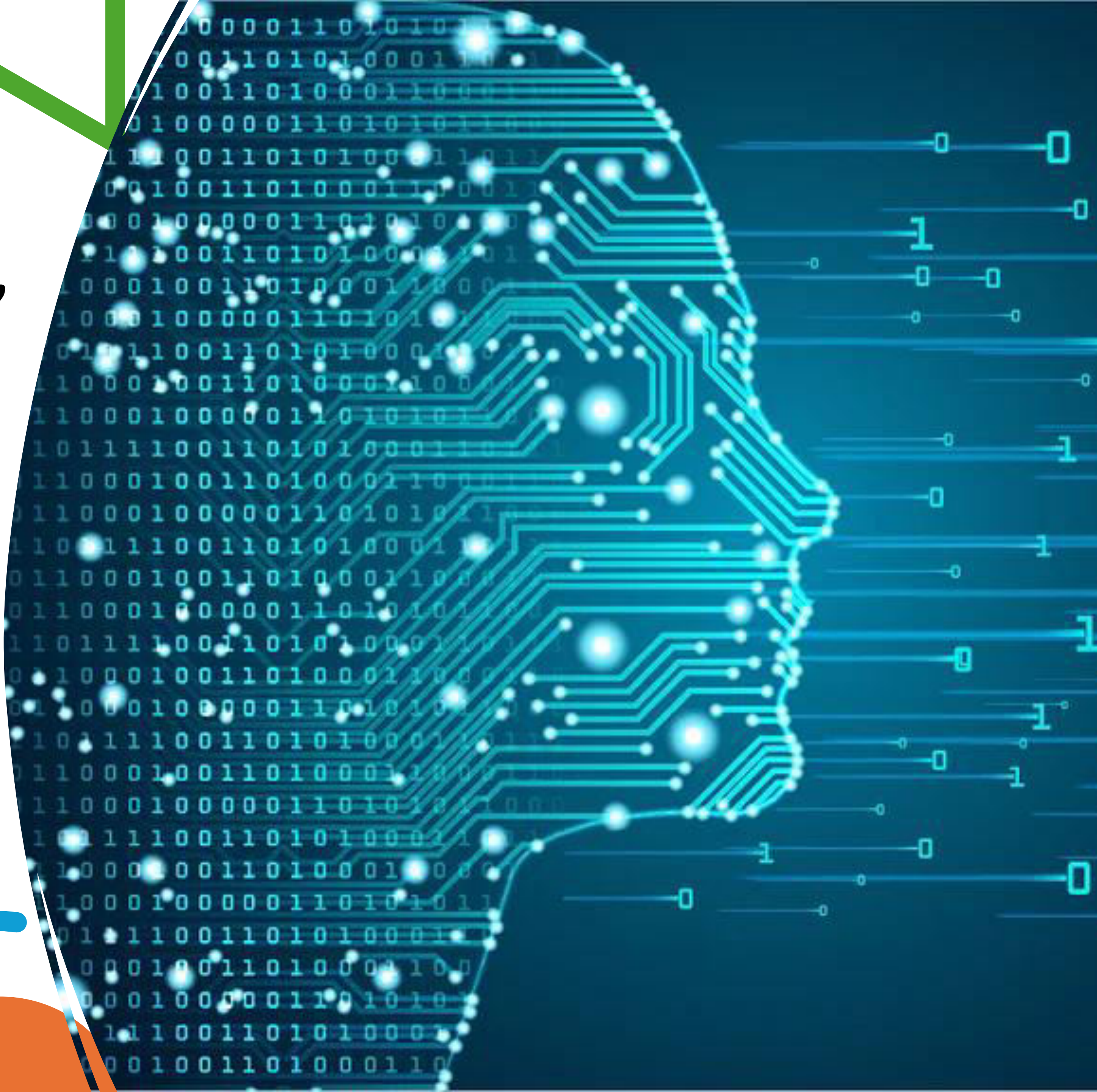


# JK Paper Vision, Mission, Core values

JK PAPER LTD.

*Creating lasting impressions*

## VISION

To be a trusted industry leader enriching lives and creating a better future

## MISSION

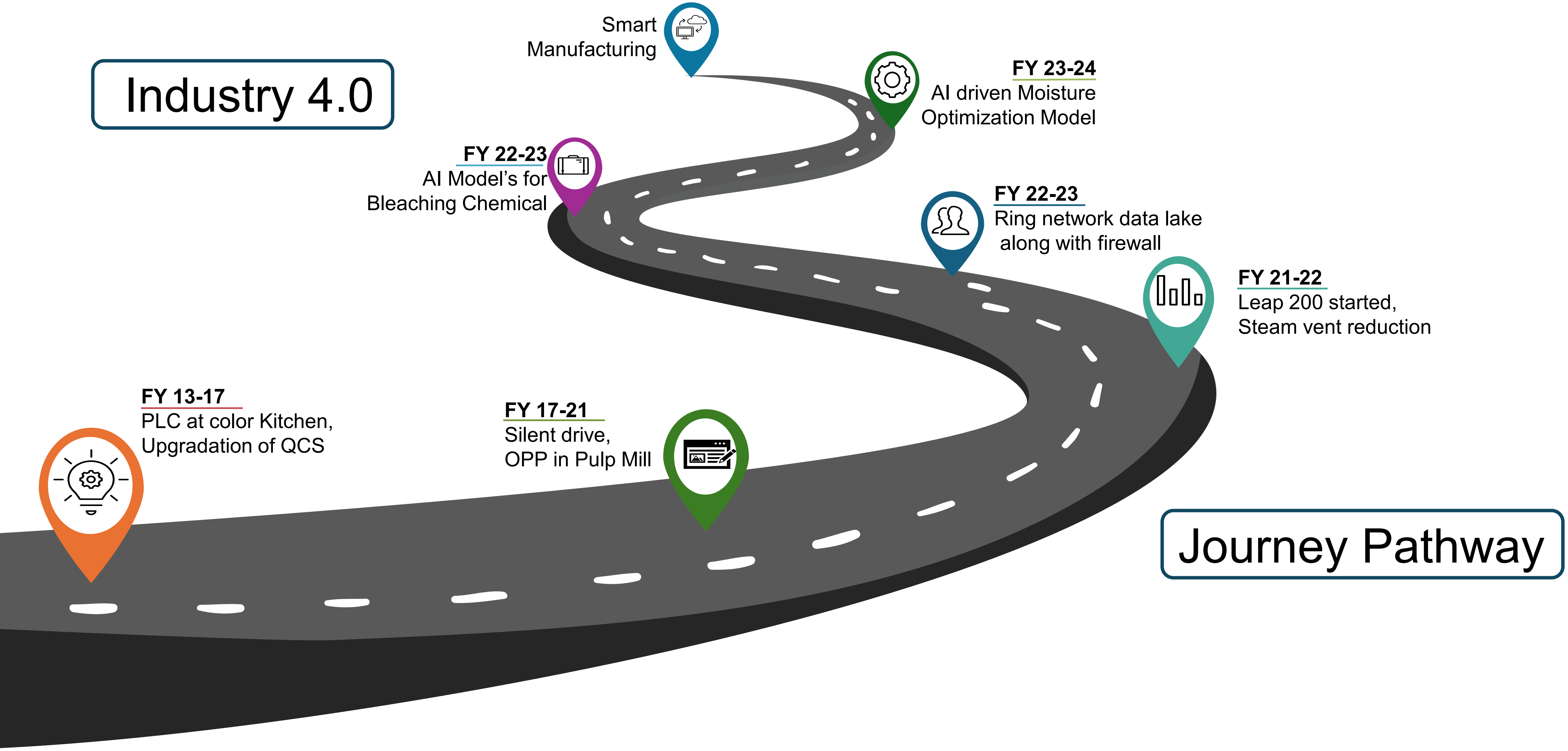
Deliver sustainable solutions & profitable growth through:

- Digitalization and Innovation
- Cost Competitiveness
- Customer Centricity
- People and Community care
- Outstanding & Agile Talent

## CORE VALUES

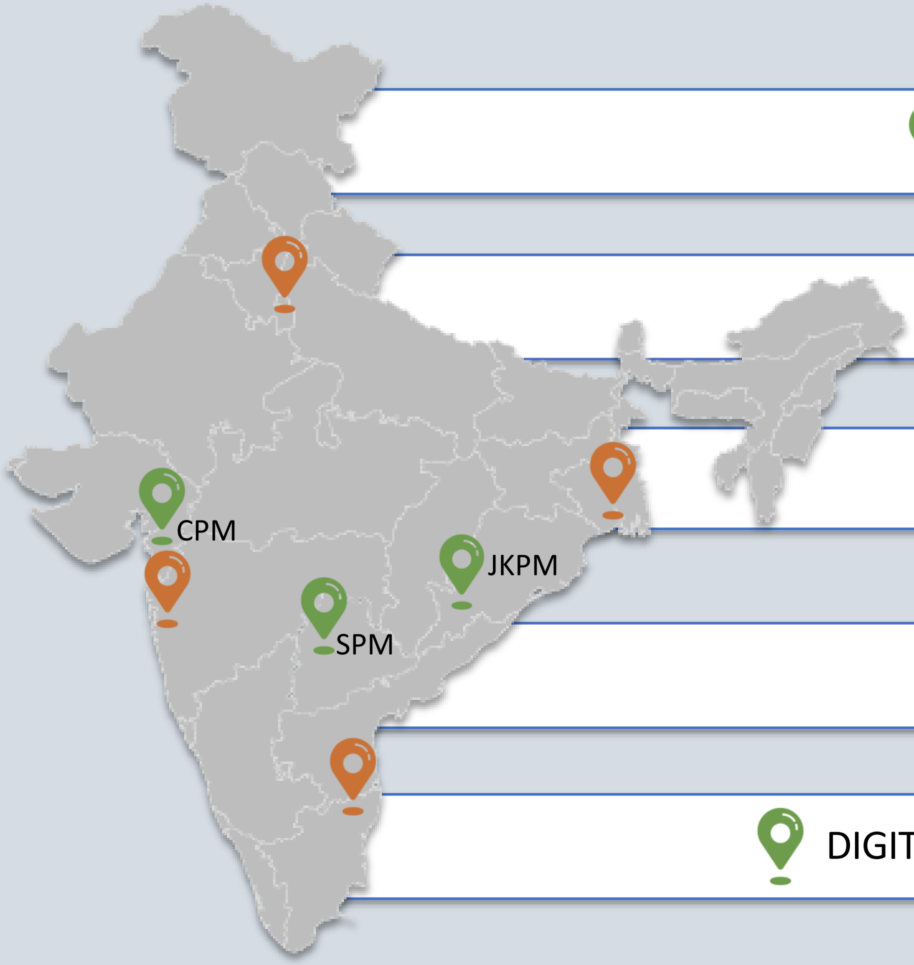
- Caring for People
- Integrity including Intellectual Honesty, Openness, Fairness and Trust
- Commitment to Excellence

# Digital Transformation Journey



# Digital Transformation Overview

**GEOGRAPHIC SCOPE**




**FUNCTIONAL SCOPE**

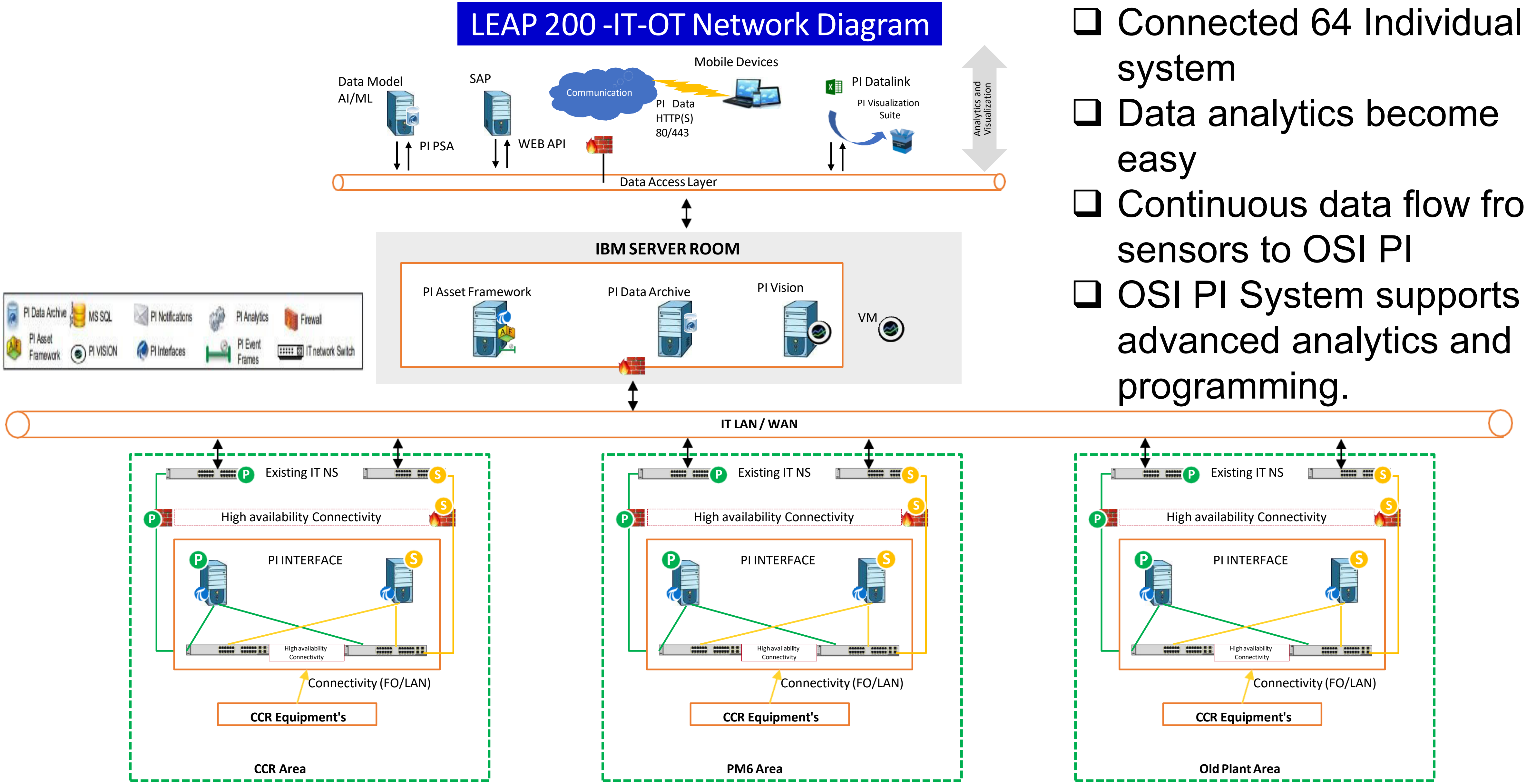
- MANUFACTURING
- LOGISTICS (inbound + outbound)
- SALES AND MARKETING
- PROCUREMENT
- DIGITAL CENTRE FOR EXELLENCE

**ENTERPRISE SCOPE**

**DIGITAL CENTER OF EXCELLENCE** TO SUSTAINABLY DELIVER DIGITAL PROJECTS

**COMMUNICATION AND CHANGE MANAGEMENT** TO DRIVE ORGANIZATION

# Handshaking of data




- ❑ Connected 64 Individual system
- ❑ Data analytics become easy
- ❑ Continuous data flow from sensors to OSI PI
- ❑ OSI PI System supports advanced analytics and programming.

# Digital Transformation in Manufacturing Section

Pulp yield Optimization

Bleaching chemical optimization

Steam Generation Improvement in Liqor fired boiler

Coal Blend Optimization at Yard

Steam Economy Improvement

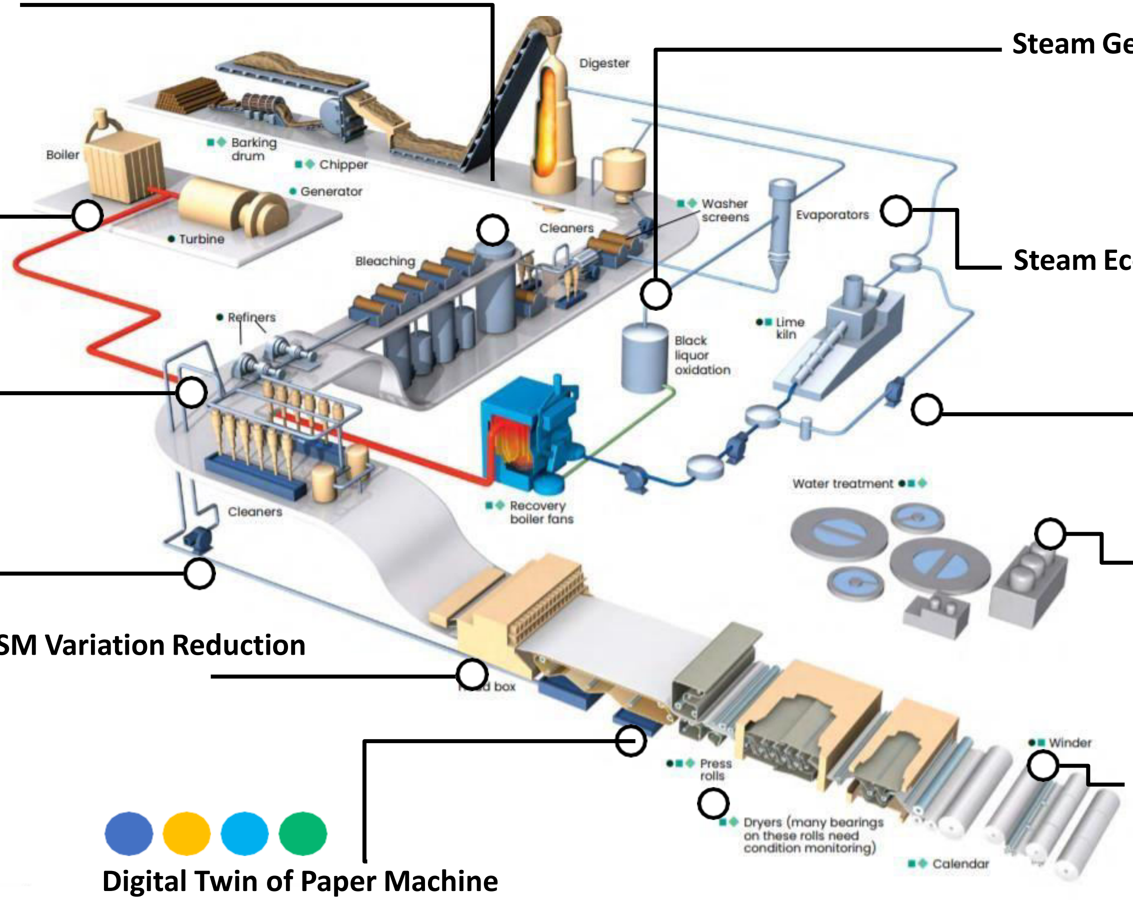
Advanced Planning & Scheduling

Lime Kiln Fuel Optimization

Advanced Condition Monitoring

Energy Management

GSM Variation Reduction




Finishing Loss Reduction

Production enhancement

Predictive maintenance

Consumption reduction

Quality improvement

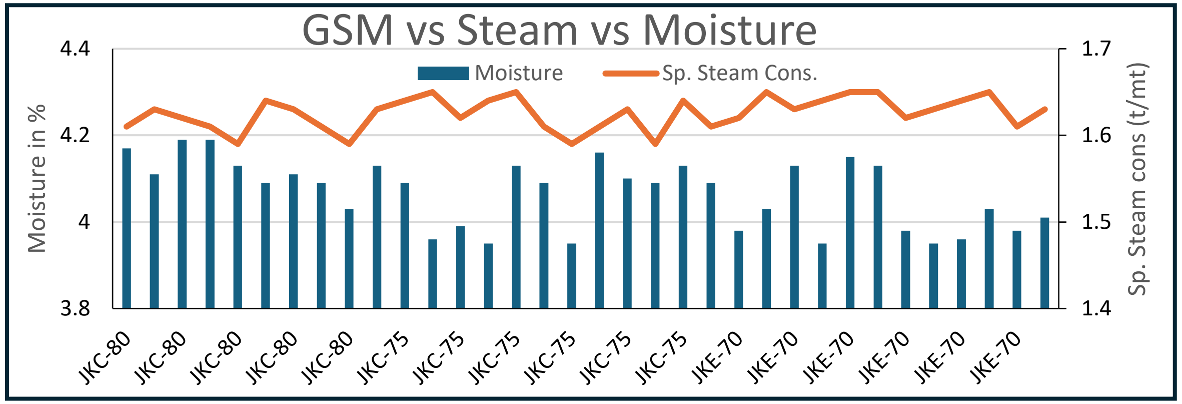
Digital Twin of Paper Machine

Ash and Moisture Optimization

"Enhancing Moisture % in paper through
AI-driven predictive
and calculative quality control measures"

# Present Scenario

- Moisture % is influenced by both operator settings and lab parameters
- Different paper grades have operator-dependent setpoints
- Lack of Real-time Monitoring & Control Decisions are based on historical data, not live process conditions.
- **No predictive** system to proactively adjust moisture levels.

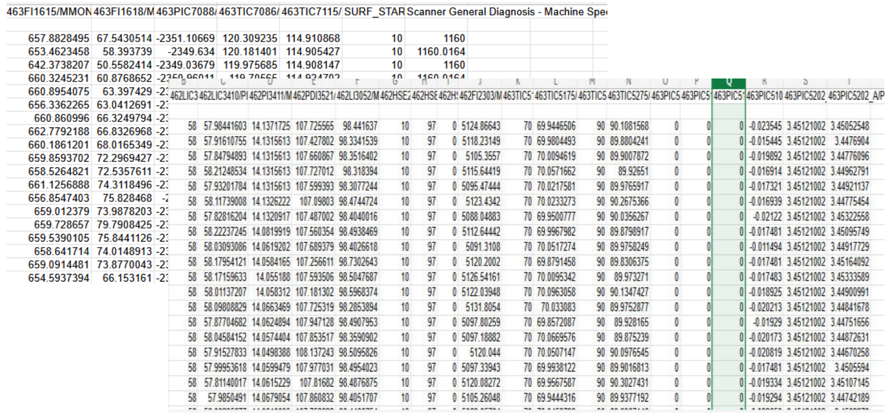



| | Grade | GSM | Caliper | Bulk | Ash % | Moisture | Stiffness (md) | stifness (Cd) |
|---|---|---|---|---|---|---|---|---|
| 1 | SKU-1 | 70 | 106+_2 | 1.50+_0.05 | 20 Min | 4.0 +_0.5 | 2.0 min | 1.0 min |
| 2 | SKU-2 | 75 | 106+_2 | 1.50+_0.05 | 20 Min | 4.0 +_0.5 | 2.0 min | 1.0 min |
| 3 | SKU-3 | 75 | 106+_2 | 1.50+_0.05 | 20 Min | 4.0 +_0.5 | 2.0 min | 1.0 min |
| 4 | SKU-4 | 80 | 106+_2 | 1.45+_0.05 | 20 Min | 4.0 +_0.5 | 2.0 min | 1.0 min |

| Time | QUALITY | PM6 QUALITY\|Bulk | PM6 QUALITY\|Caliper | Stiffness_MD ▼ | Stiffness_CD | Ash | PM6 Q... | Moisture | PM6 Q... | M/C_Roll_n |
|---|---|---|---|---|---|---|---|---|---|---|
| 09/16/2024 4:10:00 AM | JKC-75 N | 1.43 | 107.6 | 2.5 | 1.6 | | 250 | | 279 | |
| 09/17/2024 2:00:00 AM | JKC-75 N | 1.43 | 107.3 | 2.5 | 1.55 | 22 | 226 | 4.24 | 242 | |
| 09/17/2024 4:10:00 AM | JKC-75 N | 1.43 | 107.7 | 2.5 | 1.45 | | 230 | | 252 | |
| 09/17/2024 10:30:00 AM | JKC-75 N | 1.43 | 107.4 | 2.5 | 1.5 | | 241 | | 269 | |
| 09/10/2024 7:50:00 AM | JKEC-70N | 1.48 | 105.1 | 2.45 | 1.4 | | | | | |
| 09/11/2024 6:40:00 AM | JKEC-70N | 1.47 | 104.4 | 2.45 | 1.5 | 22 | 269 | 4.05 | 298 | |
| 09/11/2024 10:10:00 AM | JKEC-70N | 1.48 | 104.4 | 2.45 | 1.45 | 21.5 | 280 | 4.29 | 298 | |
| 09/11/2024 11:20:00 AM | JKEC-70N | 1.48 | 105.7 | 2.45 | 1.5 | | 271 | | 300 | |
| 09/17/2024 3:05:00 AM | JKC-75 N | 1.43 | 107.6 | 2.45 | 1.5 | | 230 | | 252 | |
| 09/10/2024 6:50:00 AM | JKEC-70N | 1.48 | 104.4 | 2.4 | 1.35 | 22.2 | 277 | 4.14 | 299 | |
| 09/10/2024 9:10:00 AM | a COPIER-70(N) | 1.47 | 104.3 | 2.4 | 1.35 | | 274 | | 295 | |
| 09/10/2024 12:30:00 PM | JKEC-70N | 1.48 | 104.3 | 2.4 | 1.3 | | 281 | | 300 | |
| 09/10/2024 5:10:00 PM | JKEC-70N | 1.48 | 104.4 | 2.4 | 1.4 | | | 4.26 | | |
| 09/10/2024 7:45:00 PM | JKEC-70N | 1.49 | 104.7 | 2.4 | 1.5 | | 278 | | 300 | |

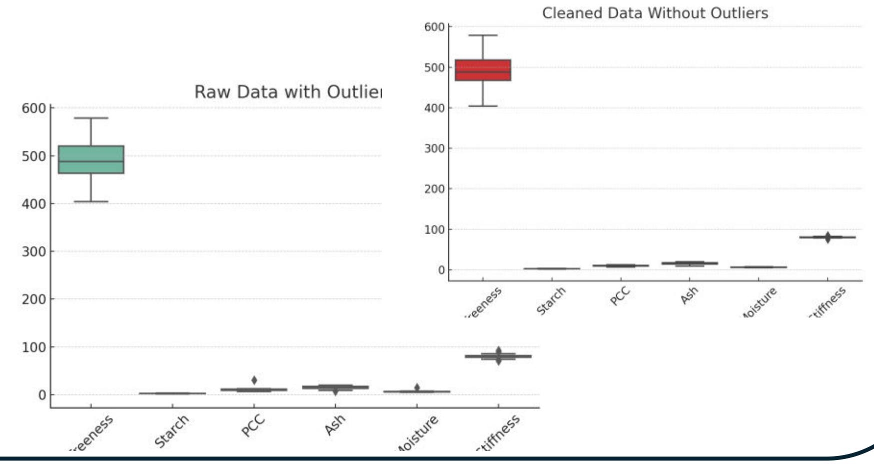
## Data collection

- Collected six months of **minute-wise** process data from PM6.
- Data extracted from **DCS logs, lab reports, and sensor readings**.




## Data Cleaning Techniques

- Outlier **removal** using statistical methods
- Handling **missing values** using interpolation techniques.
- **Standardization & normalization** to improve model accuracy.
- Ensure high-quality, **reliable input** for AI model training.



# Methodology

## Parameters Monitor

- Stock Parameter
- Chemical Parameters
- QCS Parameters
- Basis Weight
- Bulk
- **Stiffness:** A critical quality parameter influenced by bulk, moisture, and grade

## Challenges

- **Stiffness Data Delay:** Stiffness measurements were only available through **lab testing**, causing delays in feedback and process adjustments.

## Solution

- **Virtual Sensor:**A **virtual sensor** was developed using selected online variables to estimate stiffness in real-time.

# Optimization of Quality Parameters Using AI-Based Virtual Sensor

## Virtual Sensor Stiffness Prediction

- ❑ Developed a virtual sensor using key process variables.
- ❑ Using input variables, we built a model utilizing multicollinearity to predict stiffness.
- ❑ Assigned the trends in the historian for monitoring and analysis.
- ❑ The predicted virtual sensor values match lab data with **95% accuracy**.
- ❑ Enables real-time stiffness prediction to optimize moisture levels.

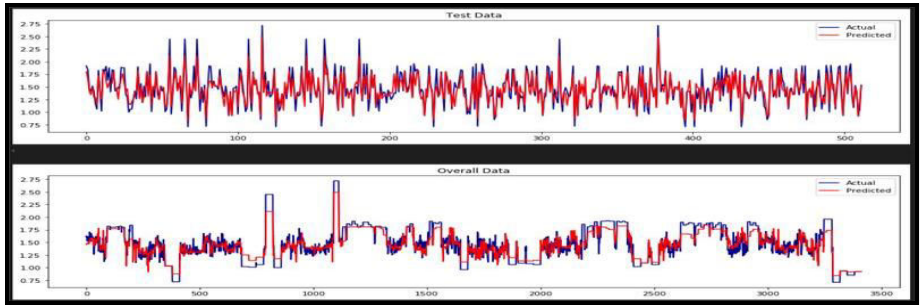
**Input variables**

| Area | Tag | Input Parameters | UOM |
|---|---|---|---|
| Approach Flow | 462HSE2002/OP_ANA.QY | Ratio broke ratio virgin | % |
| Calender | 463PIC5202_A/WR_R01.IN2 | Cal nip line force IN2 | N/mm |
| | 463PIC5102_A/WR_R01.IN2 | Cal nip line force IN2 | N/mm |
| Coating Preparation | SURF_STARCH_DILUTION/SP_SOLID.QY | Surf starch dilution | % |
| Headbox & Former | 463GI1121/MMON.QPV | Hb top lip vertical position PV | mm |
| | 463PIC1119_A/VP_WR_R1.IN1 | Jet wire ratio | m/min |
| Press Section | 463PIC1603/004-R04.QY | Press Line force nipcoflex | MPa |
| | 463PIC1603/002-R01.U | Nipcoflex press line load | KN/m |
| QCS | QCS/MD/IMC33/IMC.QPV | DCS Ash % | % |
| | QCS/MD/IMC11/IMC.QPV | Basis Weight | g/m^2 |
| | QCS/MD/IMC44_X/IMC.QPV | ADS Moisture | % |
| | Ash % | Ash % | % |
| | viscosity | Viscosity | - |
| Stock Preparation | 461EC2372/PID.QPV | BHKP freeness PV | SR |
| Wet end Chemical | DOSING_STARCH_CALC/HIC.PV | Dosing starch calc | Kg/t |
| | 464FIC0270/PID.QPV | Flow PCC filler to machine PV | L/min |

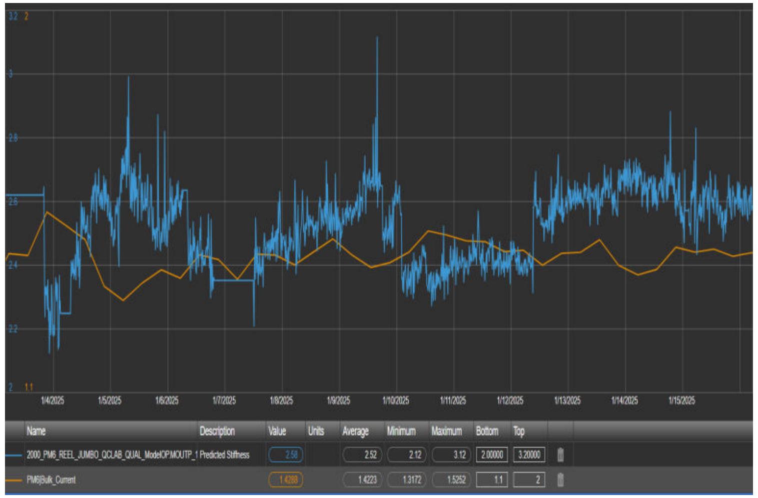
**Model building**

```
print(out_sample_data['Paper Break'].value_counts())
from sklearn.metrics import confusion_matrix
### metrics on Out of sample set
print('Metrics on Out of sample')
out_sample_data_x = out_sample_data[xcols].copy()
out_sample_data_y = out_sample_data[ycols].copy()
#y_pred_out_sample = xgb.predict_proba(scalerx.transform(out_sample_data_x))
y_pred_out_sample = xgb.predict_proba(out_sample_data_x)
```

**Lab vs virtual sensor**



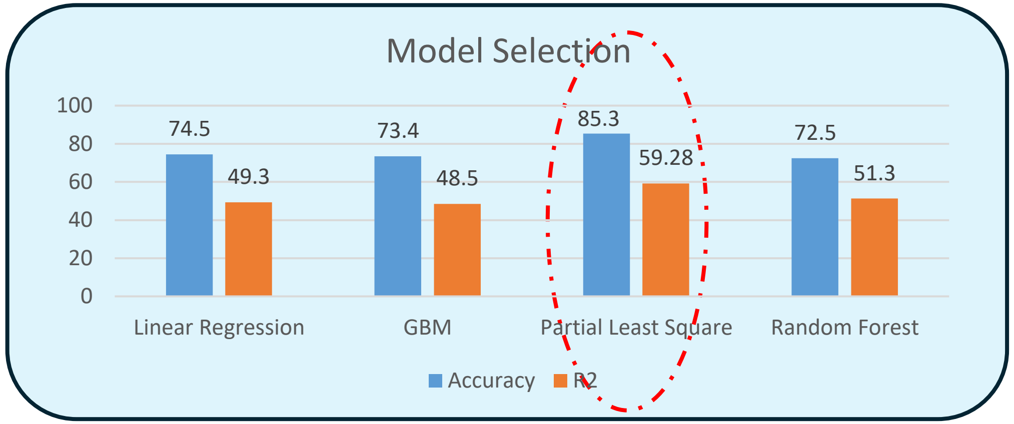

**Online predicted value**



# Moisture Model Selection And Development

## Model Selection

- ❑ We used multiple analytical approaches and selected as per their accuracy and $R^2$ value
- ❑ We have selected PLS analytical approach.




## Model Development

- ❑ All the variable were selected using correlation
- ❑ Data collected from different sources like Lab , DCS.
- ❑ After corelation we selected PLS and Linear regression for model deployment.
- ❑ Model deployed in OSI PI, trained and tested using different data sets.

# Moisture Model

- Predicted stiffness MD and bulk determine the optimal moisture setpoint

- The algorithm operates within a minimum and maximum band range to ensure stability.

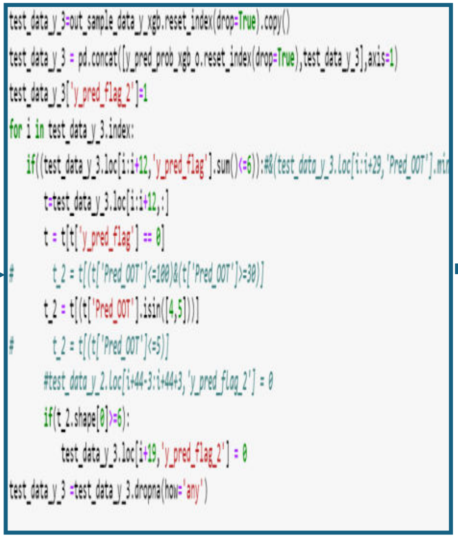
- The model helps achieve higher moisture levels while maintaining minimum quality standards.

| GSM | Grade | Min Moisture | Maximum Moisture | Minimum Bulk | Minimum Ash | Maximum Ash |
|---|---|---|---|---|---|---|
| 70 | SKU-1 | 4 | 5 | 1.46 | 20 | 24 |
| 70 | SKU-2 | 4 | 5 | 1.46 | 20 | 24 |
| 75 | SKU-3 | 4.2 | 5 | 1.41 | 22 | 24 |
| 70 | SKU-4 | 4 | 5 | 1.46 | 20 | 24 |
| 75 | SKU-5 | 4.2 | 5 | 1.41 | 22 | 24 |
| 80 | SKU-6 | 4.2 | 5 | 1.35 | 22 | 24 |

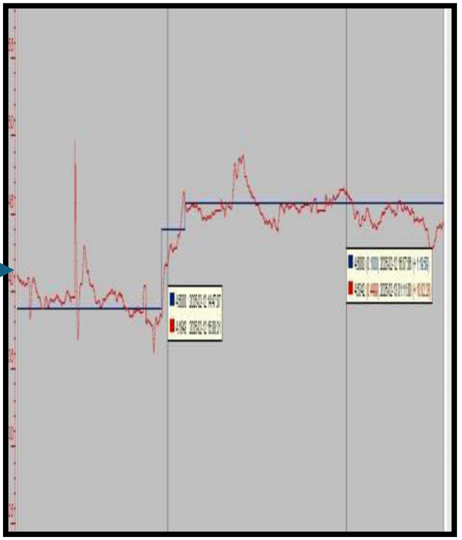
**Grade wise range**

- QCS Parameter
- Coating Parameter
- Chemical Parameter
- Calander Parameter
- Ash, Bulk, Freeness
- Stiffness Predicted

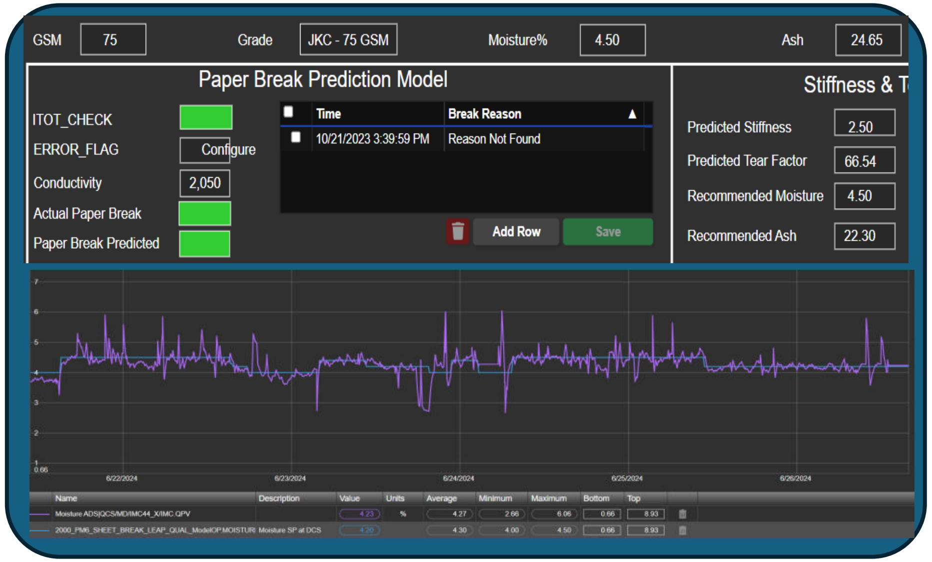
**Input Parameter**



**Algorithm**



**Recommended Moisture SP**




**Dashboard**

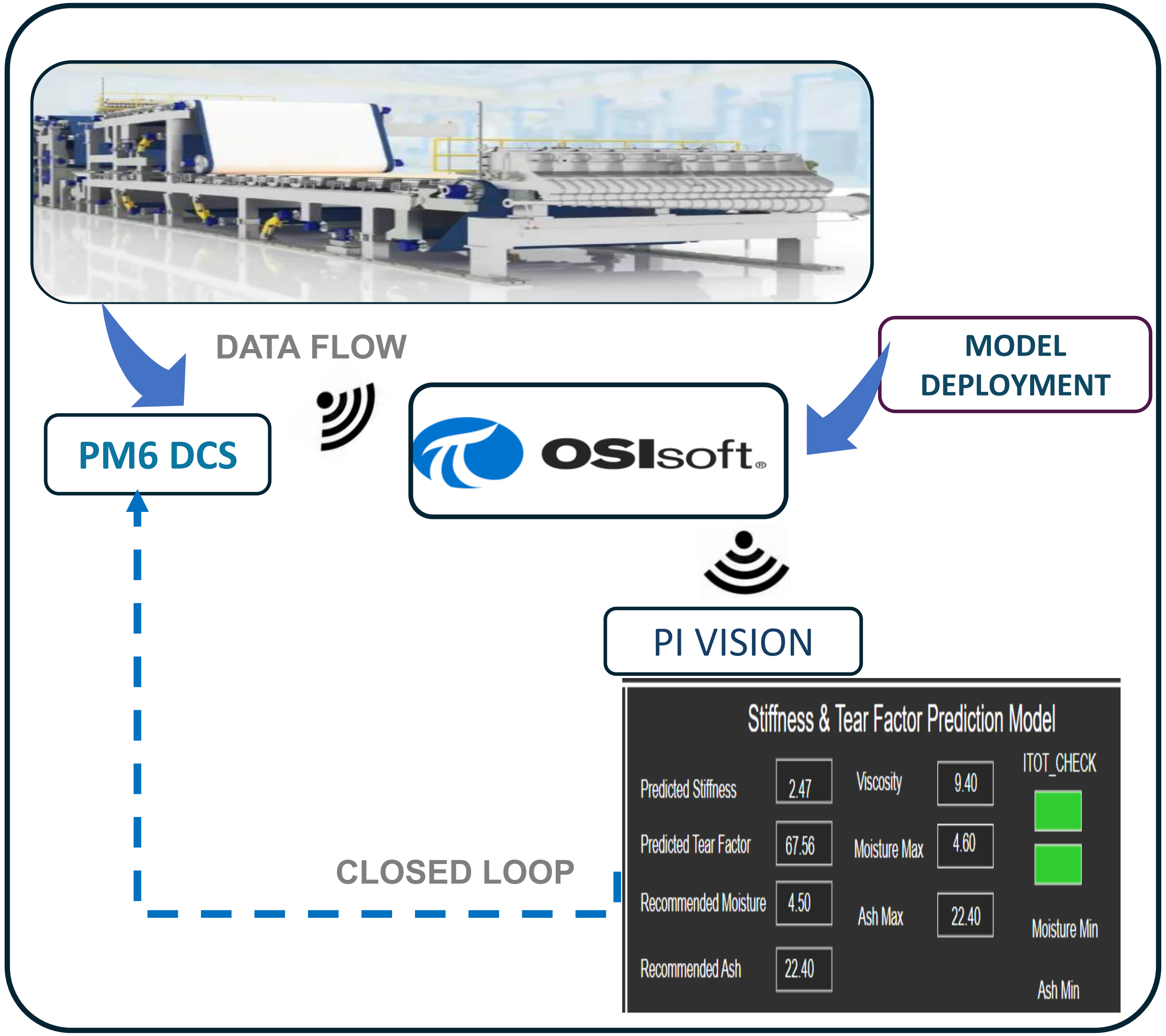
# Visualization and Closed Loop Monitoring

## Visualization

•**DCS Integration**: IT/OT connectivity for seamless operation.
•**Real-Time Optimization**: Continuous sensor data enables AI-driven adjustments.
•**Smart Dashboard**: Provides operator recommendations.

## Loop Monitoring and control

•**Cloud Monitoring**: Enables remote access and tracking.
•**Closed-Loop Control**: Initiated after a successful trial.
•**Error Handling**: Feedback system detects data failures and model anomalies.



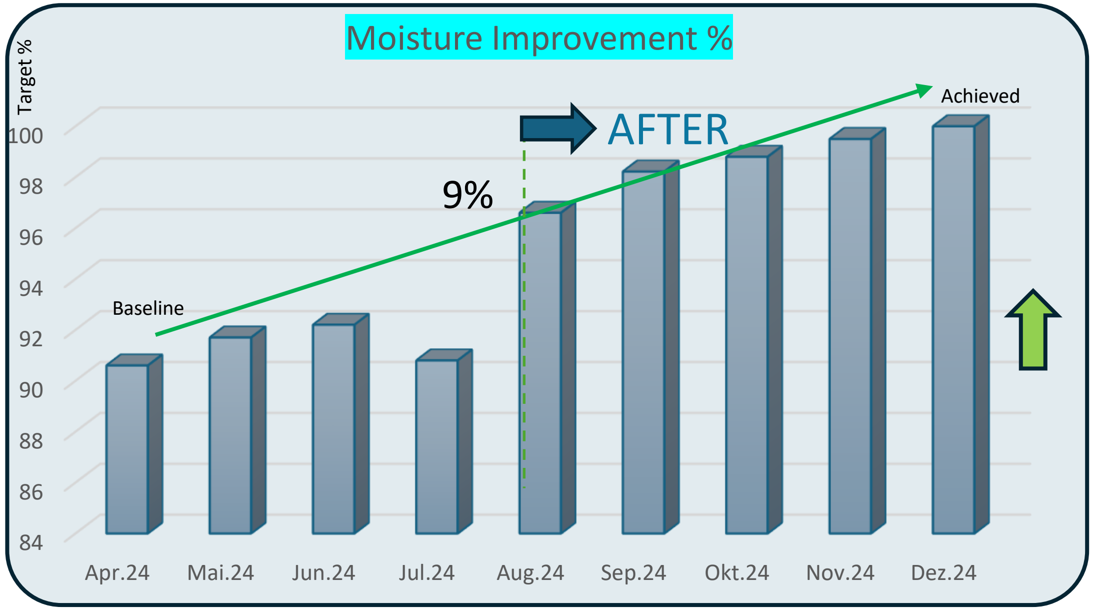
# Value Delivered by the Project

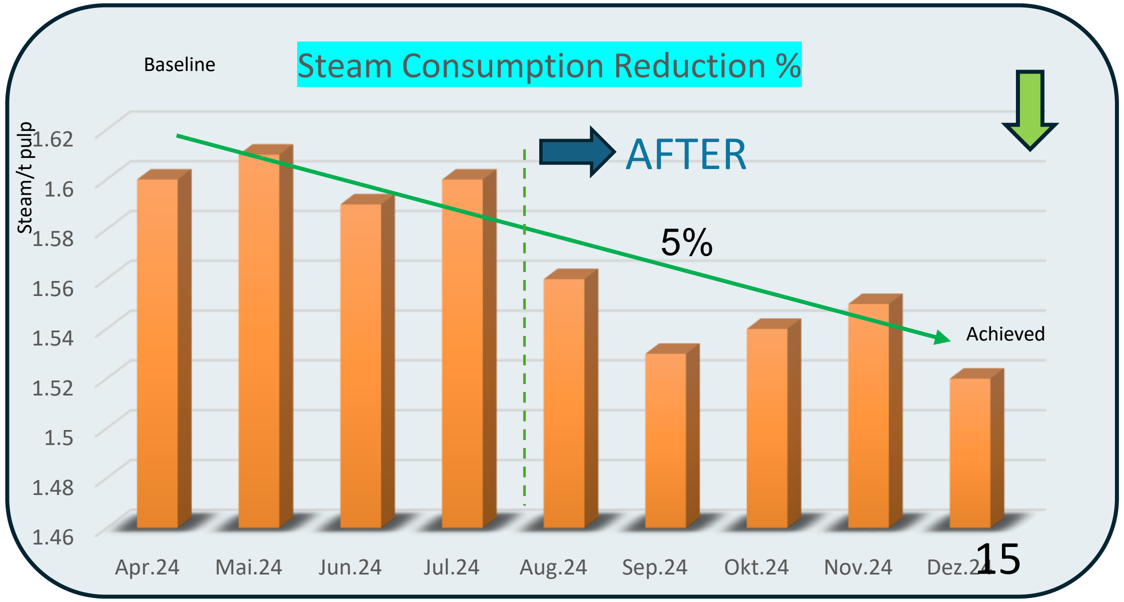
## Moisture Improvement

- Moisture improved and gained 9% from baseline to target through AI.
- AI improved consistency, reducing manual rework.
- Better control over drying process
- Improved paper strength.

## Steam Reduction

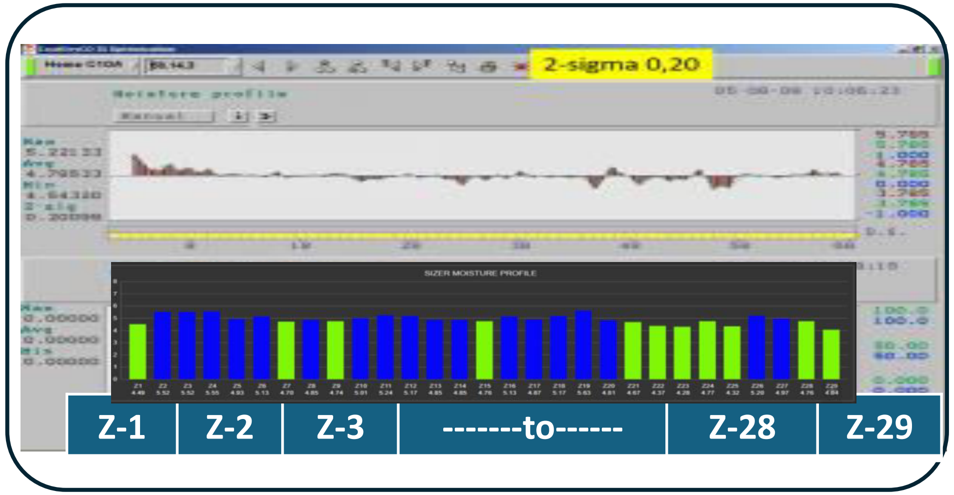
- Steam consumption reduced from baseline.
- Target achieved: 5% reduction.
- Reduction in steam usage impact on lower production costs.



# Proposed Idea for improving CD moisture profile

- ❑ AI-Driven CD Moisture Profile Optimization
- ❑ Virtual Sensor Implementation
- ❑ Intelligent Quality & Cost Optimization




## Anticipated Advantages

- ❑ **Precision**: AI minimizes manual tuning, ensuring stability.
- ❑ **Efficiency**: Automated control enhances response time.
- ❑ **Quality**: Better moisture uniformity improves the product.

# Conclusion

- **Revolutionizing paper production** through AI-driven technologies, optimizing processes from raw material handling to final product output.
- **Enhanced operational efficiency** with AI systems for predictive maintenance, real-time process monitoring, and automated adjustments, reducing downtime and improving throughput.
- **AI-enabled quality control** ensuring consistent product quality by analyzing key parameters and making data-driven adjustments during production.
- Significant **cost savings and sustainability improvements** achieved by reducing energy consumption, optimizing resource usage, and minimizing waste.

The adoption of AI continues to **transform the future of paper manufacturing** paving the way for smarter, more efficient, and environmentally responsible production methods.

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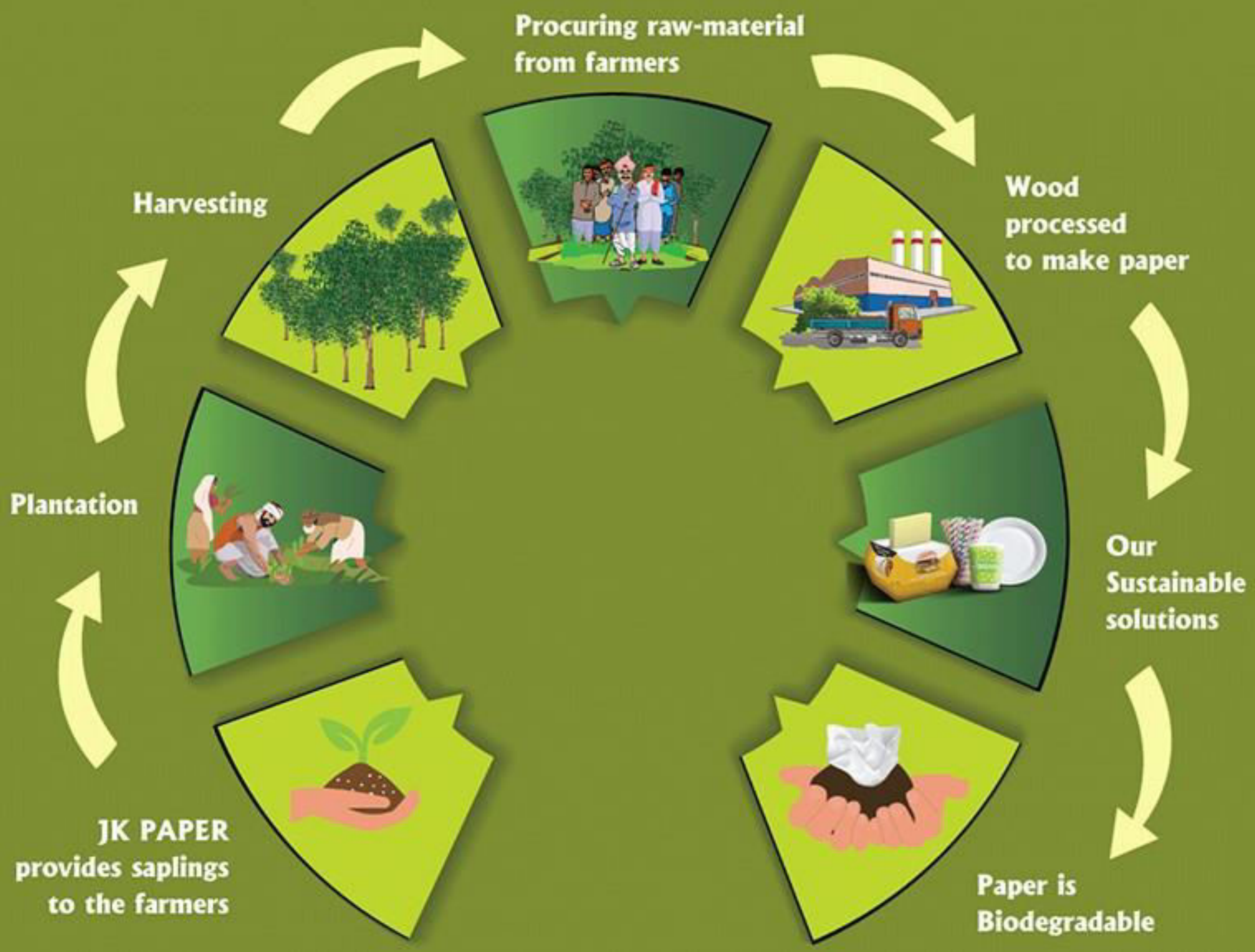


THANKS