Digital Energy Management and the Use of Artificial Intelligence

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Insatiable Global Energy Demands - Bane or Boon?

- In 2030, the world is expected to be consuming >50 percent more energy than today
- “Business as usual” will not meet world energy, environmental and economic needs
How can AI facilitate Clean Energy Development?

- AI technologies develop *smart* entities that will produce more accurate predictions for complicated problems.
- AI in Renewable Energy Management is a game changer.
- AI can *mitigate* the *unpredictability* of renewable energy sources.
- AI-based renewable *energy production forecasting systems* are steadily being perfected, facilitating their integration in power grids.
- AI for *Energy Forecasting* to manage unreliability.
Electricity Management Solutions

- Load balancing on LT
- Automated Meter Data Collection
- Enhanced Equipment Life

- Meter-less Architecture
- Theft Detection Solution
- Secure & Affordable Set-up

Transfocure

Electrocure
OptimaLoad: Automatic Load Balancing System

- 1 mile of (LT) ANT Conductor = 0.864 ohms Resistance
- Current = 50A
- LOSS = I^2r = (50)^2 \cdot 0.84 = 2160 W = 2.16 KW
- Per Year = 2.16 \cdot 24 \cdot 365 = 18921.6 KWh
  = \sim 1,300 USD

- If the current is twice = 100A
- The loss would be 4 times = 5,200 USD
## Results from Implemented Projects

<table>
<thead>
<tr>
<th>S.No.</th>
<th>Transformer Type</th>
<th>Un-Balanced Load Condition (Peak Current)</th>
<th>Balanced Load Condition (Peak Current)</th>
<th>%Age Reduction in ( I_N )</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Neutral Loss (KWh-Units)</td>
<td>Neutral Loss (KWh-Units)</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>100 KVA</td>
<td>8.48</td>
<td>0.13</td>
<td>87.51</td>
</tr>
<tr>
<td>2</td>
<td>100KVA</td>
<td>3.70</td>
<td>0.15</td>
<td>80.10</td>
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<tr>
<td>3</td>
<td>100KVA</td>
<td>1.81</td>
<td>0.17</td>
<td>69.48</td>
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<tr>
<td>4</td>
<td>200 KVA</td>
<td>7.34</td>
<td>0.10</td>
<td>88.33</td>
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<tr>
<td>5</td>
<td>200KVA</td>
<td>3.27</td>
<td>0.08</td>
<td>84.79</td>
</tr>
<tr>
<td>6</td>
<td>200KVA</td>
<td>2.41</td>
<td>0.05</td>
<td>85.34</td>
</tr>
</tbody>
</table>

**Total Lost Units in Neutral per Hour**: 27.02

**Total Lost Units in Neutral per Month**: 19440

**Total Lost Units in Neutral Per Hour**: 0.67

**Total Lost Units in Neutral Per Month**: 486.18

**%Age Reduction in \( I_N \)**: 97.5

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<th>Balanced Load Condition (Peak Current)</th>
<th>%Age Reduction in ( I_N )</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Phase 1 Loss (KWh-Units)</td>
<td>Phase 2 Loss (KWh-Units)</td>
<td>Phase 3 Loss (KWh-Units)</td>
</tr>
<tr>
<td>1</td>
<td>100 KVA</td>
<td>1.479</td>
<td>1.333</td>
<td>0.002</td>
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<tr>
<td>2</td>
<td>100KVA</td>
<td>1.146</td>
<td>4.490</td>
<td>0.014</td>
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<tr>
<td>3</td>
<td>100KVA</td>
<td>0.148</td>
<td>0.941</td>
<td>1.497</td>
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<tr>
<td>4</td>
<td>200 KVA</td>
<td>23.128</td>
<td>8.217</td>
<td>16.866</td>
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<tr>
<td>5</td>
<td>200KVA</td>
<td>30.266</td>
<td>2.188</td>
<td>5.516</td>
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<tr>
<td>6</td>
<td>200KVA</td>
<td>8.387</td>
<td>15.416</td>
<td>29.932</td>
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</tbody>
</table>

**Total Lost Units in Neutral per Hour**: 40.866

**Total Lost Units in Neutral Per Hour**: 3.966

**Total Lost Units in Neutral per Month**: 29423.5

**Total Lost Units in Neutral Per Month**: 2855.5

**%Age Reduction in \( I_N \)**: 90%

### Particulars

<p>| Units lost on 250 Transformers during Month-1 | 43,665.77 |
| Units lost on 250 Transformers during Month-2 | 49,157.18 |
| Units lost on 250 Transformers during Month-3 | 47,167.29 |
| Quarterly units lost | 1,399,902 |
| Yearly units lost | 5,599,961 |
| Yearly Revenue lost (PKR) | 83,99,414 |
| Units recoverable via 250 TransfoCures per month | 46,663.41 |</p>
<table>
<thead>
<tr>
<th>S/No.</th>
<th>Transformer #</th>
<th>Units lost in 10 days</th>
<th>Per month units lost</th>
<th>Quarterly units (KWh) lost</th>
<th>Amount lost (PKR)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>TR 05</td>
<td>455</td>
<td>1365</td>
<td>5460</td>
<td>81900</td>
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<td>TR 139</td>
<td>3167</td>
<td>9501</td>
<td>38004</td>
<td>570060</td>
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<td>3</td>
<td>TR 31</td>
<td>512</td>
<td>1536</td>
<td>6144</td>
<td>92160</td>
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<tr>
<td>4</td>
<td>TR 160</td>
<td>7040</td>
<td>21120</td>
<td>84480</td>
<td>12,67,200</td>
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<tr>
<td>5</td>
<td>TR 16</td>
<td>3085</td>
<td>9255</td>
<td>37020</td>
<td>555300</td>
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<td>TR 89</td>
<td>2</td>
<td>6</td>
<td>24</td>
<td>360</td>
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<td>7</td>
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<td>1098</td>
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<td>8</td>
<td>TR 83</td>
<td>3010</td>
<td>9030</td>
<td>36120</td>
<td>541800</td>
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<tr>
<td>9</td>
<td>TR 145</td>
<td>10</td>
<td>30</td>
<td>120</td>
<td>1800</td>
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<td>10</td>
<td>TR 122</td>
<td>284</td>
<td>852</td>
<td>3408</td>
<td>51120</td>
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<tr>
<td></td>
<td><strong>Total</strong></td>
<td><strong>18,663</strong></td>
<td><strong>55,989</strong></td>
<td><strong>2,23,956</strong></td>
<td><strong>33,59,340</strong></td>
</tr>
</tbody>
</table>
METERO-CURE

Simple Solutions To Complex Problems

House with Meter

Meter Reader Taking Meter Picture

6/19/23
Real-Time Municipal Energy Management with GIZ Pakistan
Demonstrate the advantage of **digitization and governance** tools in energy management.

Demonstrate the **improvement in quality of the utility service** through digitization.

Demonstrate the advantage of **real time energy audit in short, medium, and long-term** energy management planning.

Demonstrate the role of digitization in **local government planning**, operations, and monitoring & evaluation.

Demonstrate the advantage of Digitization and real-time monitoring in **Asset managements** of Municipalities.

Demonstrate the **reduction in Maintenance cost** through real-time Monitoring and autonomous management of tube well pumping stations.
Demonstrate the advantage of new technologies such as VFDs in auto energy management and energy consumption reduction and its feasibility in terms of ROI.

Demonstrate the efficiency in fuel consumption through real-time monitoring and rout profiling of Water supply and waste collection trucks using GPS.

Demonstrate the impact of digitization and real-time monitoring & control on energy efficiency of Streetlights.

Demonstrate the impact of introducing technological governance tools on the policy making implementation and revisiting.
Voltage Unbalance in pumping motors

- Three-phase distribution systems often serve single-phase loads. An imbalance in impedance or load distribution can contribute to imbalance across all three of the phases.
- Potential faults may be in the cabling to the motor, the terminations at the motor, and potentially the windings themselves.
- This imbalance can lead to stresses in each of the phase circuits in a three-phase power system. At the simplest level, all three phases of voltage should always have the same magnitude.

Impact: Imbalance creates excessive current flow in one or more phases that then increases operating temperatures—leading to insulation breakdown

- NEMA standard MG-1, states that polyphase motors shall operate successfully under running conditions at rated load when the voltage unbalance at the motor terminals does not exceed 1%.

Mitigation strategy: The mitigation strategies for unbalance voltage in pumping motors are; balanced supply of voltage from distribution side and installation of voltage regulators.
Voltage unbalance and winding issues are two common causes for current unbalance in pumping motors. Current variation in pumping motors led to motor inefficiency and reduced their lifespan.

When there is a voltage unbalance, the variation in phase currents exceeds the normal range of 5-7%. This imbalance leads to increased copper losses, resulting in reduced motor efficiency.

Furthermore, the prolonged exposure to unbalanced voltages can significantly decrease the motor’s lifespan. As evident from the graph, Current unbalance must be minimized below 5% to enhance energy efficiency in Motor ID “2,3,6”. Voltage was balanced in this case, so the current variation is due to winding problem.

Mitigation Strategy: Possible solution to mitigate current variation is to consider rewinding of motor, which involves replacing the faulty winding with a new one. Alternatively, if the motor is severely affected, it may be necessary to replace it entirely with a new motor that can handle the required load and operates efficiently. By taking appropriate action to rectify voltage unbalance and winding issues, motor efficiency can be improved, ensuring optimal performance and extending its lifespan.

Data was recorded from WaterScada devices installed at 6 tube wells at CDA Islamabad (22-28 March 2023)
AI

Learning

Optimization

Control

BEMS
Three level energy saving for equipment, facility and the whole building management

HVAC
Predict future conditions and adjust equipment output in advance

LS
Personnel interactive lighting control

ICT
Self-configuration, optimization & healing to optimize the service

RES + Power grid
Forecast the future weather to keep stable output with the largest amount of renewable energy

Industry
Trial & error for high energy efficiency
Universal workflow of artificial intelligence for energy saving (Energy Reports-2022)
Da-sheng Lee a,∗, Yan-Tang Chen a, Shih-Lung Chao b
This study analyzed 164 academic papers, with a total of 113 AI methods applied in six different fields of application
Funded by: Ministry of Science and Technology, Taiwan

Workable method to assist the use of AI in 6 fields
- 35% Building energy cost saving
- 25% HVAC energy saving
- 50% artificial lighting energy saving
- Up to 70% communication power saving
- Grid energy supplied with the largest renewable energy up to 30% peak power
- 30% factory peak power reduction

Energy Efficiency on Individual PC/Cell-Phone, Network and Cloud Utilization AI based Prediction System

Proposed Method: CGPRNN - Cartesian Genetic Programming Evolved RNN
Why? and Why Not?
Developing an energy management policy

- Oversee the development and implementation of the Municipal Energy Management Policy
- Oversee the development, implementation and review of the Municipal Energy Management Action Plan (MEMAP), which need to incorporate budgets/resources, timelines and responsibilities
- Review the action plan at the end of each year based on the results generated through the monitoring system and amend the plan based on the experiences of the previous year
- Develop a clear methodology and system for Monitoring and Verification

Establishing appropriate organisational structures

- Oversee appropriate allocation of energy management within the municipal organisational structure
- Ensure relevant representatives from line departments participate in the committee meeting and engagements
What are Other Dimensions?

Ensuring appropriate skills and knowledge

• Oversee energy management and energy awareness capacity building within the municipality

Establishing energy information systems

Marketing and communicating energy-related information

Investing in energy conservation

• Facilitate the establishment of an energy intervention finance competency within the municipality

Implementing energy conservation interventions

• Oversee the audit of the effectiveness of the various energy interventions carried out by the municipal units
• Outline corrective or preventive actions based on the audit of the energy interventions carried out by the municipal units
Energy-efficiency potentials are not being realised, even when they are economically cost-effective. Numerous barriers impede their adoption and rapid market diffusion.

- Lack of information on energy efficiency among consumers and the financial sector, leading to cost-effective energy-efficiency measures opportunities being missed.
- Limited know how of policy makers.
- Lack of technical capacity to develop and implement energy efficiency projects.
- Organizational and institutional gaps and overlaps.
- Limited access to capital may prevent energy-efficiency measures from being implemented.
- Inertia: individuals who are opponents to change within an organisation may result in overlooking energy-efficiency measures that are cost-effective.

**Policy interventions are required to overcome such barriers.**