Strategic Implementation of Petuum AI-pilot to Improve Energy Utilization and Yield at CEMEX

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Petuum

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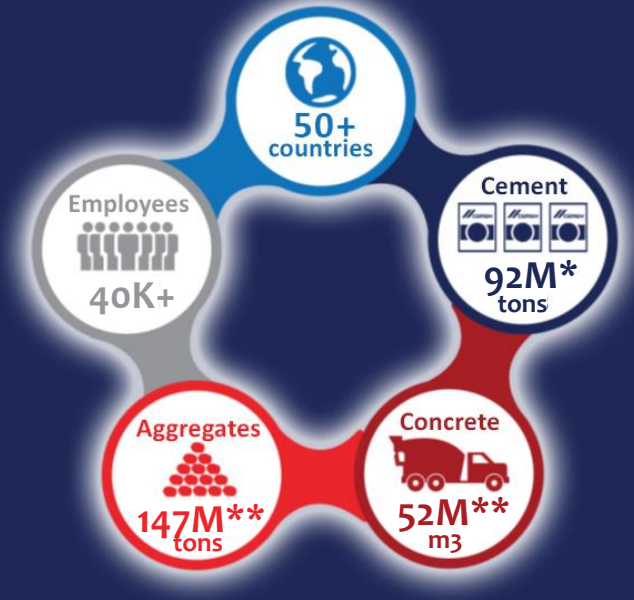
Company overview

Business

CEMEX is a global building materials company that provides high-quality products and reliable service to customers and communities in more than 50 countries throughout the world.

A global industry leader

- Annual sales of US$13.67 billion
- One of the leading cement manufacturers, ready-mix and aggregates in the world
- One of the world's top traders of cement and clinker



* Production Capacity ** Annual Production Levels

2017 Annual Report https://www.cemex.com/about-us/company-profile

Rodrigo Quintero

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About the Presenters

- Rodrigo J. Quintero
- Operations Digital Technologies Manager
- CEMEX

- Prabal Acharyya
- AVP of Industrial AI
- Petuum

CEMEX Petuum

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Agenda

- Artificial Intelligence(AI) Potential for Cement Industry
- Cemex : How we got started on the path to AI
- Petuum | Petuum Industrial AI-pilot – An Overview
- Petuum AI-pilot with “Autosteer” for Autonomous Cement Plant Operations at CEMEX
- Petuum Deployment Architecture with OSIsoft PI
- Next Steps

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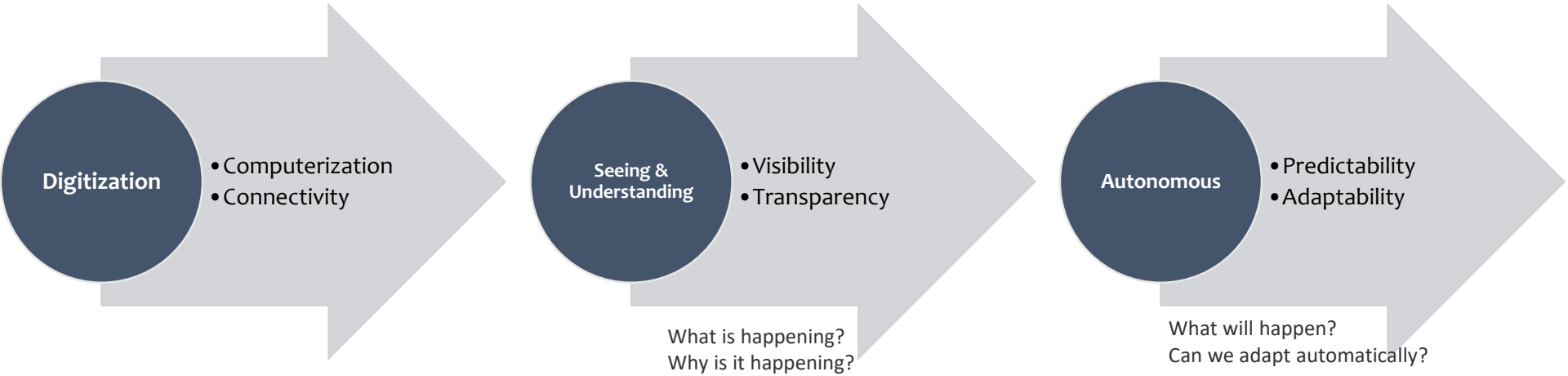
Industry 4.0 : The Digital Transformation Journey

Industry 4.0
What's next?



Connected 1

Prescriptive 2

Autonomous 3

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Why Artificial Intelligence?

Artificial intelligence holds the key to future growth and success

In cement operations, artificial intelligence assisted operation can help our plants realize manufacturing process improvements and achieve strategic goals in:

- Safety performance
- Operational Efficiency
- Energy efficiency and alternative fuels substitution
- Quality Assurance and product design

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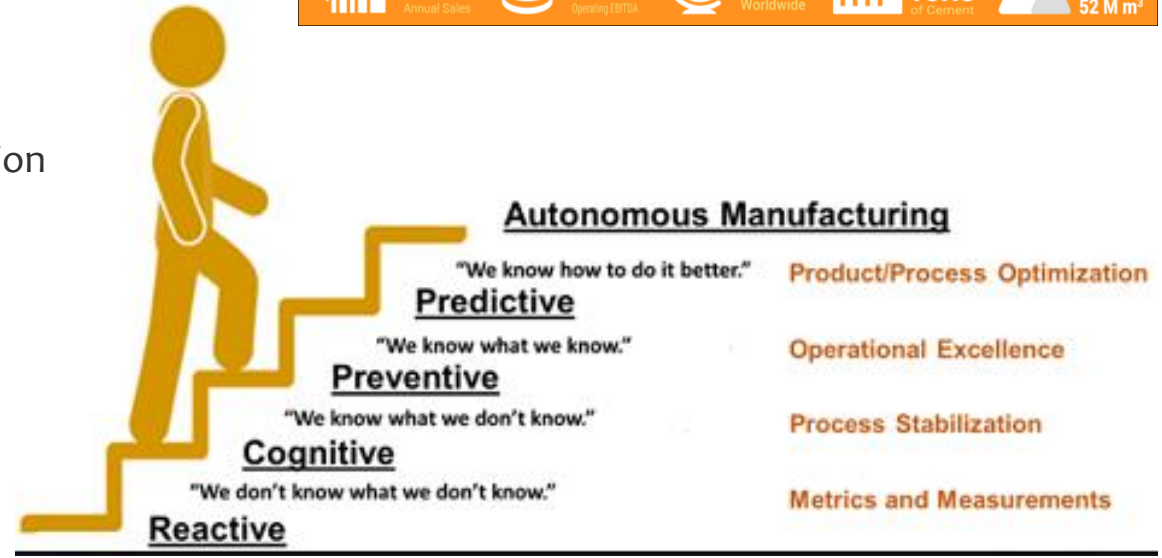
CEMEX: On an Industry 4.0 Journey

CEMEX Autonomous kiln 2022

- Increased Efficiencies
- Reduced fuel & energy consumption
- Better Quality
- Reduced Costs
- Improved Decision Making



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Why Petuum AI-pilot with Autosteer

- Collaborative approach/engagement
- Phased approach:
  - **Predict :** Real time forecasts help boost understanding
  - **Prescribe Only (Autosteer OFF) :** Prescriptions can be validated by operators before updating the setpoints.
  - **Autosteer ON:** Supervised controlled autopilot operation integrated with plant control systems

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Use Case: Clinker Cooler Optimization

The cooler transfers the heat from clinker to combustion air to:

- Increase heat recovery
- Obtain clinker at a temperature suitable for grinding
- Maximize clinker potential strength through rapid cooling

Goal

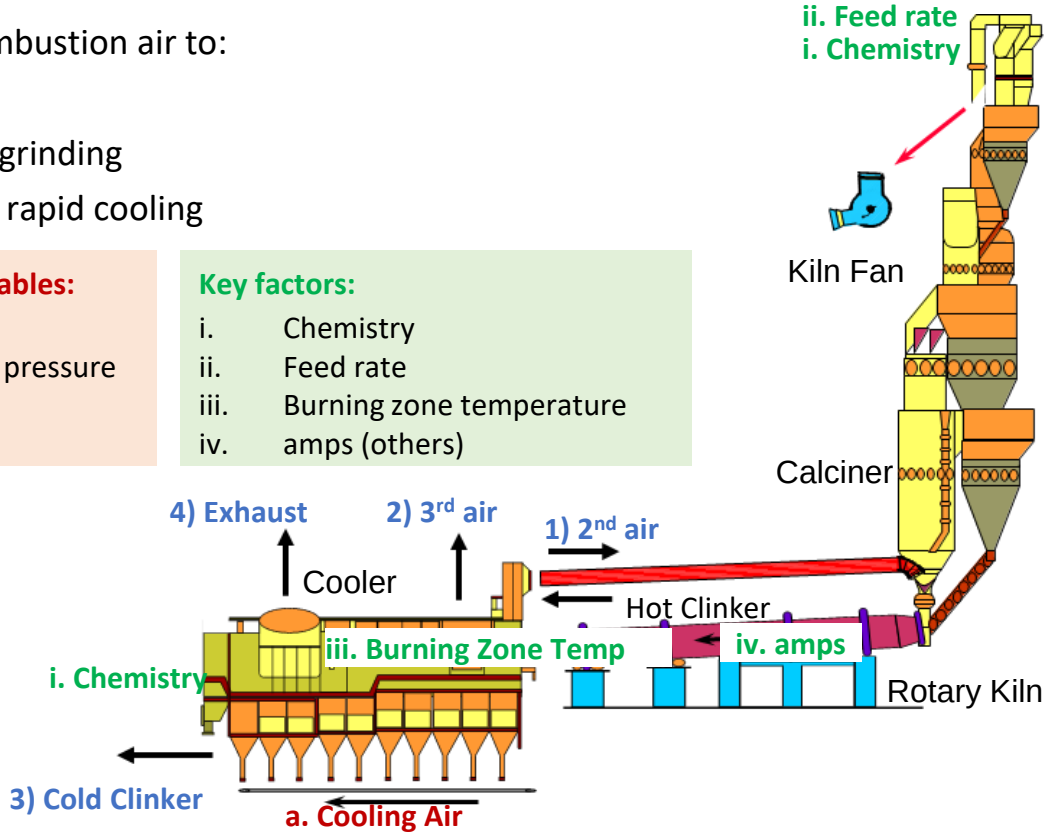
1) Maximize 2nd air heat
2) Maximize 3rd air heat
3) Minimize Cold Clinker heat
4) Minimize exhaust gas heat

Controllable variables:

a. Fan flow
b. Undergrate pressure

Key factors:

i. Chemistry
ii. Feed rate
iii. Burning zone temperature
iv. amps (others)



Note: Variables and key factors full list depends on use case complexity; typically contains 40+ variables

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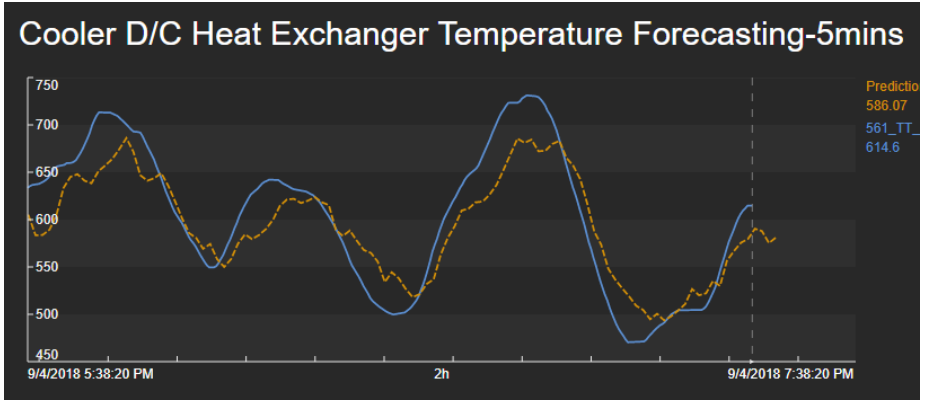
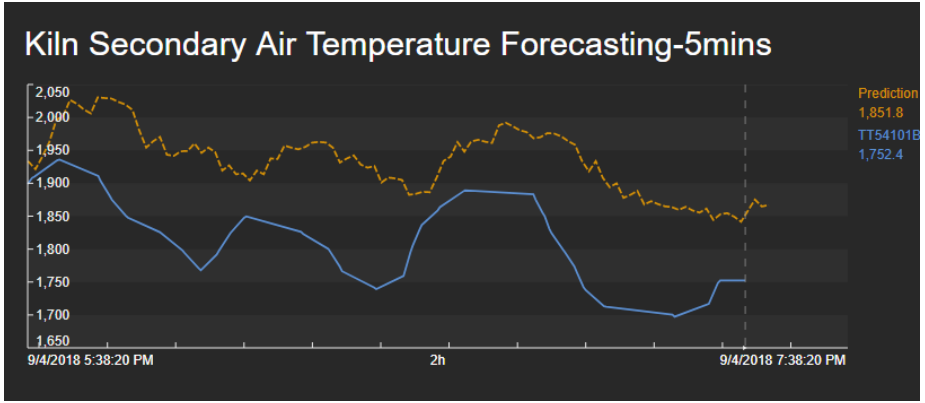
Phased Development

Phase I: Forecast prediction in real-time (Mode: Prediction)

- Identify output variables for AI model to predict behavior 5 to 15 minutes in advance
- Allows kiln operators to take actions if they identify issues before these occur
- Forecast can predict values
- Forecast can predict change in slope

All actionable items rely on kiln operator's knowledge, experience and intuition





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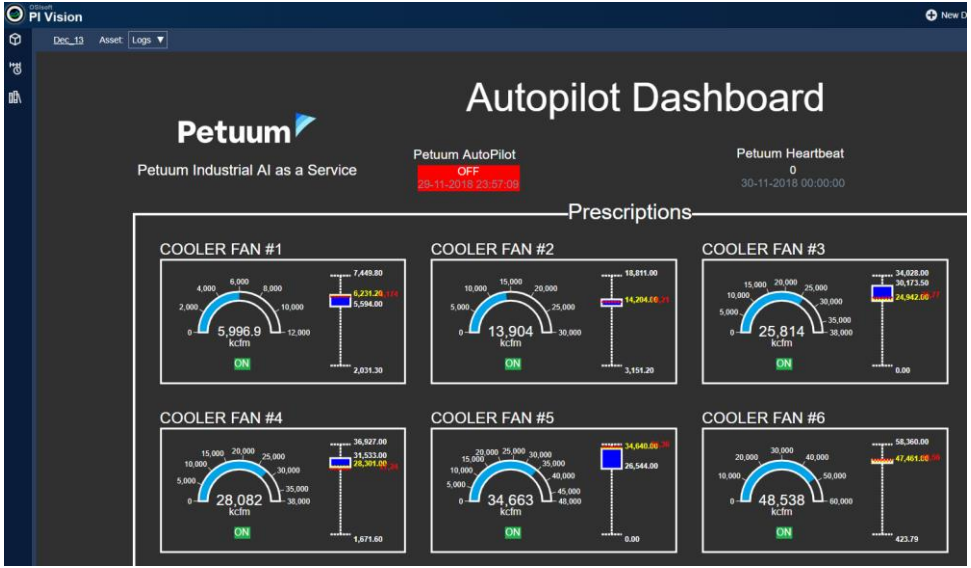
Phased Development

Phase II: Prescriptive Recommendations in real-time (Mode: Prescription)

- The AI model can recommend setpoints for the control variables in real time
- Operators need to validate if recommended setpoints are within operating range before making a decision
- Kiln operator has to accept and input manually the prescriptive recommendation into the control system

All actionable items support kiln operator's knowledge and experience to improve performance



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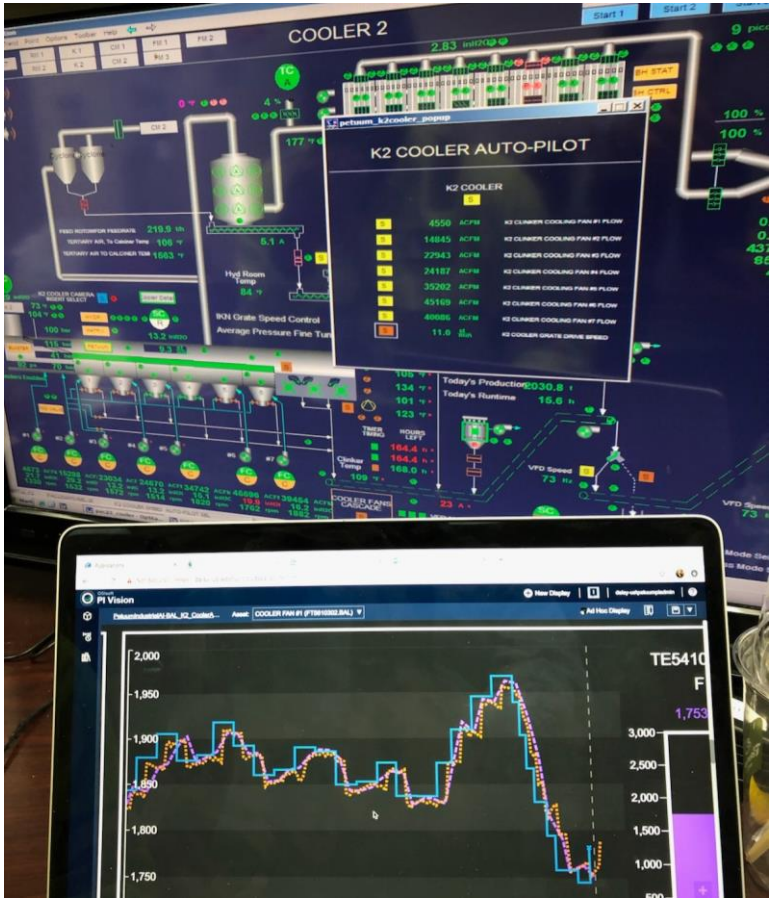
Phased Development

Phase III: Auto-pilot operation of kiln's cooler section (Mode: Autosteer)

- The AI model submits setpoints for the control variables in real time to control system via PI
- Operators can monitor in real-time if auto-pilot operation is aligned to normal operating parameters
- Kiln operator can engage-disengage autopiloting the control system in case of process disruptions (i.e.- power failure, kiln push, blockages, etc.)
- Operators continue to use Phase 1's prediction as an additional tool to monitor process behavior

Operators can supervise auto-pilot operation while concentrating on other kiln parameters. AI-pilot disengages if it hits any static or Dynamic Constraints

(similar to a car's dynamic cruise control).



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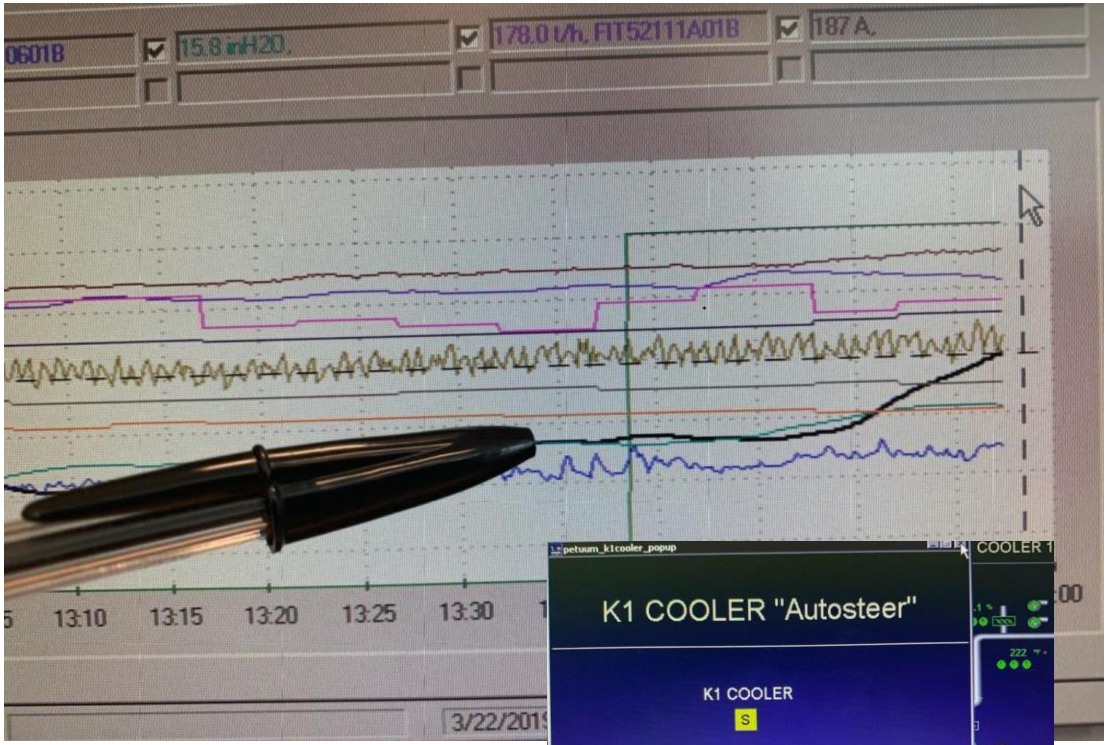
Autosteer delivers Immediate Results

As soon as “Autosteer” picks up driving the asset operation, immediate results are achieved.

- Secondary Air Temp for K1 Cooler (black line), resulting in energy savings as soon as the Autosteer is switched ON by the Operator.



CEMEX Petuum

Multi-site deployment of Petuum AI-pilot using PI

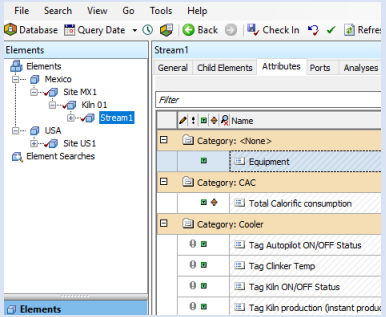
PI Component

PI-Enabled

Outside PI

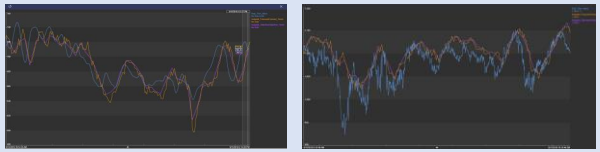
We leveraged our PI infrastructure, therefore reducing the effort to operationalize the AI models from US site to MX site and other global sites.

AF & Analytics (site configuration)

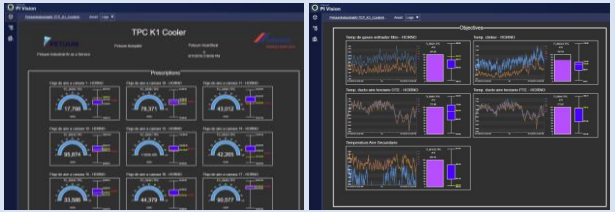


PI Vision visualizations for autopilot phased deployment

Phase 1: Forecasting

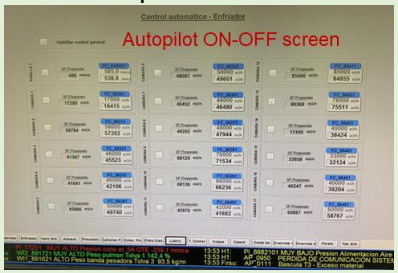


Phase 2: Prescriptive Recommendations



Control System customization

Phase 3: AI-pilot



AI-pilot product (SaaS)

Petuum

Autopilot Perf & Analysis

Partner Solutions Integrated with PI

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Achievements

Phase I: Forecast prediction in real-time

- ✓ Successfully predicted Clinker and Air temperatures and trend slope changes as outputs of cooler up to 15minutes in advance
- ✓ AI Prediction model showed better results compared to previous POCs using linear modeling to forecast clinker quality (free-lime modeling)

Phase II: Prescriptive Recommendations in real-time

- ✓ Relayed recommendations to kiln operators. Model improvements introduced additional constrains to make recommendations reasonable and actionable

Phase III: Autosteer operation of kiln's cooler section

- ✓ Successfully ran kiln cooler using artificial intelligence
- ✓ AI-supported kiln cooler is obtaining higher exit air temperatures when auto-pilot is engaged

Phase IV: Multi-site global deployment

- ✓ Successful replication process using PI infrastructure
- ✓ Best practices identified to improve ML models and ease deployment

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Petuum

Petuum Industrial AI-pilot

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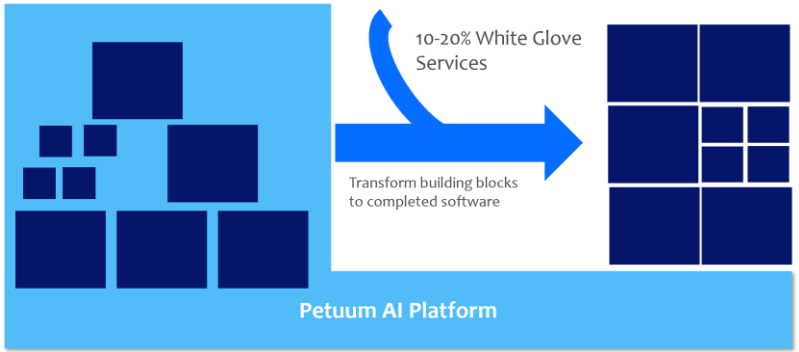
About Petuum

Industrialize AI technology

Turning it from black-box artisanship into standardized engineering process

AI as "Civil Engineering"



World Class Multi-Disciplinary ML Team

Eric Xing, Ph.D
- Founder
- CEO and Chief Scientist
- AAAI, IEEE Fellow
- **#1 ML scientist in the world***

Qirong Ho, Ph.D
- Co-Founder
- CTO
- KDD Best Ph.D. Dissertation Award, 2015
- ~40+ papers, 1200+ citations

180+ team members, 30+ Ph.Ds

- Over 30,000 citations across the team, comparable to Google & Facebook
- Talented in several AI/ML disciplines: computer vision, natural language processing, knowledge models, deep neural networks, document management …

* Source: www.csrankings.org

Industrial | Financial Services | Healthcare

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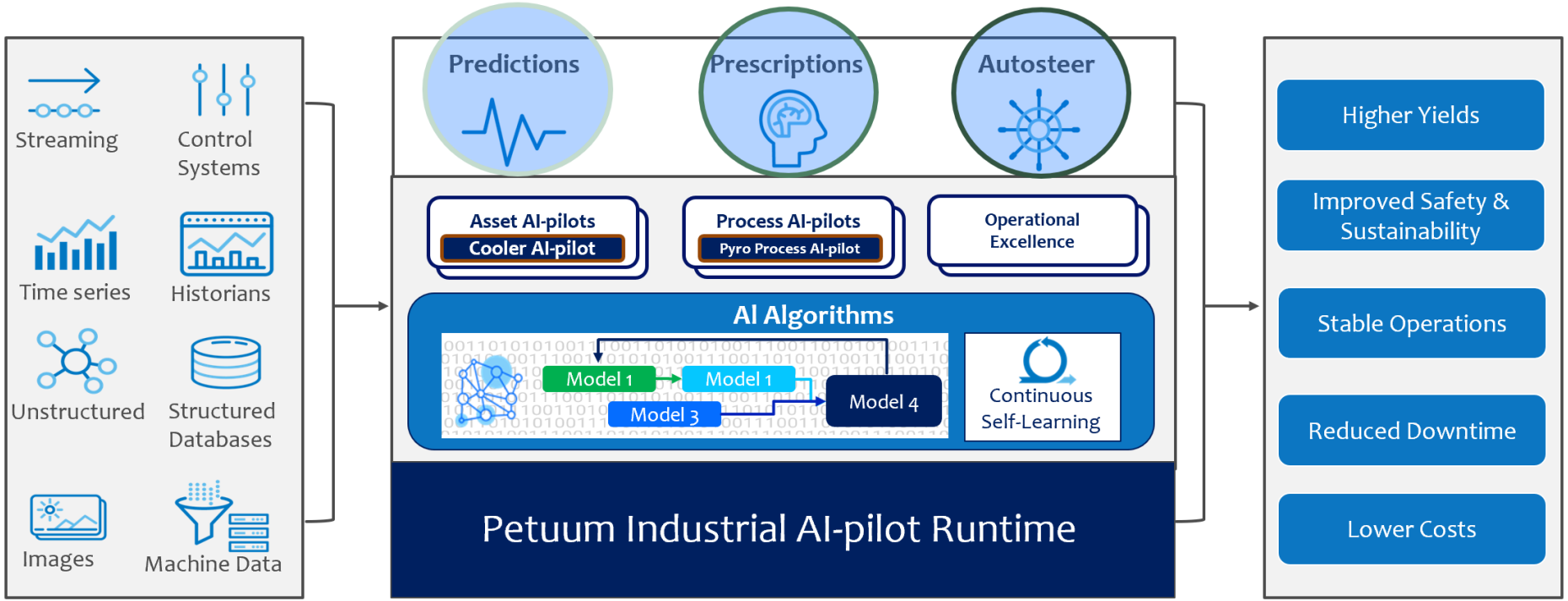
Petuum Industrial AI-pilot



Powered by Petuum's advanced AI Platform, expert-built ML/DL algorithms deliver precise predictions, optimal prescriptions and optional autosteer for assets, processes and operational excellence initiatives

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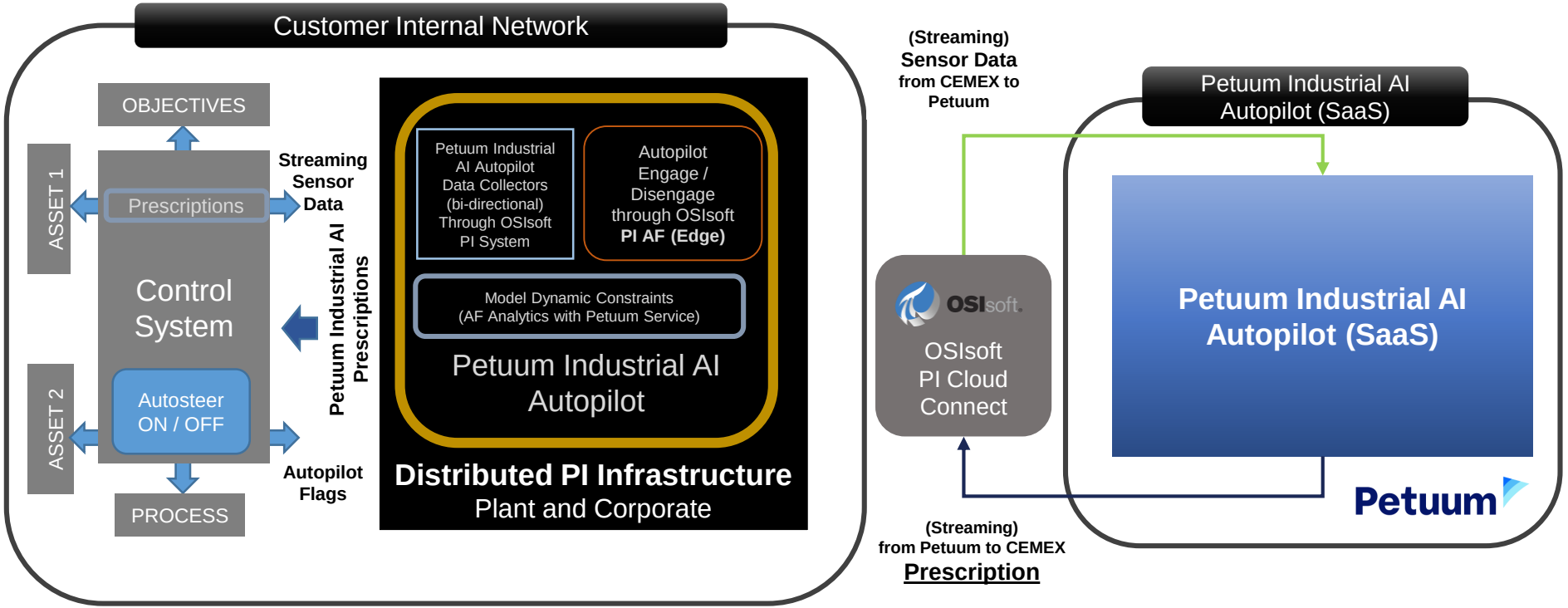
Petuum Industrial AI Autopilot Architecture



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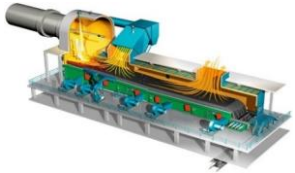
AI-pilot Mode of Operation



Predictions

Predicting objectives and constraints 5 minutes in future on expected trend of forecast and auto-steer behavior.

Prescription

Prescribing every minute for recommended optimized state of operation

Autostee r

Supervised auto-steering that enables automatic control of prescribed variables

Example Cooler Modes of Operation

Objectives/Goals
- Maximize Secondary Air
- Maximize Tertiary Air
- Minimize Clinker Out Temp

Prescriptions / AI Controls
- Fan Flows
- Stroke Speed

Constrains
- Cooler Vent Temp
- Under Grate Pressure

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CEMEX – PETUUM AI-PILOT TO DRIVE AI-ENABLED AUTONOMOUS OPERATION

CHALLENGES

- Predictable, repeatable ”golden day” operations – high yield, high quality at low cost sustainably
- Prove AI / ML capabilities to optimize production processes
- Complex, highly variable operations
- No real time prediction, reactive operator actions

SOLUTION

- Petuum Industrial AI-pilot taps into PI system and other sources to deliver real time prediction of process variables, prescriptions for operator actions and a supervised auto-steer.
- Integration with OSIsoft suite of products for configuration, data streaming and visualization. OSIsoft cloud Services - PI Cloud Connect, PI AF, PI Vision

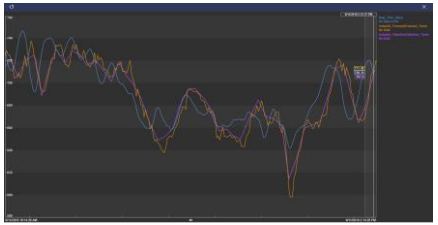
BENEFITS

- Expected yield and energy improvement by **2-7%** from combined AI-pilot use cases
- Cost reductions from energy recovery

	US	MX
• Secondary Air ΔT (°C):	+55	+47
• Tertiary Air ΔT (°C):	+8	+44
• Clinker Temp ΔT (°C): (increased but acceptable)	+2	+7

- Reduce process variability ↓½ σ
- Increased throughput

Petuum



“This is a giant step in digital transformation towards safe, highly standardized operations, that will help us strengthen our high-quality products portfolio while also ensuring we meet our operational and sustainability goals and minimize costs.” *- Rodrigo J. Quintero, Operations Digital Technologies Manager, CEMEX*

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Lessons Learned (1)

- ✓ Company **commitment** from both corporate and plant **leadership is key** to successful implementation of new technologies
  - Initial implementation took about 2-3 months.
  - Continue CEMEX- Petuum collaboration to deploy AI-pilot with Autosteer at multiple sites and use-cases.
  - **PI-Enabled architecture** and **Petuum's Software as a Service (SaaS)** Architecture allows for subsequent **implementations reduced to weeks**.
  - Commitment from **Petuum** and **CEMEX's corporate, regional and local leadership** in each site for deployment in 5 regions
    - ➢ USA
    - ➢ Mexico
    - ➢ Europe
    - ➢ SCAC – South, Central America & Caribbean
    - ➢ AMEA – Africa, Middle East & Asia

Petuum AI-pilot Modules being Deployed

- **Kiln = Cooler + Kiln + Fuel Mix + PreHeater AI-pilots**
- **Cement Mills (Ball Mills and Vertical Mills)**

- ✓ **AI is not magic**: Autosteer mode initially started to run only under stable conditions; it is being expanded to other conditions with different dynamic and static modes.
  - **SME input** to improve modes of operation
  - **CEMEX Resources** required at every step to ensure joint success.
  - **Reliable sensors** and data are **critical**

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Lessons Learned (2)

- ✓ **Change Management is critical**: Autosteer started with engagement only when plant supervision is available (day-shift only).
  - Our goal is to run Autosteer round the clock as plant **operators take full ownership** of the process.
  - A good **change management process** can make transition to new technologies faster, easier.
  - **Support is key**:
    - **CEMEX's** Center of Excellence and Mexico's C3 (Centralized Control Center) to provide **process support**
    - Regional **process team's** key participation as **SME** in model customization
    - **Petuum's Live Tracking** & Alerting 24x7 to achieve continuous operation.
  - CEMEX has now **trained engineers for global and regional AI-pilot deployment**; Petuum team and SME providing remote support & Live Alerts for Autosteer.

- ✓ **Continuous monitoring of model performance:** some process disruptions may affect the AI models
  - Even with self-learning models, these can start drifting upon process changes or disruptions, thus **retraining or model tweaking** may be necessary to ensure best results over time.
  - Upkeeping models fosters continued **model adoption and usage,** and allows to improve models for replicating **best practices** to other sites.
  - Petuum and CEMEX works regularly to update AI-pilot model as part of Petuum's SaaS.

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Petuum | OSIsoft Integrations

1. PI Web API

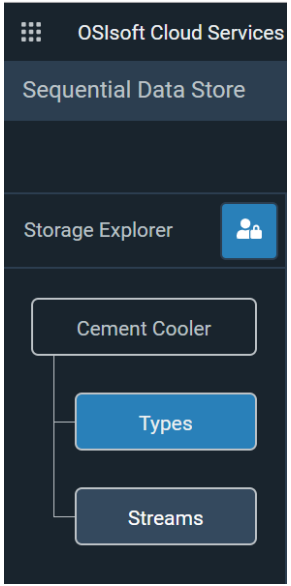
2. PI Connectors and Interfaces

3. Asset Framework and Asset Analytics

4. PI Vision including custom controls

5. OSIsoft PI Cloud Connect

COMING SOON



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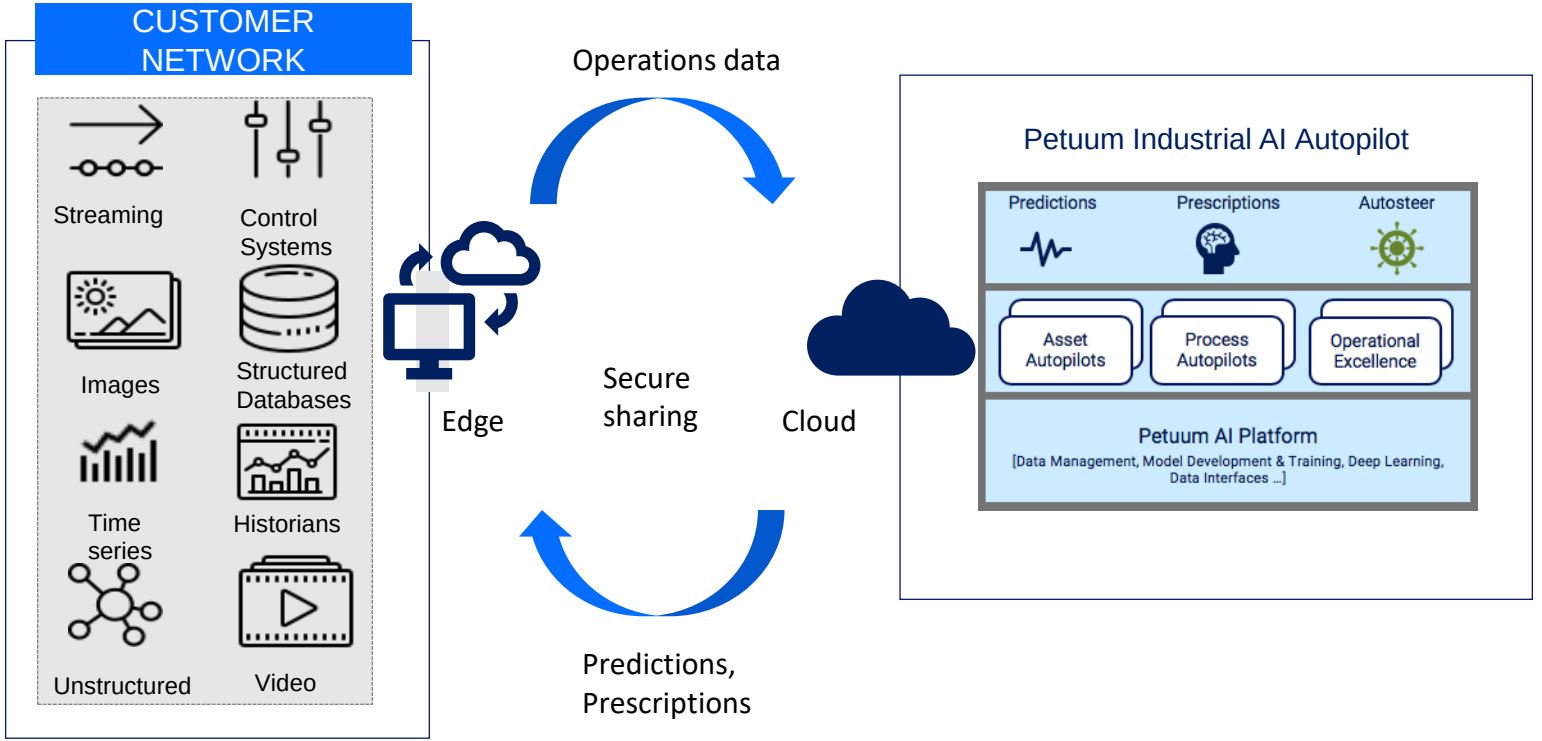
Petuum Industrial AI as Service



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name & company

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Navigate to this session in
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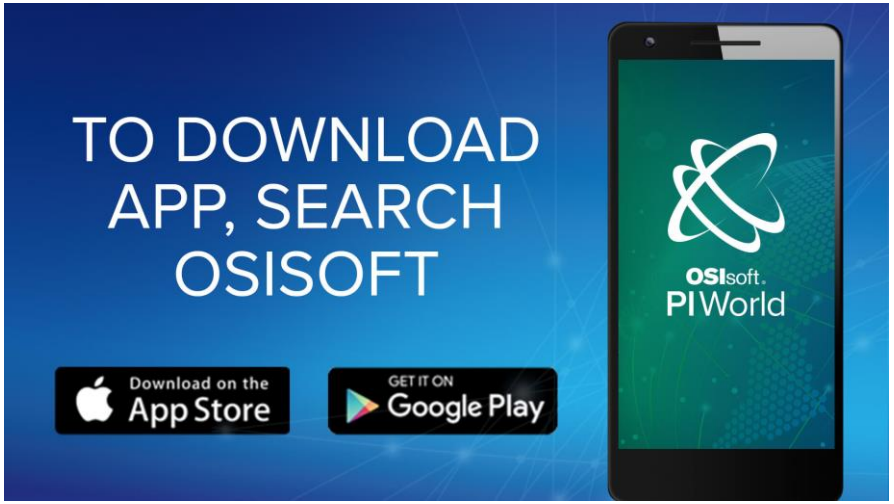

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