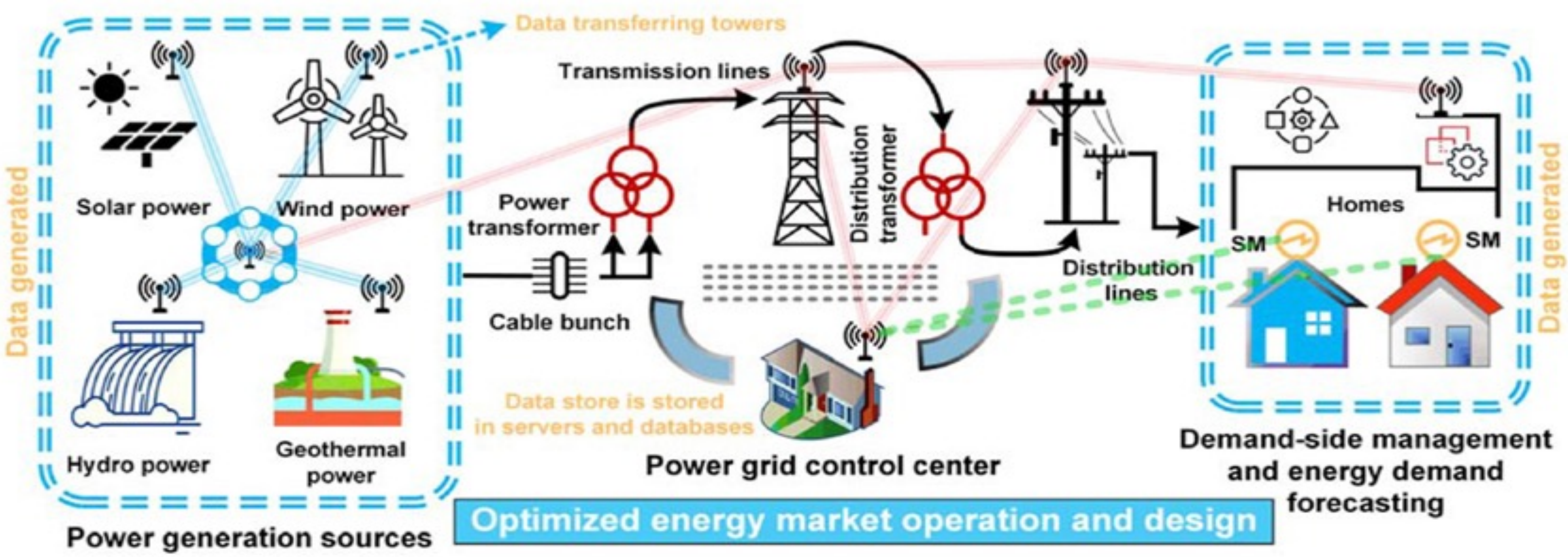
Digital Energy Management and the Use of Artificial Intelligence

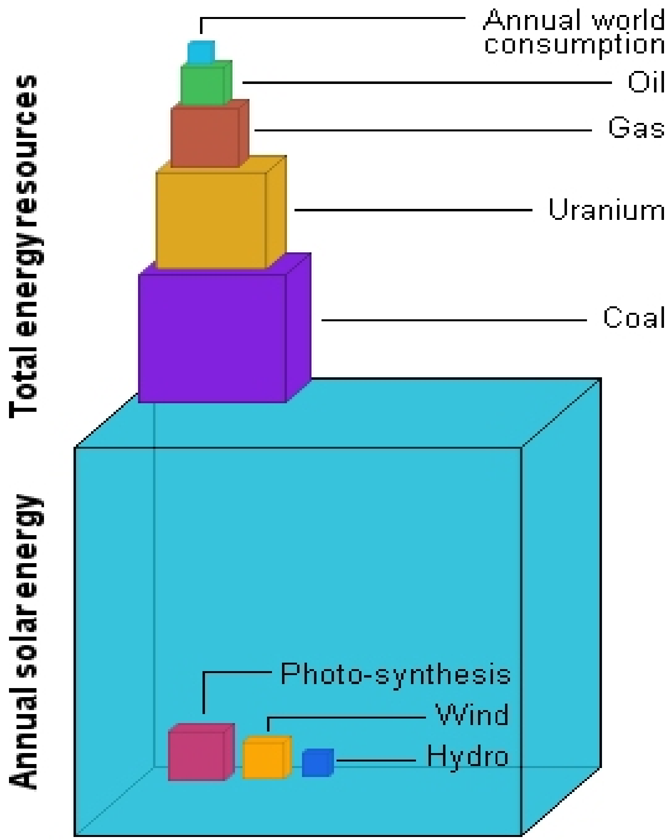


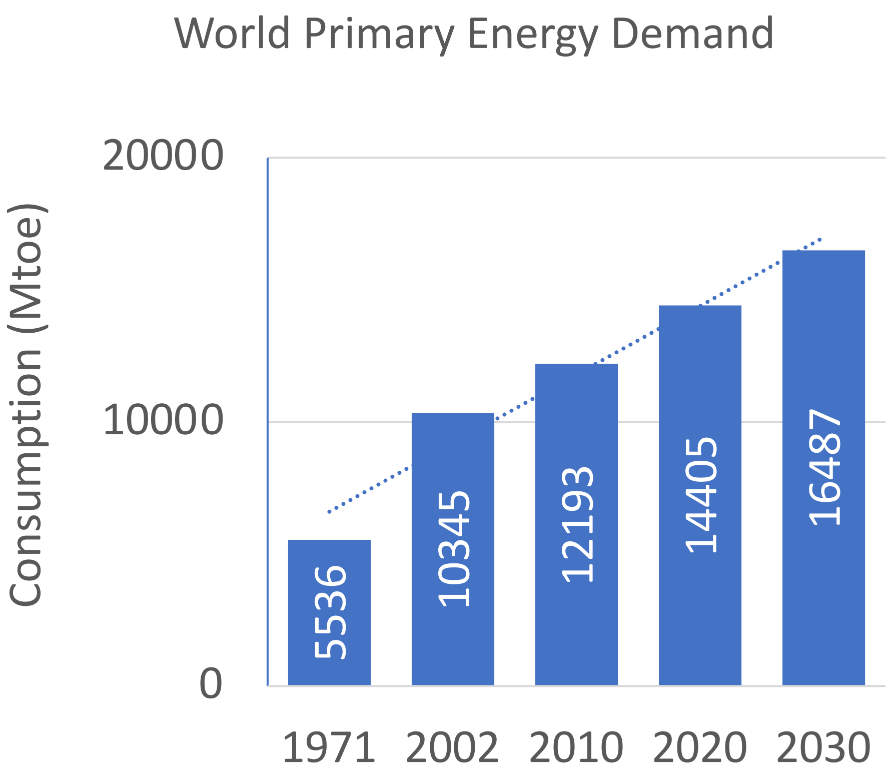
Prof. Dr. Gul Muhammad khan, Director

Center of Intelligent Systems and Network Research (CISNR) & National Centre of AI, Intelligent Systems Design, UET Peshawar.

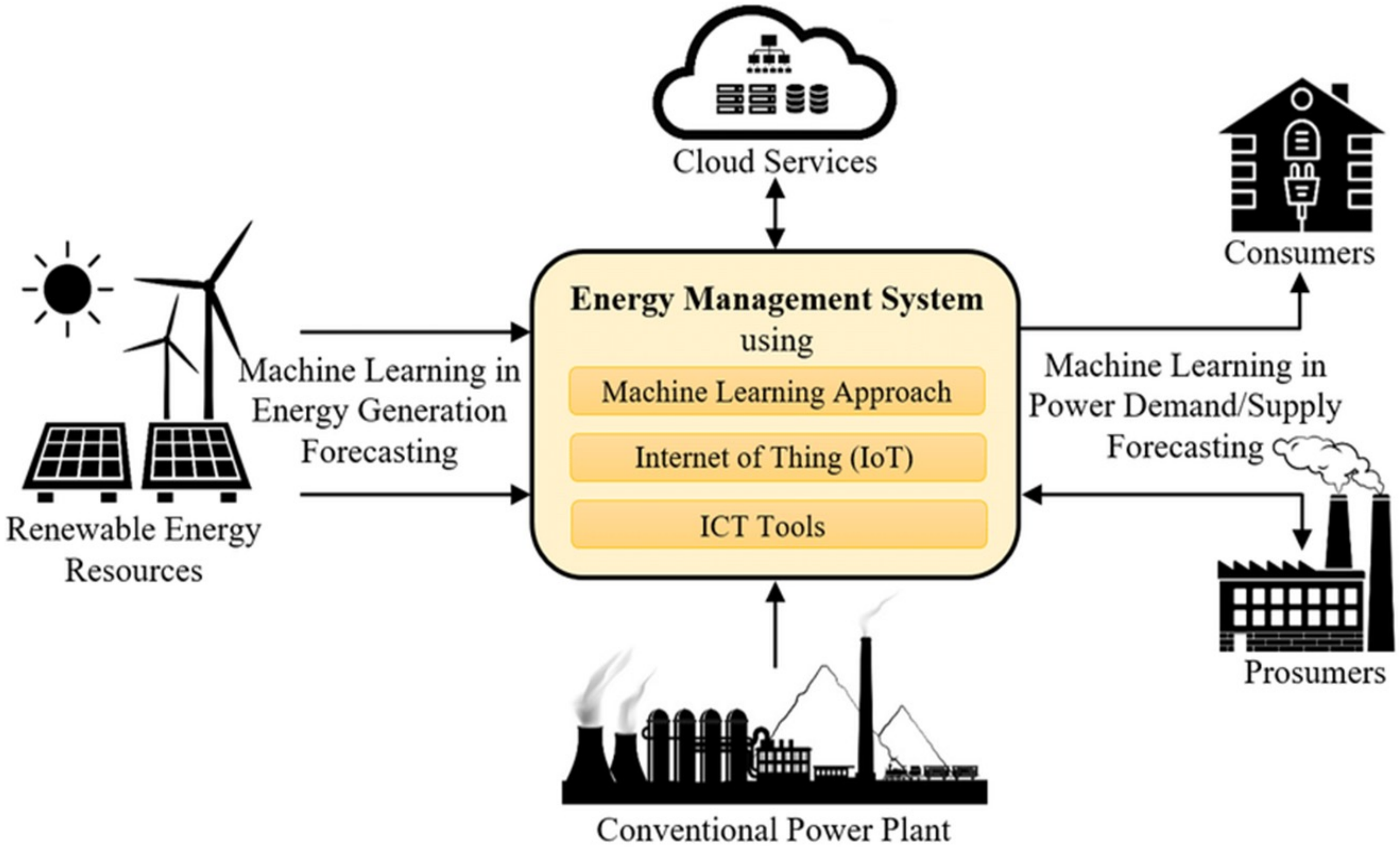
Insatiable Global Energy Demands - Bane or Boon?

- 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**

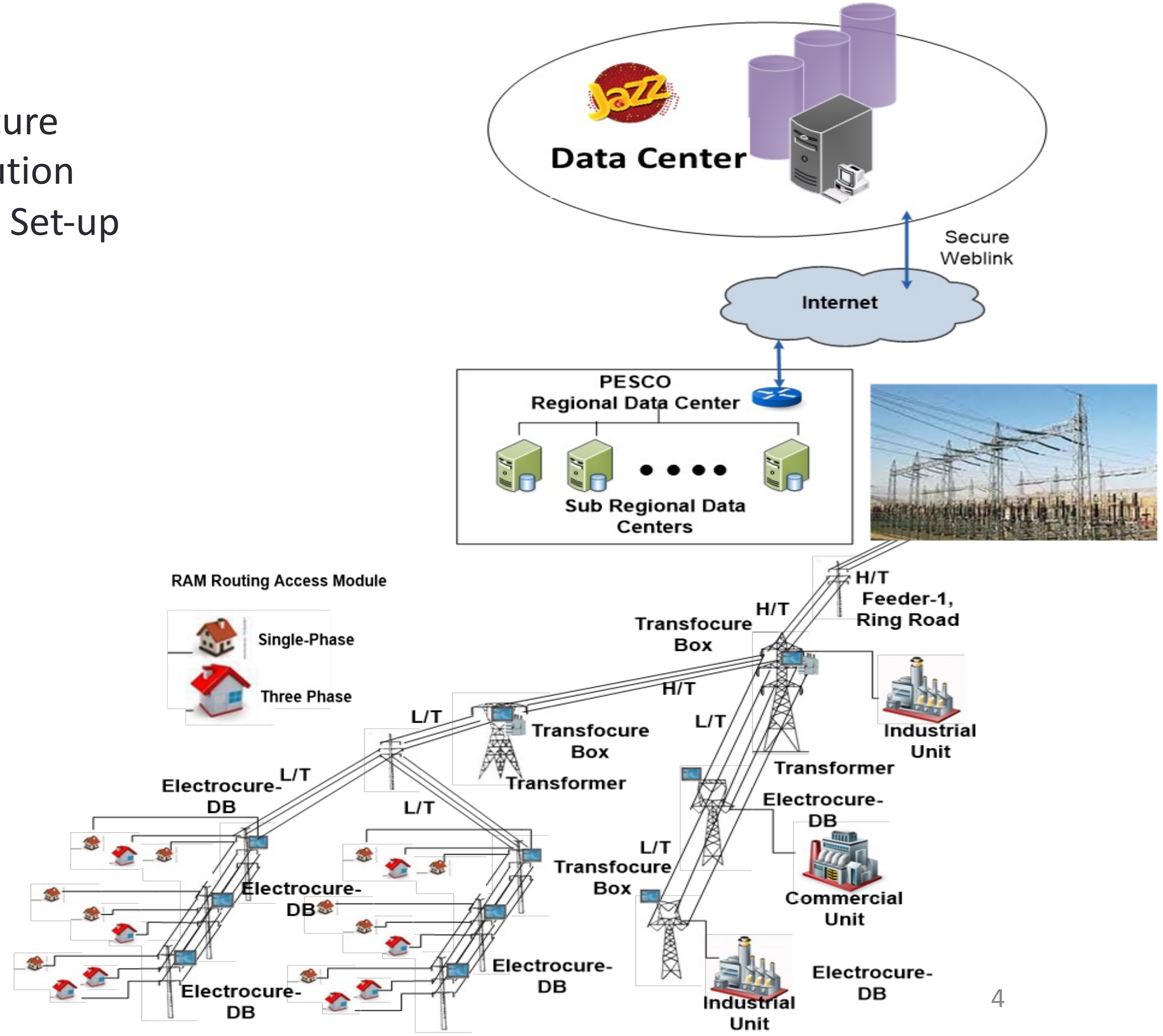
Electricity Management Solutions

Transfocure

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

Electrocure

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



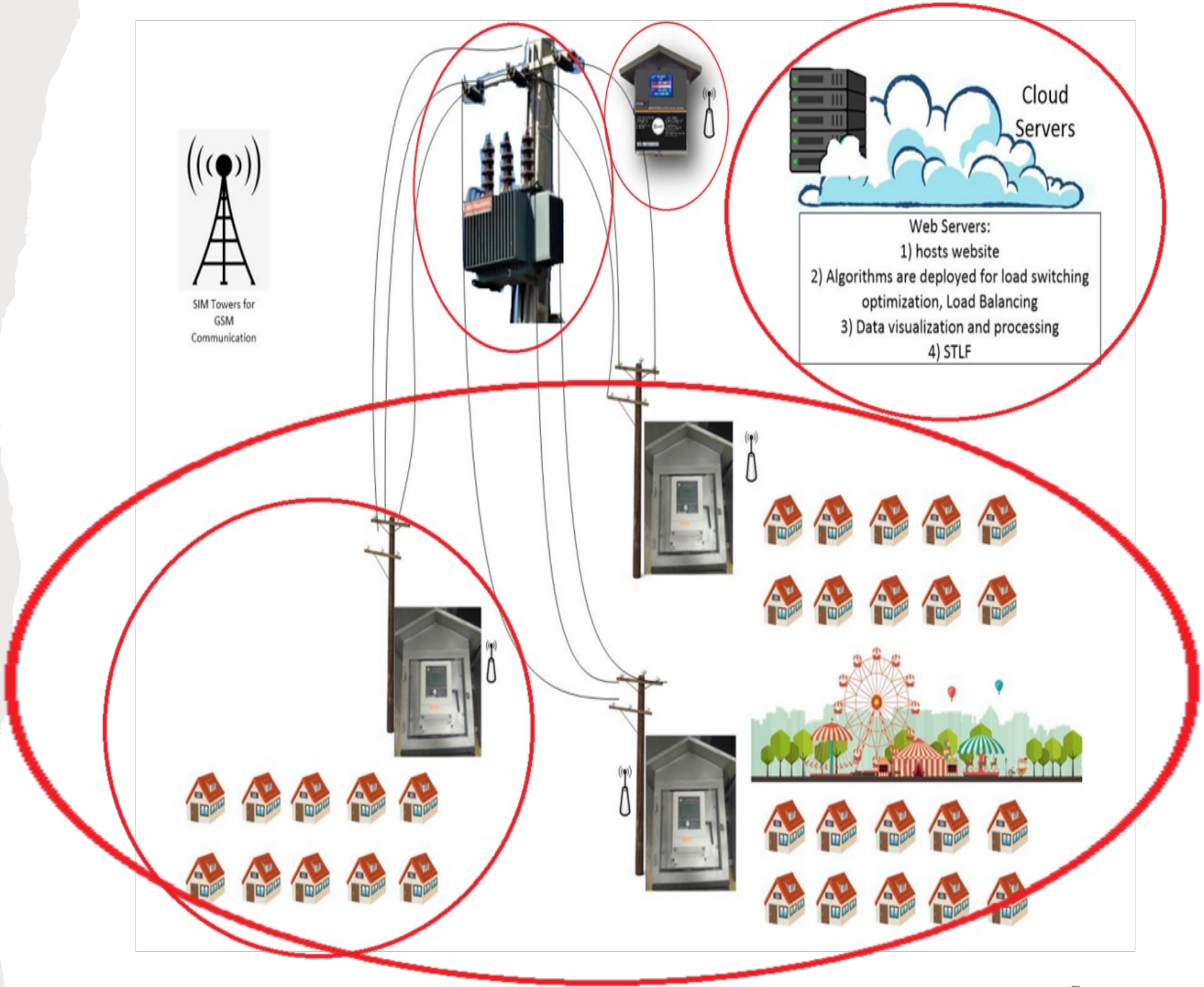
OptimaLoad: Automatic Load Balancing System

- **1 mile of (LT) ANT Conductor = 0.864 ohms Resistance**
- **Current = 50A**
- **LOSS = $I^2r = (50)^2 * 0.84 = 2160$ W =**

  2.16 KW
- **Per Year = 2.16 * 24 * 365 = 18921.6 KWh**

  = ~ 1,300 USD

- **If the current is twice = 100A**
- **The loss would be 4 times = 5,200 USD**



Results from Implemented Projects

S.No.	Transformer Type	Un-Balanced Load Condition (Peak Current)	Balanced Load Condition(Peak Current)	%Age Reduction in I_N
		Neutral Loss (KWh-Units)	Neutral Loss (KWh-Units)	
1	100 KVA	8.48	0.13	87.51
2	100KVA	3.70	0.15	80.10
3	100KVA	1.81	0.17	69.48
4	200 KVA	7.34	0.10	88.33
5	200KVA	3.27	0.08	84.79
6	200KVA	2.41	0.05	85.34
Total Lost Units in Neutral per Hour		27.02	Total Lost Units in Neutral Per Hour 0.67	97.5
Total Lost Units in Neutral per Month		19440	Total Lost Units in Neutral per Month 486.18	97.5

S.No.	Transformer Type	Un-Balanced Load Condition (Peak Current)				Balanced Load Condition(Peak Current)				%Age Reduction in I_N
		Phase-1 Loss (KWh-Units)	Phase-2 Loss (KWh-Units)	Phase-3 Loss (KWh-Units)	Neutral Loss (KWh-Units)	Phase-1 Loss (KWh-Units)	Phase-2 Loss (KWh-Units)	Phase-3 Loss (KWh-Units)	Neutral Loss (KWh-Units)	
1	100 KVA	1.479	1.333	0.002	1.289	0.575	0.525	1.021	0.062	78.00
2	100KVA	1.146	4.490	0.014	3.980	1.513	1.248	1.050	0.020	92.87
3	100KVA	0.148	0.941	1.497	0.889	0.785	0.726	1.224	0.013	88.10
4	200 KVA	23.128	8.217	16.866	5.278	21.677	10.227	19.05	0.883	59.09
5	200KVA	30.266	2.188	5.516	18.179	14.482	6.225	8.894	0.738	84.79
6	200KVA	8.387	15.416	29.932	11.251	15.011	26.115	11.84	2.250	55.28
		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**	**90%**

Particulars	Values
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	1,39,990.2
Yearly units lost	5,59,961
Yearly Revenue lost (PKR)	83,99,414
Units recoverable via 250 TransfoCures per month	**46,663.41**

Electrocure – Administrative(Theft) Losses (10 Transformers) Recovery

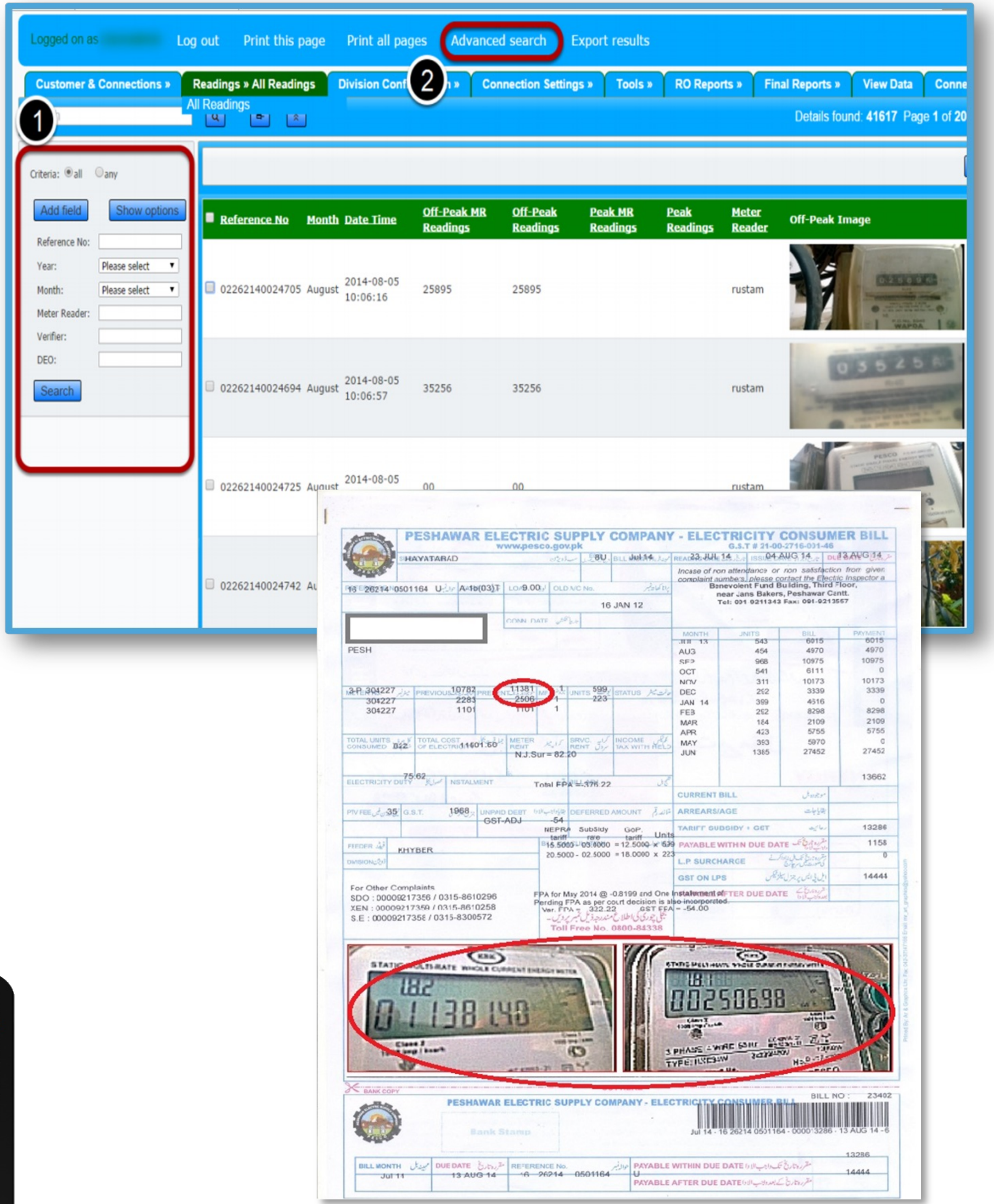
S/No.	Transformer #	Units lost in 10 days	Per month units lost	Quarterly units (KWh) lost	Amount lost (PKR)
1	TR 05	455	1365	5460	81900
2	TR 139	3167	9501	38004	570060
3	TR 31	512	1536	6144	92160
4	TR 160	7040	21120	84480	12,67,200
5	TR 16	3085	9255	37020	555300
6	TR 89	2	6	24	360
7	TR 136	1098	3294	13176	197640
8	TR 83	3010	9030	36120	541800
9	TR 145	10	30	120	1800
10	TR 122	284	852	3408	51120
Total		**18,663**	**55,989**	**2,23,956**	**33,59,340**

METERO-CURE

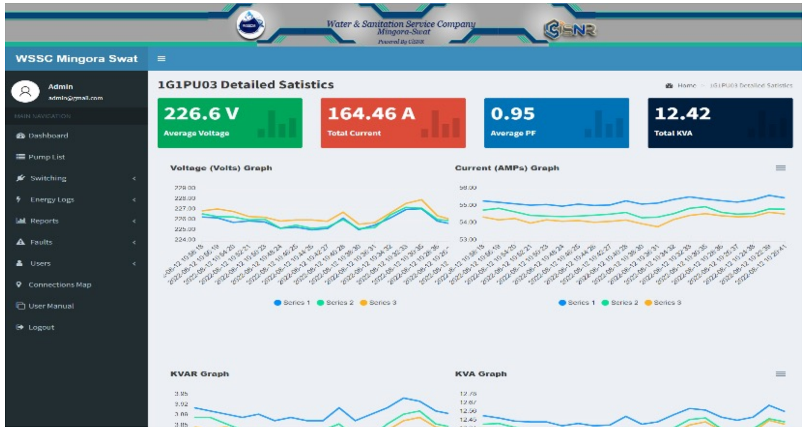
Simple Solutions To Complex Problems

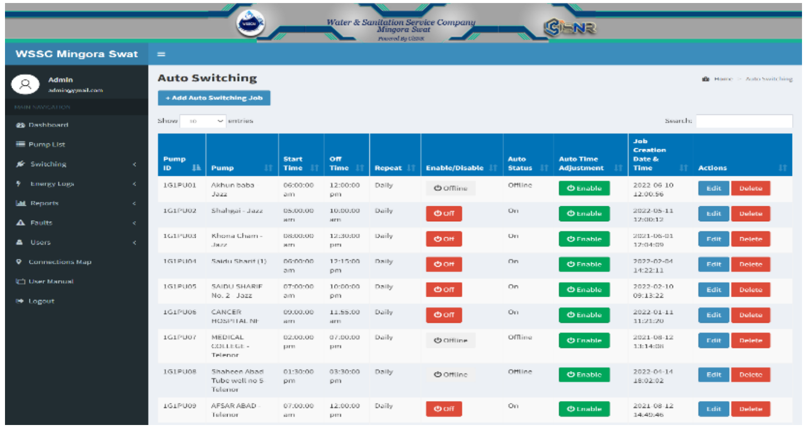
Meter Reader Taking Meter Picture

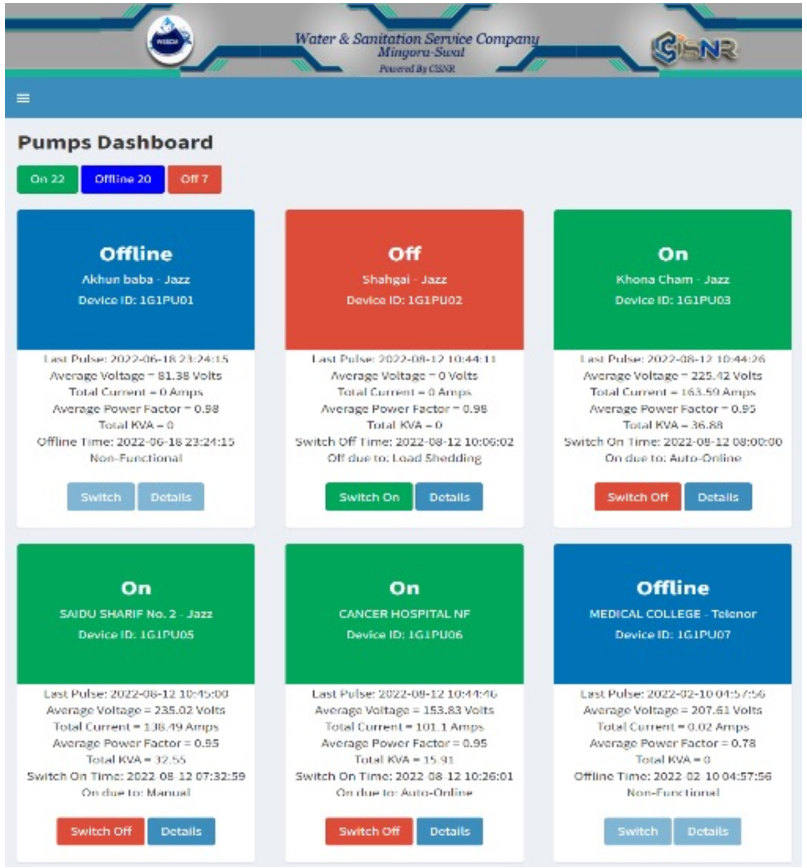
House with Meter

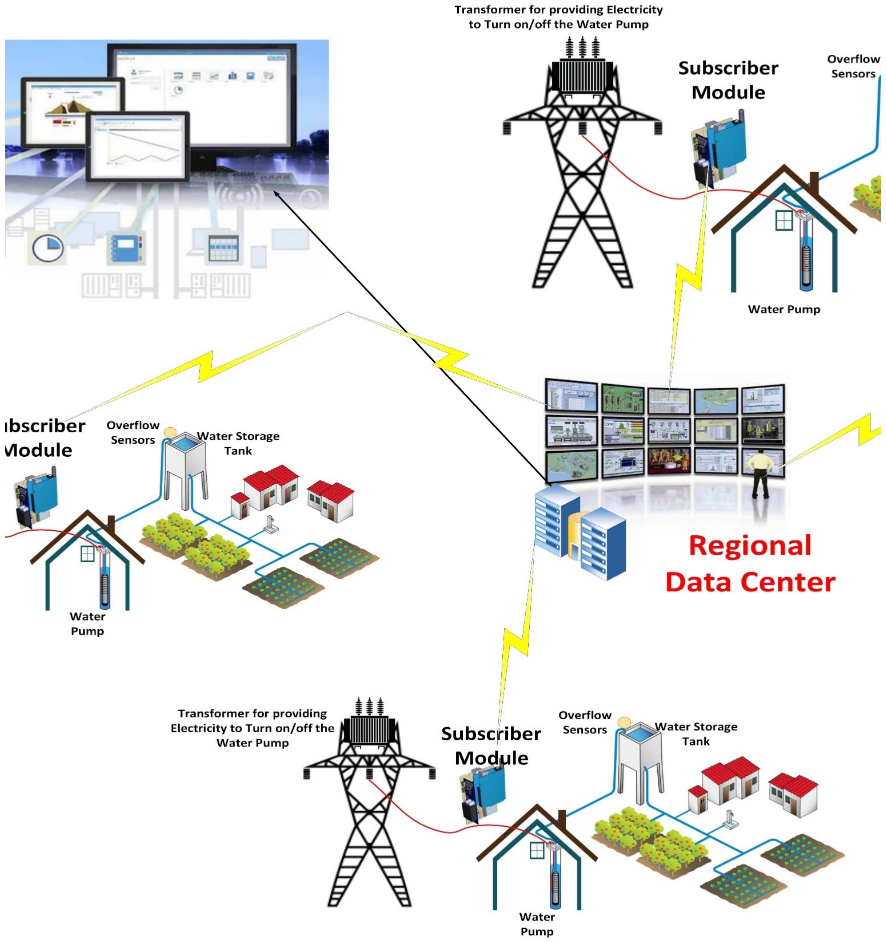


Real-Time Municipal Energy Management with GIZ Pakistan









Increasing Energy Efficiency through Digitization

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.

Increasing Energy Efficiency through Digitization

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.

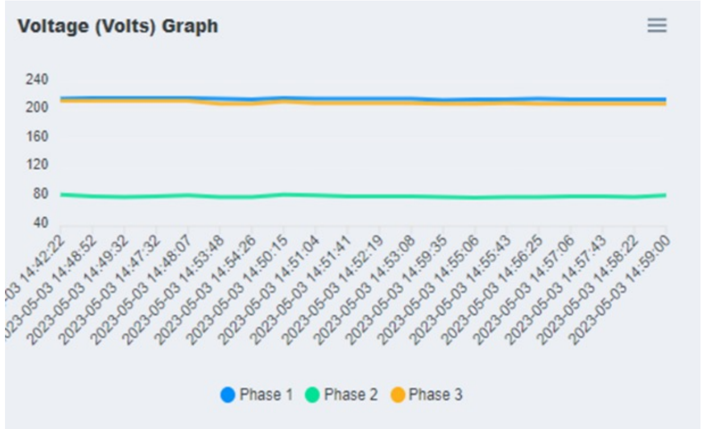
Impact: Imbalance creates excessive current flow in one or more phases that then increases operating temperatures–leading to insulation breakdown

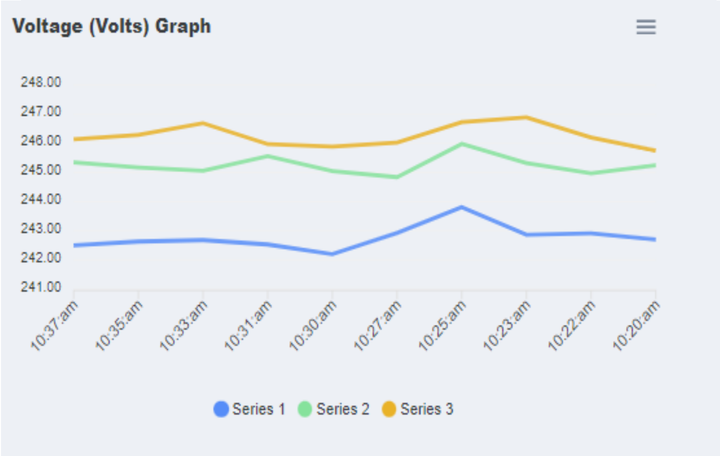
- NEMA standard MG-1, states that polyphase motors shall operate successfully under running conditions at rated load when the voltage unbalance at the motor terminals does not exceed **1%.**

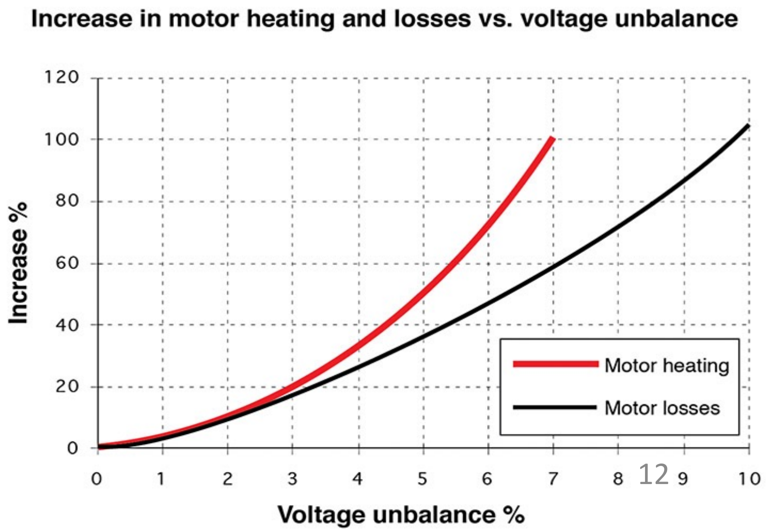
Characteristic	Performance		
Average voltage	230	230	230
Percent unbalanced voltage	0.3	2.3	5.4
Percent unbalanced current	2.4	17.7	40
Increased temperature rise (∞C)	<1	11	60

Figure 1: Effects of voltage unbalance on a 5 hp motor.

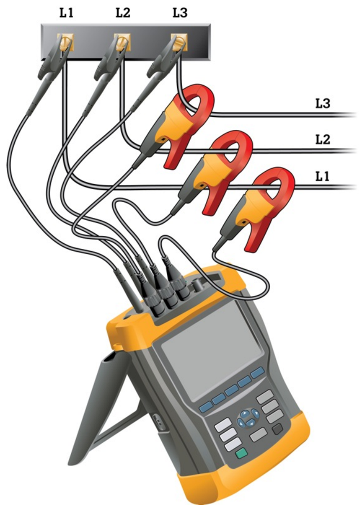
Mitigation strategy: The mitigation strategies for unbalance voltage in pumping motors are; balanced supply of voltage from distribution side and installation of voltage regulators.







Current Unbalance in pumping motors

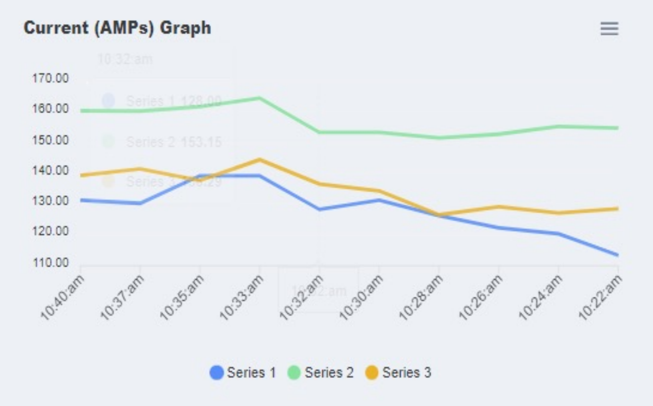


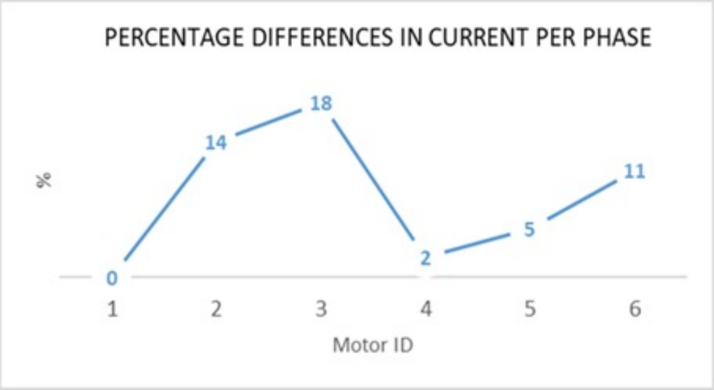
Voltage unbalance and winding issues are two common causes for current unbalance in pumping motors. Current variation in pumping motors led to motor inefficiency and reduced their lifespan.

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.

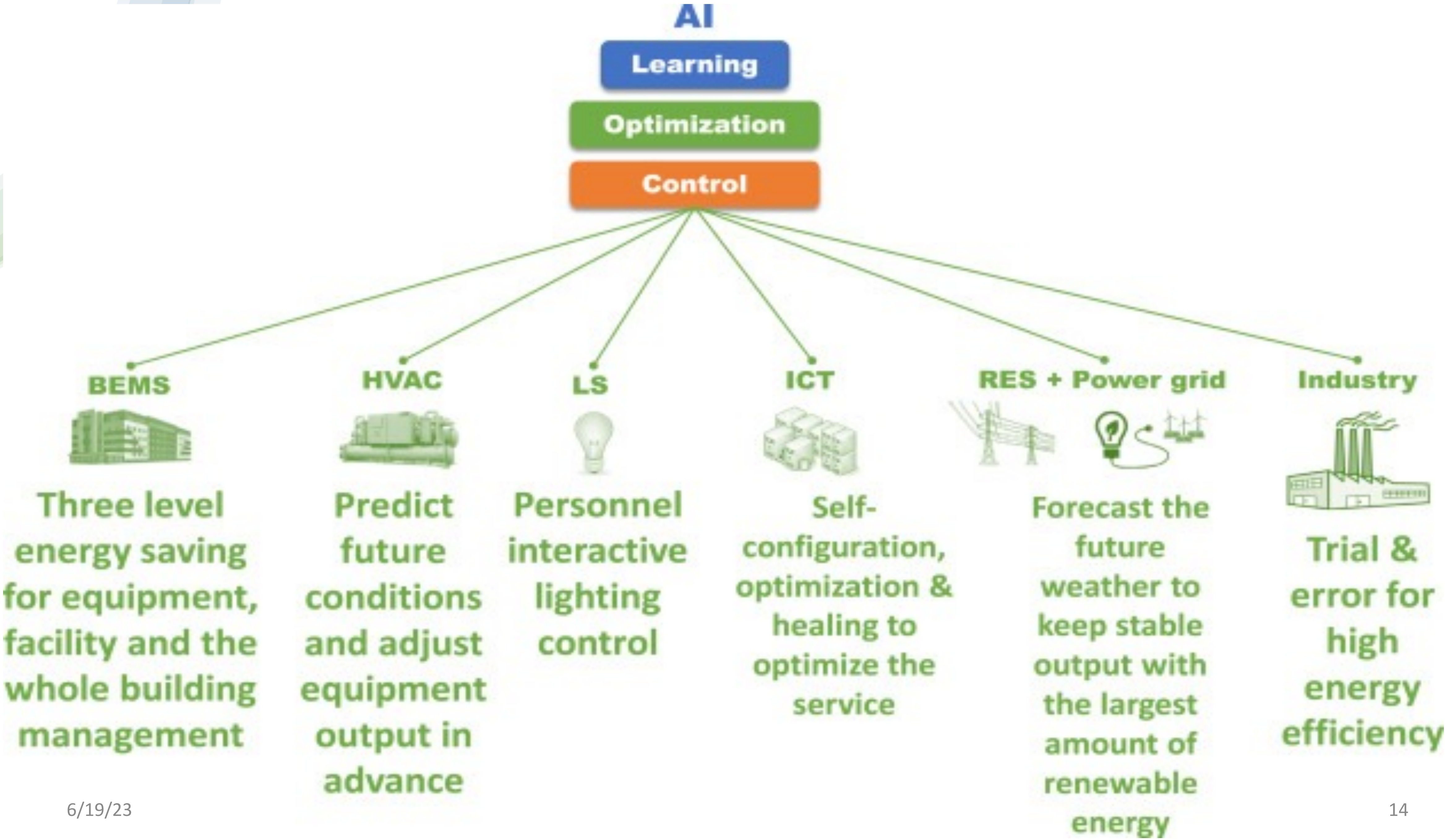
Furthermore, the prolonged exposure to unbalanced voltages can significantly decrease the motor's lifespan. As evident from the graph, Current unbalance must be minimized below 5% to enhance energy efficiency in Motor ID “2,3,6”. Voltage was balanced in this case, so the current variation is due to winding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

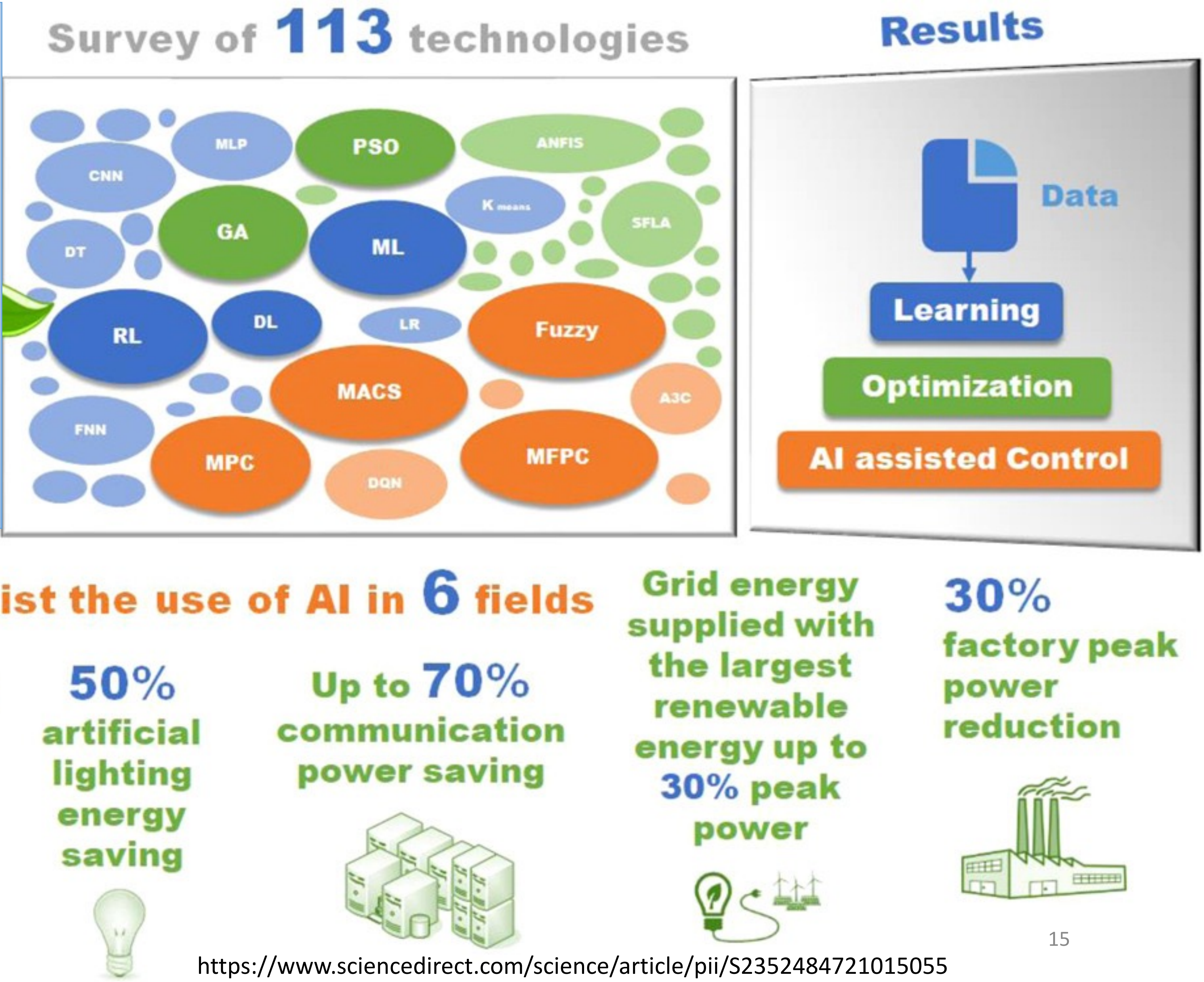

AI
Learning
Optimization
Control
BEMS
HVAC
LS
ICT
RES + Power grid
Industry
Three level energy saving for equipment, facility and the whole building management
Predict future conditions and adjust equipment output in advance
Personnel interactive lighting control
Self-configuration, optimization & healing to optimize the service
Forecast the future weather to keep stable output with the largest amount of renewable energy
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

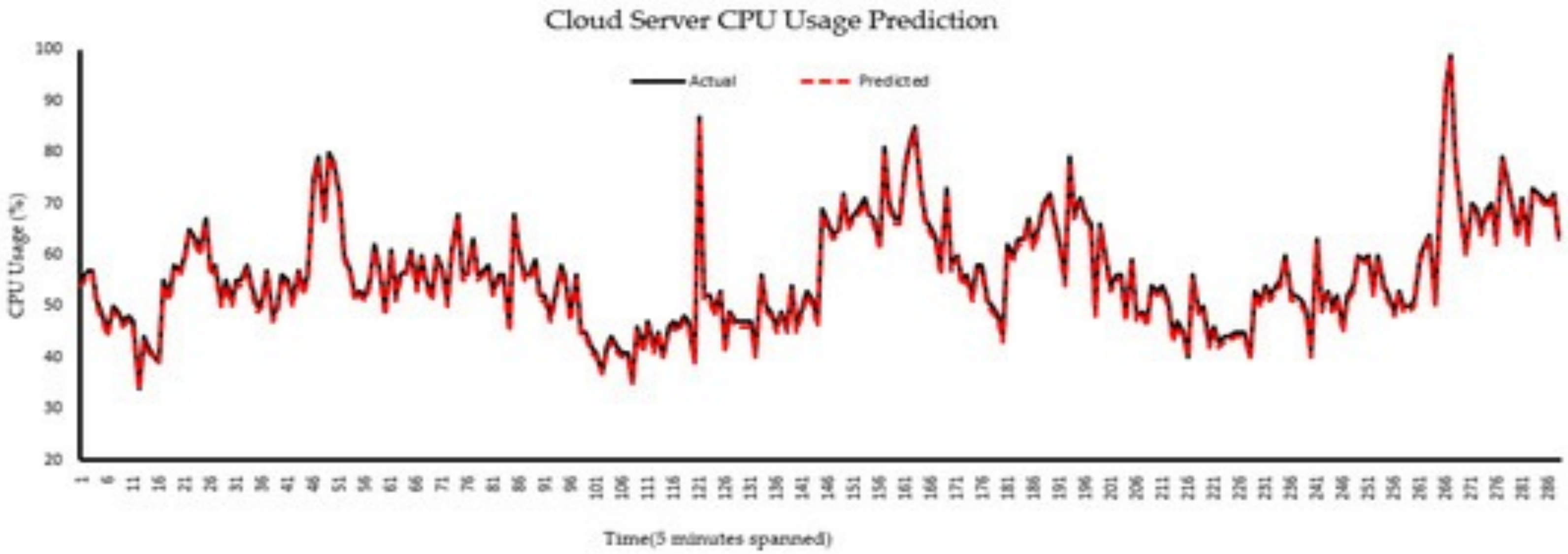
This study analyzed **164 academic papers**, with a total of **113 AI methods** applied in **six different fields** of application

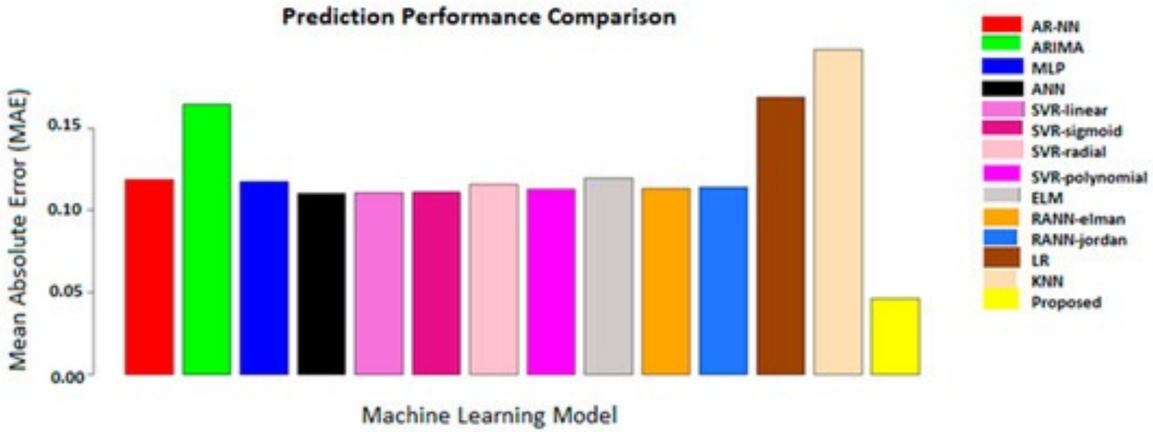
Funded by: **Ministry of Science and Technology, Taiwan**

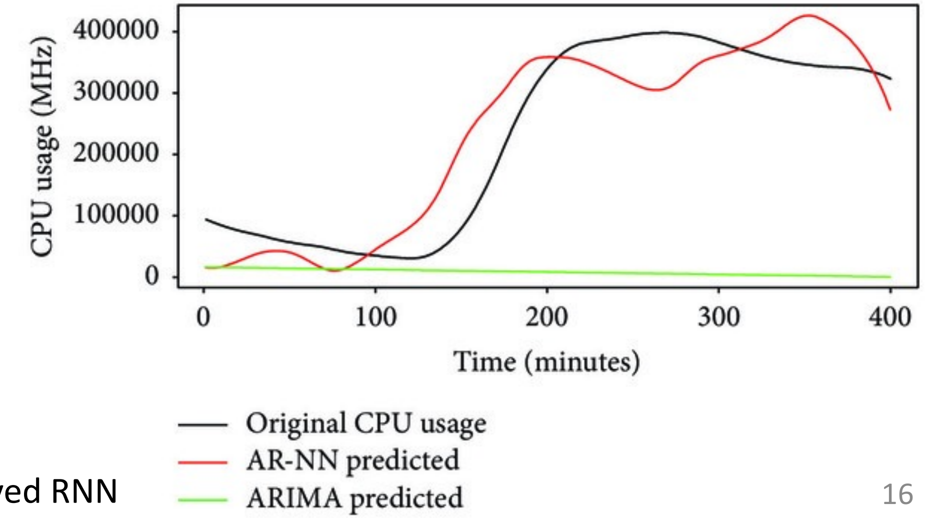


https://www.sciencedirect.com/science/article/pii/S2352484721015055

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

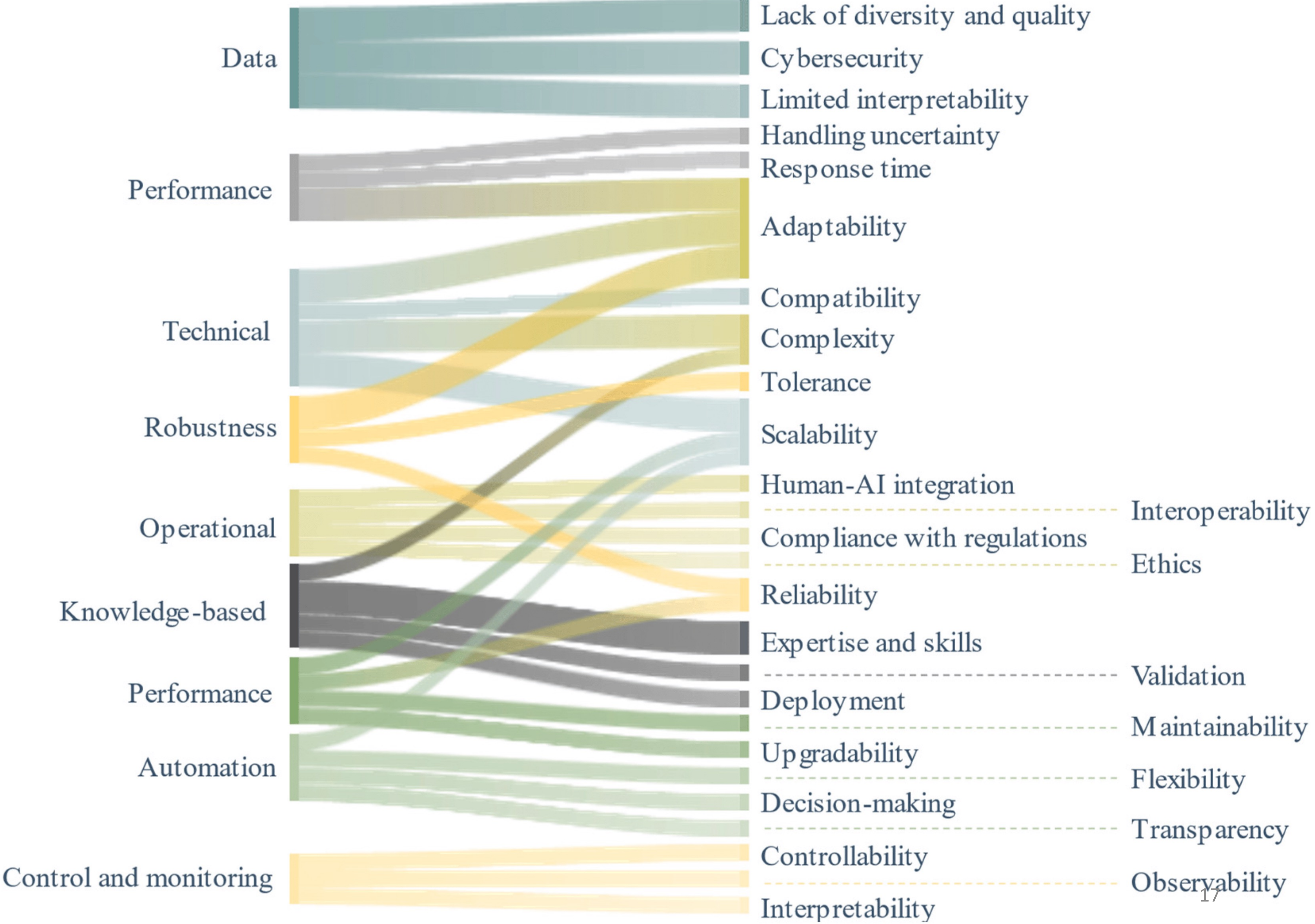






Proposed Method: CGPRNN- Cartesian Genetic Programming Evolved RNN

Why? and Why Not?



What are Other Dimensions?

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

What is Blocking the Application of and Investments in Energy Efficiency in the World?

- 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**