EDC’s 5Cs Digitalization Strategy

Mr. Emmanuel “Manny” Portugal
Chief Technology and Digital Transformation Officer
Energy Development Corporation (EDC)

• 40 years of Geothermal Operations in the Philippines
• 4 Sites nationwide with a total of 25 Operating Turbine Units
• EDC is part of the First Gen Corporation (“First Gen”) Group, which has the largest portfolio of power plants using clean and renewable technology in the Philippines with capacity of 2,763 MW – about 10% of the total Philippine Capacity 13,272 MW.

The Philippines is geographically a prime location for harnessing geothermal energy, making it the second largest producer in the world. Geothermal energy accounts for approximately 17% of the country’s energy mix, with an installed capacity of approximately 1,904 megawatts.
Some of EDC’s Operational Challenges

- 2018 Unplanned Outage Factor at 13.72%
- 2018 Availability Factor at 84.81% (Target is 95%)
- 90% of Preventive Maintenance Schedule (PMS) has extended work
- Incomplete fleetwide operational data standards
- Limited operational awareness of well performance
- Heat/steam losses along the Steam Fielded Pipeline network
- Data management by Excel/Screenshot/CSV files

OBJECTIVE

Improve Operation & Maintenance by leveraging Operational Data - data generated by our assets
Digital Transformation Vision and Strategy

IMPROVE O&M BY DIGITIZING THE VALUE CHAIN

<table>
<thead>
<tr>
<th>UPSTREAM</th>
<th>DOWNSTREAM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Drilling</td>
<td>Steam Field</td>
</tr>
<tr>
<td>Reservoir Management</td>
<td>Power Plant</td>
</tr>
</tbody>
</table>

5C STRATEGY

- CONNECT
- COLLECT
- COMPUTE
- COMMUNICATE
- CORRELATE

- Digital Drilling
- Digital Reservoir
- Digital Steam Field
- Digital Power Plant
- Digital Geo Sciences
- Digital Solar
- Digital Wind

- Real-time Data
- Situational Awareness
- Operational Insight
- Data Driven Decisions
- Automated Reports
- Quick Access to Info
- Analytics
DELIVER OPERATIONAL INSIGHT WITH VISIBILITY AND REAL-TIME DATA
Operational Data Flow

Enterprise-wide visibility of operational data
EDC Digital Transformation Roadmap

2018

- Pressure and Flow Sensors
- PI + Integra
- Smart Steam Field
- Smart Power Plant
- Thermal Mapping
- PI Server Implementation
- Pressure and Flow Sensors

2019

- Well Head Availability
- Alert Notifications via Email and SMS
- Alert Notifications via Email and SMS
- Alert Notifications via Email and SMS
- Alert Notifications via Email and SMS
- Alert Notifications via Email and SMS

2020

- Well Head Variation
- Reinjection Loading
- Well Output
- Steam Loss / Inefficiency / Revival
- Critical Asset Risk Score
- Asset Management

2021+

- Early Warning System
- Reservoir Decline
- Priority 1 Wells
- Equipment Monitoring
- Vibration
- Rotating Equipment
- Turbine and Generator
- Priority 1 Wells
- MHPS Collaboration
- Priority 1 Wells

INCREASING COMPLEXITY
PI Vision Displays
Facility Daily Operation Report (FODR) – Real Time
# Sample Datalink Reports

## YTD September Total Unplanned Outage and Deration

<table>
<thead>
<tr>
<th>Unplanned</th>
<th>Unit 1</th>
<th>Unit 2</th>
<th>Unit 3</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>External - Market Intervention</td>
<td>0.60</td>
<td>0.41</td>
<td>0.00</td>
<td>0.22</td>
</tr>
<tr>
<td>Power Plant - Gas Removal System</td>
<td>3.19</td>
<td>2.17</td>
<td>0.30</td>
<td>6.66</td>
</tr>
<tr>
<td>Power Plant - Turbine System</td>
<td>-</td>
<td>6.02</td>
<td>0.20</td>
<td>6.22</td>
</tr>
<tr>
<td>Resource - Steam/RCAP Shutdown</td>
<td>0.61</td>
<td>3.27</td>
<td>8.11</td>
<td>9.99</td>
</tr>
<tr>
<td>Power Plant - Cooling/Circulating System</td>
<td>2.61</td>
<td>4.79</td>
<td>3.02</td>
<td>10.42</td>
</tr>
<tr>
<td>Power Plant - Others</td>
<td>1.10</td>
<td>0.76</td>
<td>0.15</td>
<td>1.01</td>
</tr>
<tr>
<td>Power Plant - Inlet Steam System</td>
<td>0.10</td>
<td>-</td>
<td>-</td>
<td>0.10</td>
</tr>
<tr>
<td>Power Plant - Maintenance Shutdown</td>
<td>1.03</td>
<td>-</td>
<td>1.33</td>
<td>1.33</td>
</tr>
<tr>
<td>FCRS Testing</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Power Plant - Generator System</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Power Plant - Condensing System</td>
<td>-</td>
<td>0.16</td>
<td>-</td>
<td>0.16</td>
</tr>
<tr>
<td>FCRS Problem</td>
<td>0.61</td>
<td>0.39</td>
<td>-</td>
<td>0.63</td>
</tr>
<tr>
<td>Power Plant - Electrical System</td>
<td>1.99</td>
<td>1.75</td>
<td>0.25</td>
<td>4.02</td>
</tr>
<tr>
<td>Power Plant - Switchgear &amp; TL</td>
<td>-</td>
<td>-</td>
<td>0.45</td>
<td>0.45</td>
</tr>
<tr>
<td>Power Plant - Controls and Protection System</td>
<td>-</td>
<td>-</td>
<td>1.44</td>
<td>1.44</td>
</tr>
<tr>
<td>External - Others</td>
<td>0.61</td>
<td>0.77</td>
<td>0.12</td>
<td>1.47</td>
</tr>
<tr>
<td>External - Plantショー</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Total</td>
<td>12.94</td>
<td>14.24</td>
<td>6.25</td>
<td>33.42</td>
</tr>
</tbody>
</table>

### Top 10% Unplanned Outages/Derations

<table>
<thead>
<tr>
<th>Unit</th>
<th>Outage/Deratin: generation loss (MWh)</th>
<th>Cause: Circumstances and Location of Outage/Loss</th>
<th>Actions Taken</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unit 1</td>
<td>Outage</td>
<td>2.571</td>
<td>Power Plant - Cooling/Circ</td>
</tr>
<tr>
<td>Unit 1</td>
<td>Outage</td>
<td>1.79</td>
<td>Power Plant - Inlet Steam</td>
</tr>
<tr>
<td>Unit 1</td>
<td>Outage</td>
<td>1.503</td>
<td>Power Plant - Maintenance Extended PM</td>
</tr>
<tr>
<td>Unit 1</td>
<td>Outage</td>
<td>1.986</td>
<td>Power Plant - Electrical System</td>
</tr>
<tr>
<td>Unit 1</td>
<td>Outage</td>
<td>1.768</td>
<td>Power Plant - Gas Removal Low Condenser Vacuum</td>
</tr>
<tr>
<td>Unit 1</td>
<td>Outage</td>
<td>1.064</td>
<td>Power Plant - Others</td>
</tr>
<tr>
<td>Unit 2</td>
<td>Outage</td>
<td>1.768</td>
<td>Power Plant - Electrical System</td>
</tr>
<tr>
<td>Unit 2</td>
<td>Outage</td>
<td>2.928</td>
<td>Power Plant - Gas Removal Low Condenser Vacuum</td>
</tr>
<tr>
<td>Unit 2</td>
<td>Outage</td>
<td>1.22</td>
<td>Resource - Steam/RCAP Low steam pressure due</td>
</tr>
<tr>
<td>Unit 2</td>
<td>Outage</td>
<td>4.605</td>
<td>Power Plant - Condensing System</td>
</tr>
<tr>
<td>Unit 3</td>
<td>Outage</td>
<td>2.949</td>
<td>Power Plant - Cooling/Circ Outage of heater pump</td>
</tr>
<tr>
<td>Unit 3</td>
<td>Outage</td>
<td>1.441</td>
<td>Power Plant - Controls and Detectors Main Bus Valves</td>
</tr>
</tbody>
</table>

### YTD September Generation Losses due to Unplanned Outages and Derations

- Unit 1: 12.24
- Unit 2: 14.14
- Unit 3: 6.25

Total: 32.63

| Unit | 12.24 | 14.14 | 6.25 | 32.63 |

## YTD September Generation Losses due to Unplanned Outages and Derations

- Unit 1: 12.24
- Unit 2: 14.14
- Unit 3: 6.25

Total: 32.63
PI AF - Early Warning System
INCLUDED LRVP AND HOT WELL PUMP VIBRATION IN THE DISPLAY PAGES
PI Notifications

ADDITIONAL EMAIL NOTIFICATION FOR LEVEL DUMP VALVE

BGBU FCRS SV 405 Warning - Level Dump Valve Notification

notify@energy.com.ph
Yesterday, 4:03 PM
Alexa Tolentino

BGBU FCRS SV 405 Level Dump Valve Logic is triggered at Jul-18-2018 03:51:29
Level High is triggered and Level Transmitter reached its limit (2 out of 3) parameters are triggered. LDV potentially will Open.

See link:
EWS Display

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Exergy Analysis Model using the real time data and historical data
Exergy Analysis Model Algorithms in Asset Framework
PI Integrator for ESRI
Secured PI System Architecture with Waterfall
Google Sheets – Manual Logs
SMS or Email Event Annotation

Given constraints with the PI Vision access, this allows the user to annotate an event received. Annotation and attachment could be sent out via SMS or Data.

1. PI Notification Server sends out Notification
2. Recipient receives notification
3. User sends out response or annotation back to the PI Server
## Some Early Wins

<table>
<thead>
<tr>
<th>Before</th>
<th>After</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>72 hours</strong> needed to revive PAL25D well</td>
<td>Reduced to <strong>15 hours</strong> with online well head pressure visibility</td>
</tr>
<tr>
<td><strong>Silo’ed data</strong> - Steam Field data not readily available to Power Plant and vice versa</td>
<td><strong>End-to-end visibility</strong> helps consistent power plant generation</td>
</tr>
<tr>
<td><strong>1-4 hours</strong> needed by Operator to inform concerned stakeholders when forced outage occurs</td>
<td>System-generated alert notifications sent <strong>within minutes</strong> when thresholds are breached and outage occurs (April 18 and May 1)</td>
</tr>
<tr>
<td><strong>Operator-dependent and reactive</strong> issue resolution</td>
<td><strong>Faster issue identification and resolution</strong> with critical asset visibility (controlled shutdown last May 1)</td>
</tr>
<tr>
<td><strong>Hourly manual logging</strong> of operational data.</td>
<td>Reduced manual logging</td>
</tr>
</tbody>
</table>
Next Steps…

• Integration to CMMS
• PI Integrator for Business Analytics
• More Data
  • HART IP for Steam Field Devices
  • Geo Sciences
    • Weather Stations
    • Landslide / Soil Monitoring
• Safety Notifications
Energy Development Corporation

5Cs Digitalization Strategy

**CHALLENGE**

Data was in Silos and not delivered Real Time to Users for accurate decision making.

- Power Plant and Steam field Data are not correlated
- Root Cause Analysis takes some time

**SOLUTION**

Real Time Data Visibility has immediate impact as different groups now work together more seamlessly.

- PI System as Single Source of Data
- **Connect** and **Collect** all – Manual, Digital, LIMS, Historical, Sciences Data
- **Communicate** – Visualize and Notify
- **Compute and Correlate** – automate calculations, continuous improvement

**RESULTS**

Ability to have a more accurate forecast on Well Head Pressure that translate into faster resolution and availability of Steam to the Turbine

- Est. 75% increase in time to revive a Well for immediate operation
- Faster Root Cause analysis
- With Real time notifications and Early Warning System, they can detect and prepare for the Well reviving operation as a team.
Contact Persons:

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- CEO
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Questions?

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