GEO SMART™

INDIA 2021

THEME

ADVANCING THE ROLE OF GEOSPATIAL KNOWLEDGE IN INDIAN ECONOMY

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HICC Hyderabad, India

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Geo smart Energy - Building a National Integrated Management System

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At Geosmart India 2019

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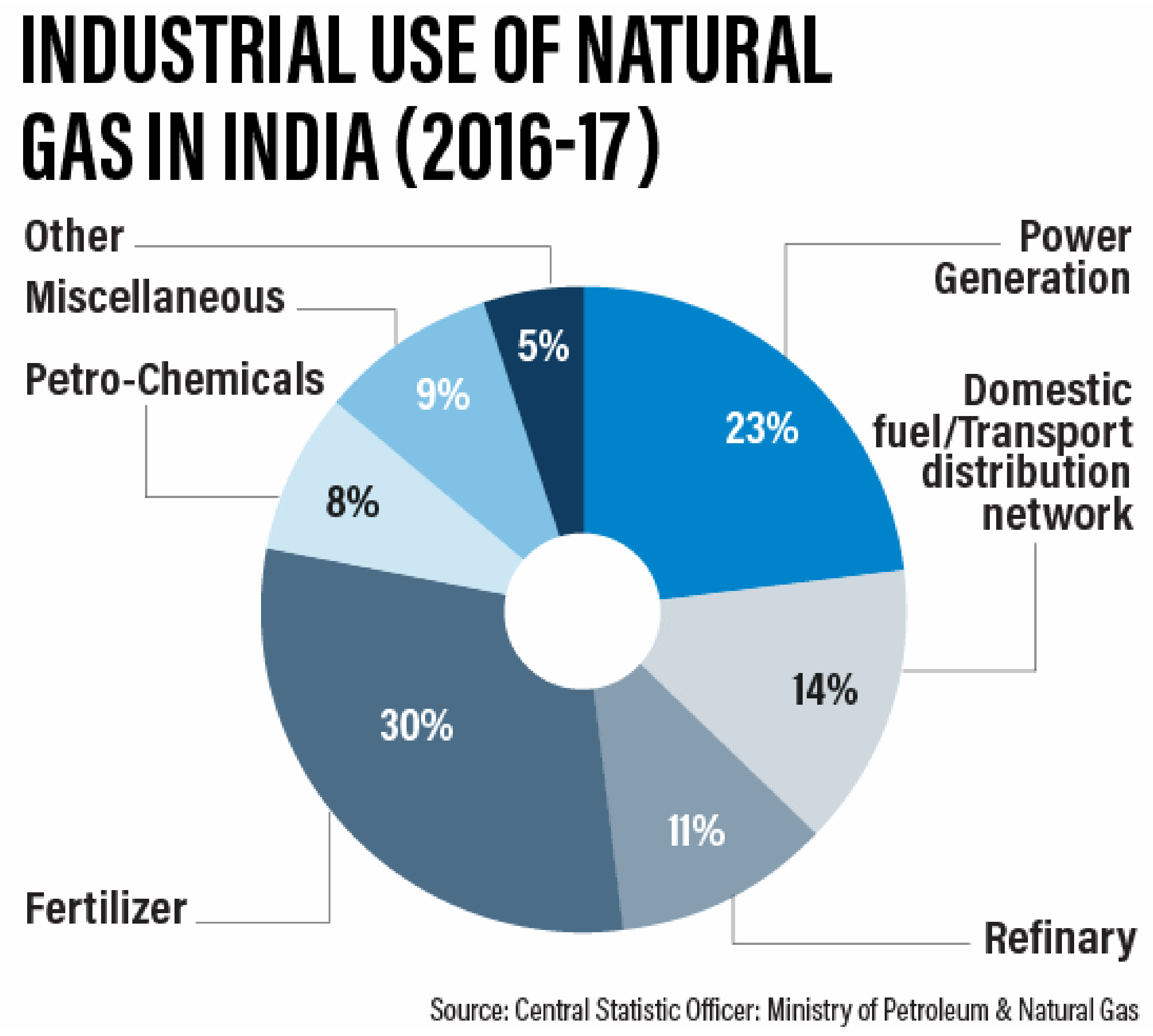
Energy Security

- Energy is the lifeline of any country. Therefore, energy security is the key to a nation's progress.
- India imports 82% of its crude oil requirements, 50% of its natural gas requirement, 85% of its coking coal requirement and 20% of its non-coking coal requirement (most of which is used for power generation).
- India is trying to reduce imports of petroleum products and coal, by switching to renewable energy and electric vehicles.

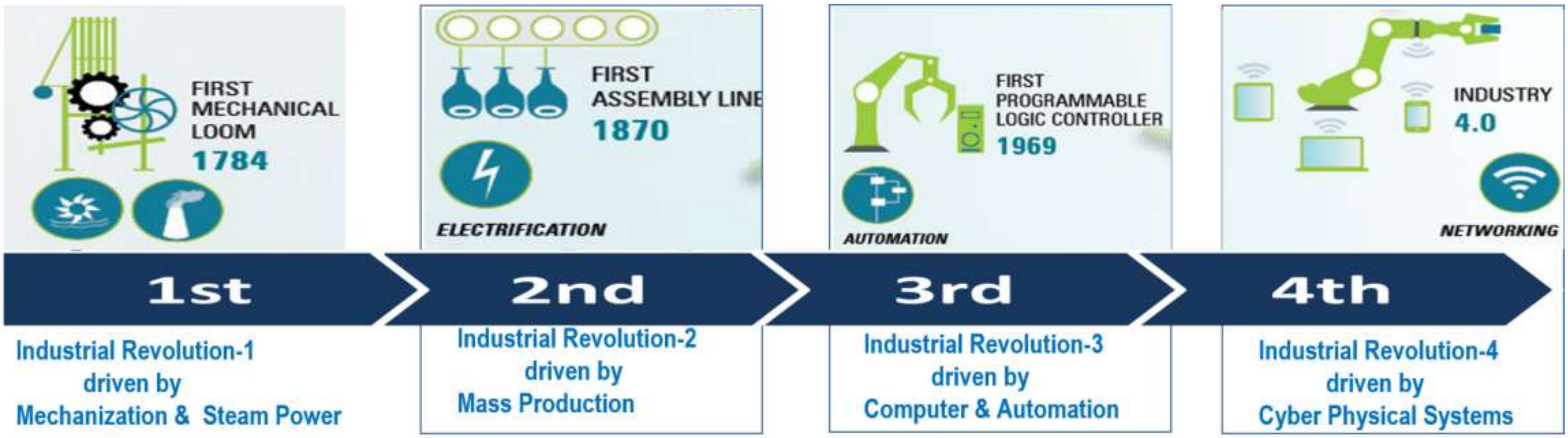
Natural Gas Utilization in India



Can we switch to renewable energy ?

- Yes, with use of technology, this can be achieved.
- Intermittency of renewable energy can be dealt with by use of demand response, energy storage technology, flexible generation, flexible transmission, flexible distribution, flexible markets and flexible tariff.
- This is achievable using **digital transformation** of the entire power sector.
- The costs of digitalization are not much and can be recovered in a period of a couple of years, through increase of efficiency and reliability.

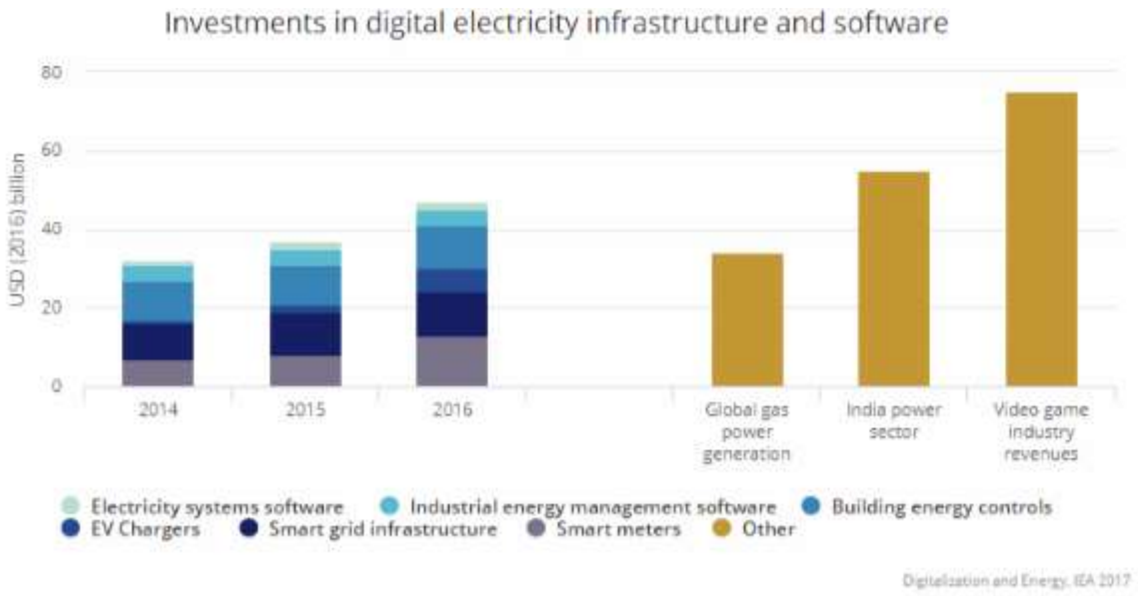
Evolution of Technology



Fourth Industrial Revolution

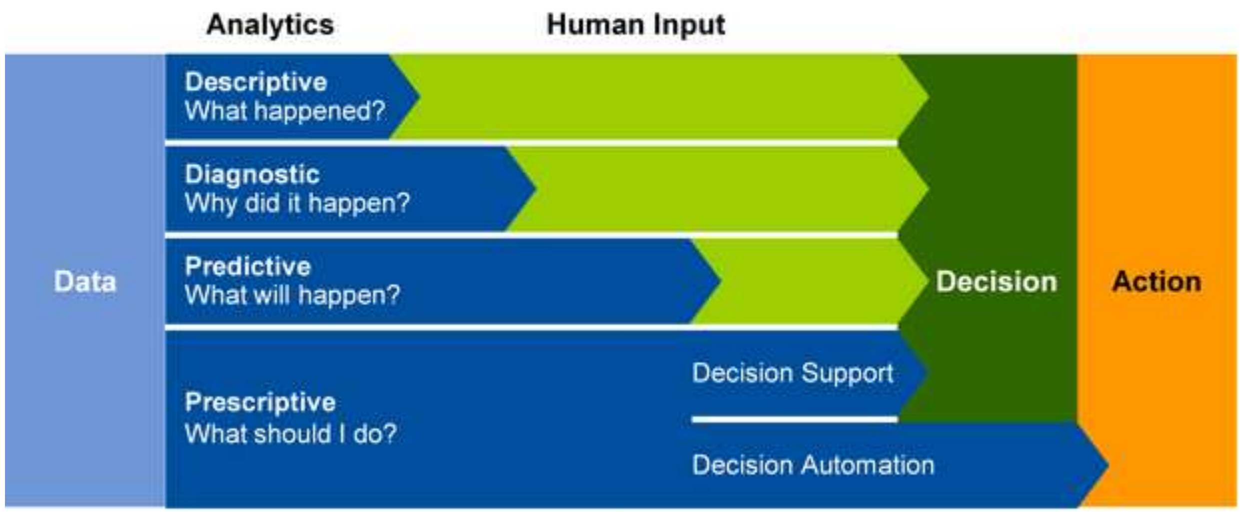
- The **Fourth Industrial Revolution** (4IR) is characterized by a fusion of technologies that is blurring the lines between the physical, digital, and biological spheres, collectively referred to as cyber-physical systems.
- It is marked by emerging technology breakthroughs in a number of fields, including robotics, artificial intelligence, nanotechnology, quantum computing, biotechnology, the Internet of Things, the Industrial Internet of Things (IIoT), Blockchain, fifth-generation wireless technologies (5G), additive manufacturing/3D printing and fully autonomous vehicles.

Spends on Digitalization in the power sector



Sources: IEA analysis based on MarketsandMarkets (2016), Internet of Things in Utility Market; BNEF (2016), Digital Energy Market Outlook.

The Analytics Spectrum



Analytics in the Power Plant context

(Courtesy NTPC)

Operations Optimization

- **M**easure, **V**isualize and **I**mprove operational parameters
- Get the last penny from your process

Maintenance Optimization

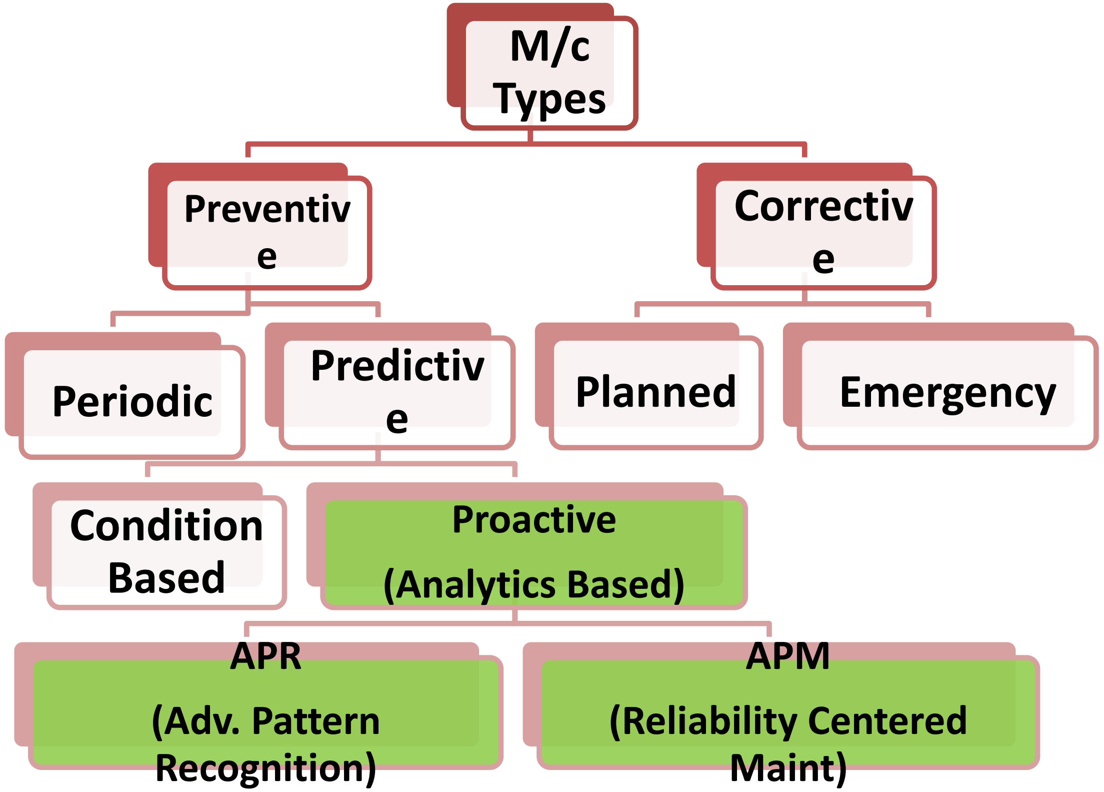
- Strike the right mix of **A**vailability, Cost of **M**aintenance & **R**isk

Business Optimization

- Enterprise level O&M Optimization
- Market Intelligence
  - Demand Forecasting
  - Solar Power Prediction
- Portfolio Management
  - Resource planning

Analytics: Maintenance Optimization

(Courtesy NTPC)



Digital Twin

(Courtesy NTPC)

Dimensional Model

3D modeling Software

- Walk Through
- One Stop Documentation

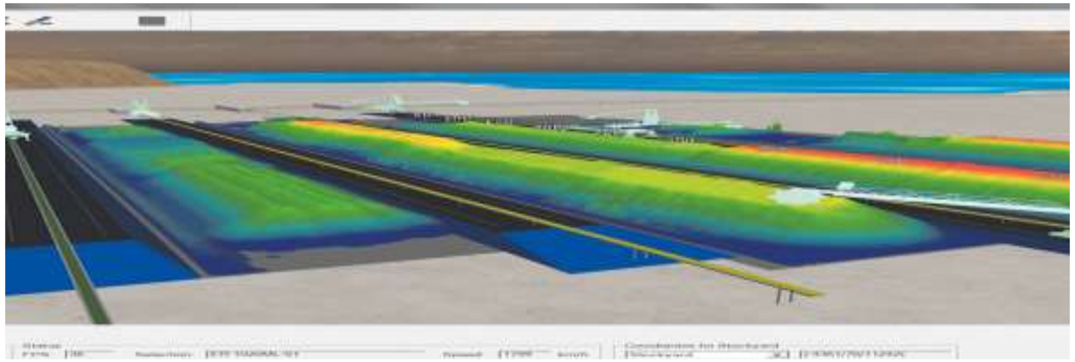
Functional Model

First Principle Software

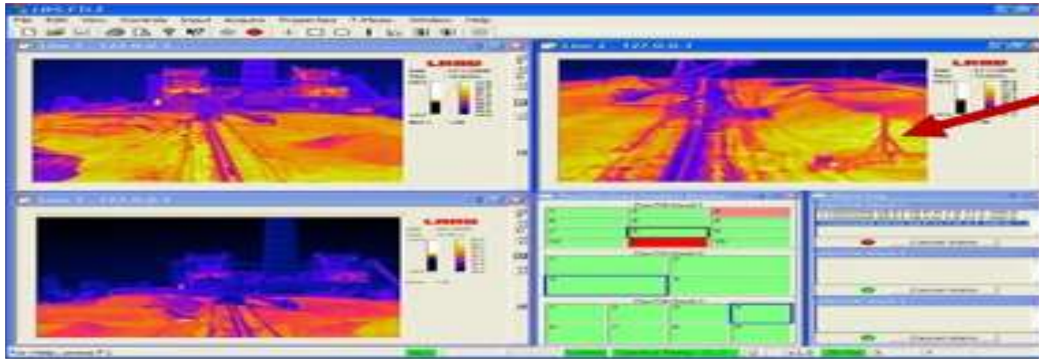
- “What Ifs” to evaluate operating scenarios.

Advanced Monitoring of Stockyard : 3 D Stock Profiling & Hot Spot Detection

(Courtesy NTPC)



3D Profiling

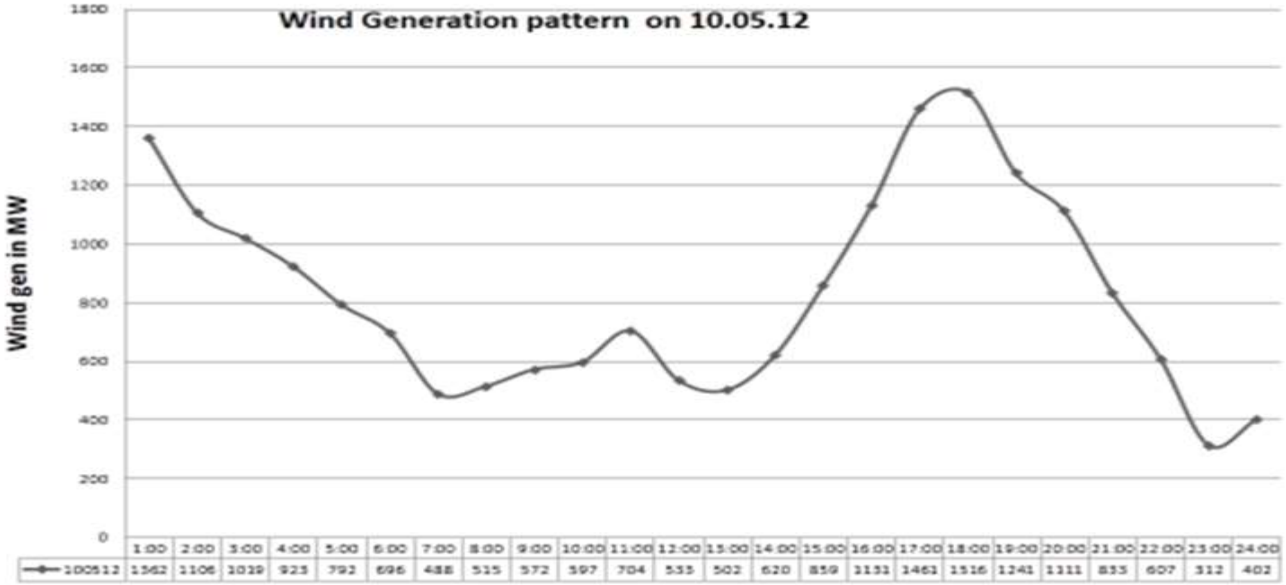


Hot Spot Detection

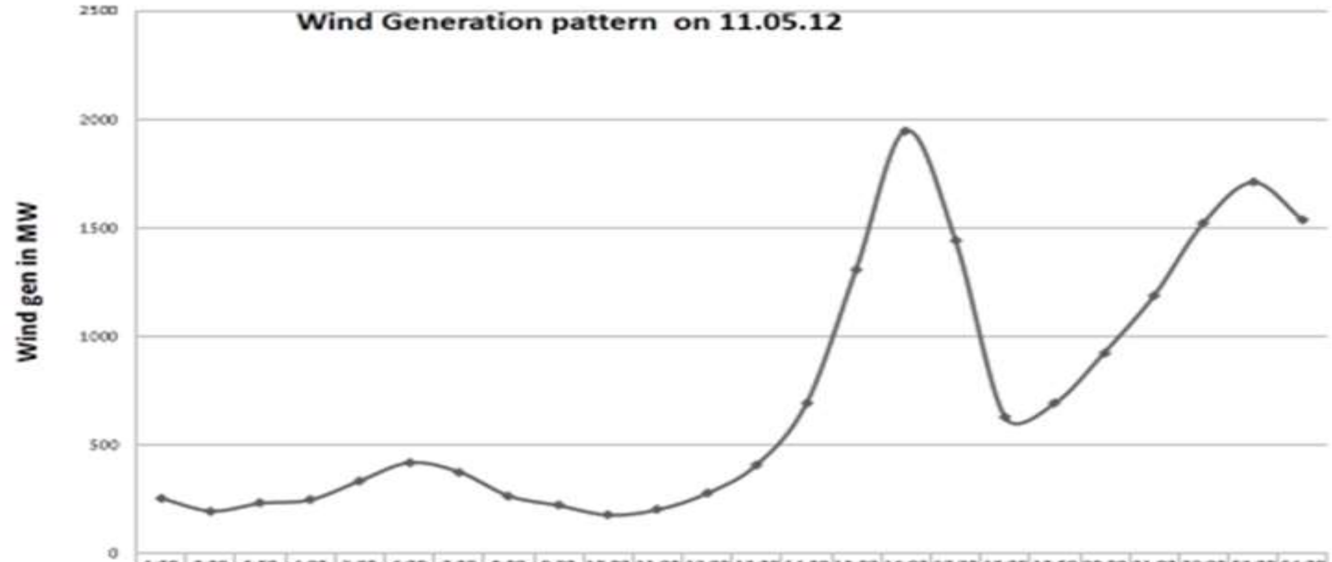
Operator can visualize
Exact replica of the coal heap
Cross sectional volume and other details available in a particular heap of coal.

Different Color Gradient indicates the different thermograms or temperature zones of the stock yard.

Wind generation on consecutive days



Wind generation on consecutive days



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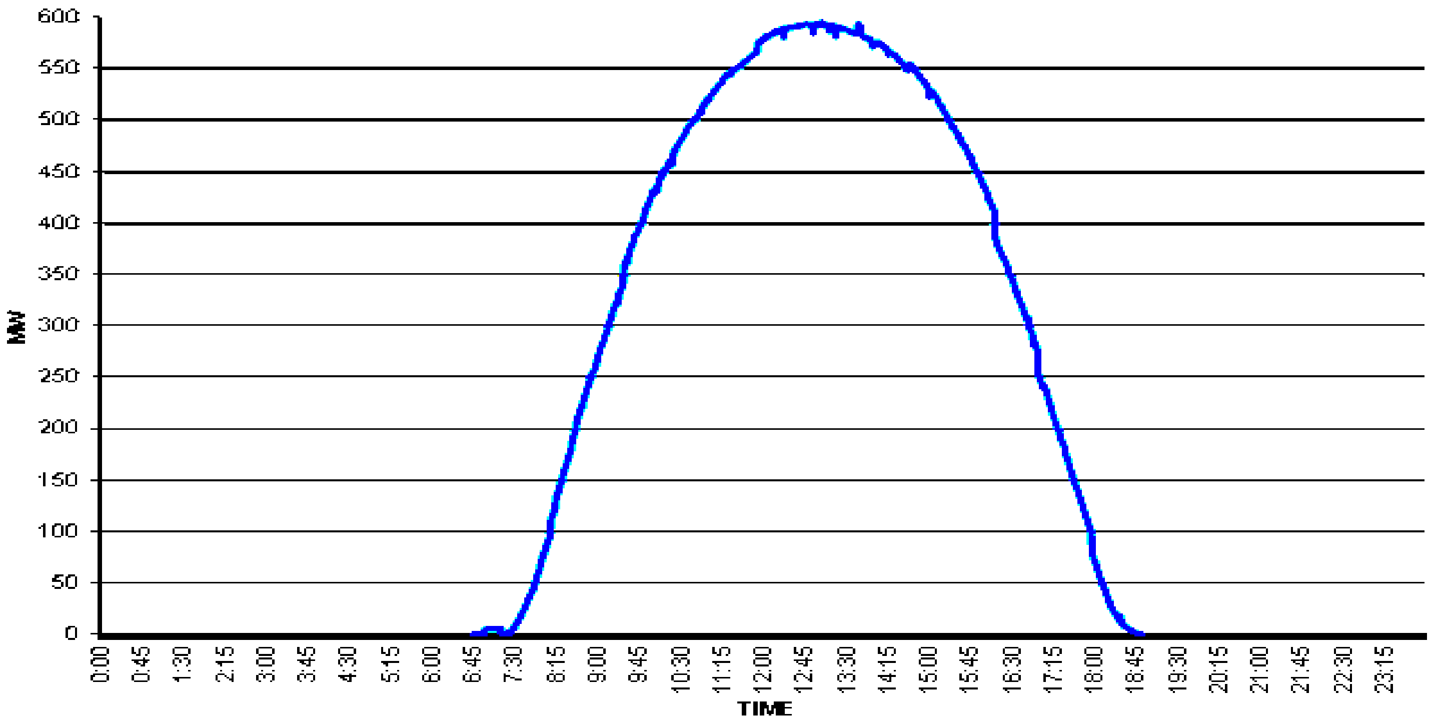
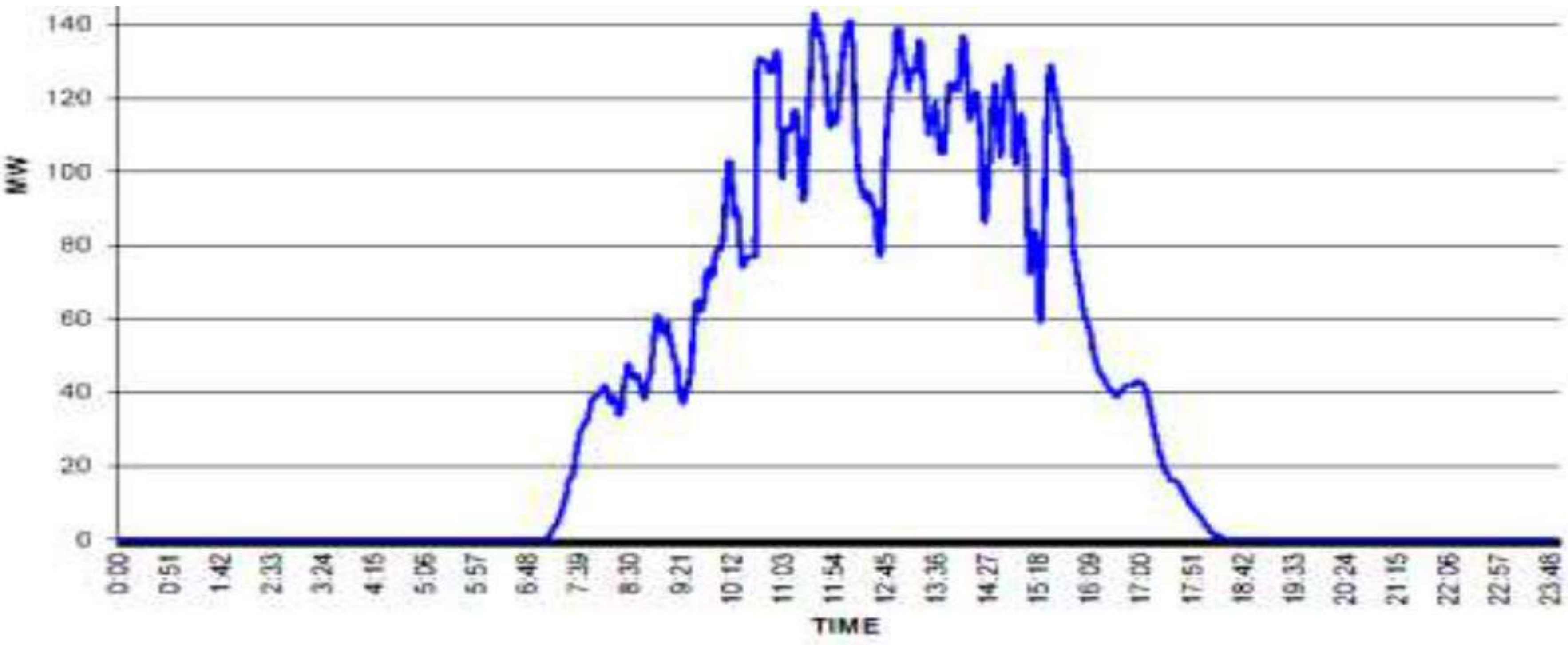
Series1	254	196	231	247	335	418	376	265	221	177	202	277	409	692	1308	1947	1441	627	690	924	1186	1521	1708	1554

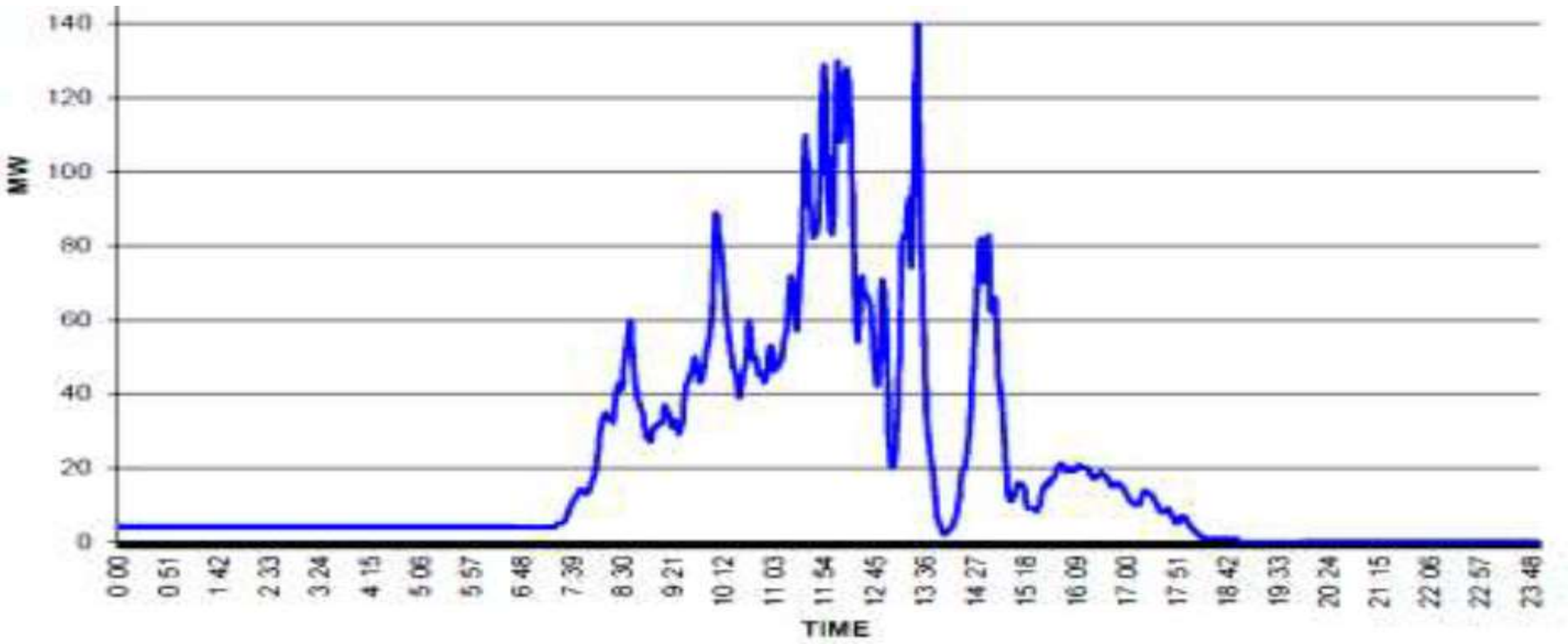
Typical solar generation over a day in Gujarat for a non-cloudy day



Solar generation on a cloudy day 1-9-2012 in the **Charanka Solar Park** Gujarat (capacity of about 200 MW)



Solar generation on a cloudy day 9-9-2012 in the **Charanka Solar Park** Gujarat



Issues and Challenges in Grid Operation

- Frequency Stability
- Voltage Stability
- Transmission congestion
- Angular Stability

Powergrid efforts

- **Wide Area Monitoring System (WAMS)**
- **Digital Substation and Substation Automation**
- **FACTS (Flexible AC Transmission System)**
- **NTAMC**: State-of-the-art ‘National Transmission Asset Management Centre’ (NTAMC) at Manesar, Haryana, set up for managing the assets and monitoring various parameters remotely on real time basis

Wide Area Monitoring System

- Phasor Measurement Units (PMUs) are installed across the power system network for measurement. The time synchronized measurements of PMUs at different locations measure the voltage, current and phase angle - 1400 Nos. PMUs installed along with analytics and applications in 32 control centre.
- PMUs measure the voltage, current and phase angle of a particular location as well as of the adjacent location and gives a direct indication of whether the angular stability limit is being approached.
- WAMS therefore provides a comprehensive view of the entire grid and improves situational awareness of the system operator.
- Improves reliability and utilization of the grid.

Digital Substation and Substation Automation

- Input parameters like voltages, currents are taken through optical fibres and processed for Protection and Control functions.
- Use of fibre optic cables eliminates most of the copper cabling and cable trench requirements, thus reducing capital cost and construction period.
- Reliability of the system is comparatively higher and maintenance is easier.
- In India, more than 50 substations are already digitalised.

FACTS (Flexible AC Transmission System)

- Enhanced controllability and stability of the transmission system.
- Increase of the power transfer capabilities.
- **Series compensation :** Since the current through the transmission line directly "drives" the MVAr output from the capacitor, the compensation concept is "self-regulating”. Extremely cost effective solution. 40 Series capacitors are already installed in India, in lines of 400 kV and above.
- **Dynamic Compensation :** Increases system stability and power quality by providing voltage control and support, Reactive power control, Power oscillation damping as well as Power transfer capacity increase.18 Nos. SVC / Statcoms are installed / under implementation.

Robot monitoring a switchyard

AI is far superior to humans when it comes to carrying out complex tasks at speed.

Distribution

- **Distribution Management System (DMS) -** Distribution **SCADA (Supervisory Control and Data Acquisition System).**
- **Outage Management System (OMS)**
- **Advanced Distribution Management System (ADMS) -** fault location, isolation and restoration; volt/var optimization; load reduction through voltage reduction; peak demand management; and support for micro grids and electric vehicles.

Distribution

- Data available consumer wise and transformer-wise would be of immense help
- Accurate season-wise demand forecasting (hourly/15 minute)
- Accurate distribution planning,
- Optimal procurement of power and optimal utilization of the distribution system.
- Monitoring the performance of the distribution system and calculate reliability indices like SAIDI, SAIFI, CAIDI, etc.

Prosumers and engaged consumers

- Prosumers can sell power back to the grid
- Control of consumption of power through mobile apps.
- For example, scheduling the home’s washing machine cycle can mean savings for the consumer.
- Engagement of consumers in the process of demand generation balancing.

Distributed Energy resources (DER)

- DERs, along with smart inverters and advanced distribution management systems, can add flexibility and resilience to the grid.
- In times of hurricanes and storms, DER with energy storage, along with equivalent load can split into islands of self-supporting microgrids, which run autonomously.
- Buying and selling of electricity between the DER owning consumers using blockchain technology is being experimented with.

Electric vehicles

- Electric vehicles accounted for just 1% of U.S. and global light-duty vehicle purchases in 2016, but sales are growing rapidly. Customer interest is rising as prices fall and driving ranges increase.
- China, the U.K., France, and India have all announced plans to phase out fossil-fuel-powered vehicles.
- Increased EV penetration would actually have benefits in managing the grid. EVs with onboard batteries could help utilities balance the grid, integrate renewables, through regulating the rate of charging, in accordance with the quantum of power available in the grid due to the intermittent renewable, or even feeding back to the grid, when required.

Smart Grid

- The grid would become “smart”, with digitalization. Model Smart Grid Regulations were formulated by Forum of Regulators in 2015.
- The benefits associated with the Smart Grid include:

1. More efficient transmission of electricity
2. Quicker restoration of electricity after power disturbances
3. Reduced operations and management costs for utilities, and ultimately lower power costs for consumers
4. Reduced peak demand, which will also help lower electricity rates
5. Increased integration of large-scale renewable energy systems
6. Better integration of customer-owner power generation systems, including renewable energy systems
7. Improved security

Geographical Information System (GIS)

- GIS is an effective tool that can bind together the various pieces of an electricity distribution system and thus ensure better asset management, improved customer service, improved outage management and more accurate data.
- In Tata Power DDL, there are 18+ lakh assets in field. GIS helps keep track of their assets.
- GIS based mapping for renewable energy and for transmission line, in order to see the topology for proper planning.

Artificial intelligence (AI)

- **Artificial intelligence** in its broadest form, refers to the ability of machines to exhibit human-like intelligence.
- AI encompasses several different technologies and systems of which **machine learning** is one. Others include **natural language processing, computer vision, and speech recognition**.
- **Machine learning** refers to the practice of using algorithms to parse large volumes of data, learn from it, detect patterns, and make decisions or predictions based on these patterns.

Artificial intelligence (AI)

- **Natural language processing** (NLP) is the ability of a computer program to understand human language as it is spoken.
- **Computer vision** is an interdisciplinary scientific field that deals with how computers can be made to gain high-level understanding from digital images or videos. From the perspective of engineering, it seeks to automate tasks that the human visual system can do.
- **Speech recognition** is the ability of a machine or program to identify words and phrases in spoken language and convert them to a machine-readable format. Rudimentary speech recognition software has a limited vocabulary of words and phrases, and it may only identify these if they are spoken very clearly. More sophisticated software has the ability to accept natural speech.

Artificial Intelligence (AI)

- AI could be used to create forecasts for electricity demand, generation and weather.
- AI could be used to manage electricity shortfalls by briefly switching off power demand of certain previously identified loads across entire communities or regions.
- AI can now also show how much electricity each of your home appliances is using.
- AI home energy management systems would enable scheduling your washing machine to run when the electricity price is lower.
- Decision-making would be with a scale and complexity that would not be possible by a human operator.

Some Applications of AI for Utility

- **Load forecasting.** Machine learning could be used to forecast supply and demand in real time and optimize economic load dispatch. In the UK, Google's DeepMind has teamed up with National Grid to predict supply and demand peaks and hopes to reduce national energy usage by 10%.
- **Yield optimization.** With AI, power providers can optimize generation efficiency with real-time adjustments across their assets. GE Renewable Energy's "Digital Wind Farm" concept includes software that monitors and optimizes the turbine as it runs, increasing energy production by up to 20%.
- **Predictive maintenance** can be bolstered with **drones** for asset inspections, replacing time intensive and risky manual inspections. The drones are trained using deep learning algorithms to automatically identify defects and predict failures without interrupting operations.
- **Demand management** can be automated and made smarter with machine learning. In the UK, Upside Energy uses machine learning to manage a portfolio of storage assets to support the grid, while Open Energi controls devices with flexibility in their energy consumption to shift demand in real time. It is estimated that machine learning could be used to help unlock up to 6GW of demand-side flexibility which can be shifted during the evening peak without affecting end users.
- **Energy theft** is a huge problem in some developing countries, such as Brazil, where theft accounts for up to 40% of the electricity distributed. AI can be used to detect usage patterns, payment history, and other customer data that may signal irregular behavior.

Some Applications of AI for Utility in the retail side

- **Customer insights.** Machine learning applications could allow utilities to craft electricity prices that maximize their margins while minimizing customer churn. AI could be used to create individual offers and services to help utilities retain their most profitable customers.
- **Energy trading.** In this era of the prosumer generating their own renewable energy and sending the excess back into the grid, platforms are emerging to allow peer-to-peer trading between producers and consumers. As supply and demand continuously fluctuate, AI can be used to more quickly match producers with consumers. In the Netherlands, Vandenbron connects consumers with renewable energy providers.
- **Virtual agents** will revolutionize call centers, being able to respond to consumer queries and provide instant assistance. They will be able to automatically segment consumers based on service history and provide early warning of bad debts. The development of natural language technologies will eventually unlock the capacity to fully automate customer service.

Some Applications of AI for Consumers

- **Supplier selection.** Machine learning can help customers choose their energy retailer by learning about their preferences – such as energy generation type, how much they're willing to pay and their consumption patterns – and then scanning the market for the most suitable offers. Lumator, using software developed at Carnegie Mellon University, does this and can also automatically make the switch without interrupting supply.
- **Consumption insights.** Meter data can be analyzed to extract the consumption profiles of a household's hungriest appliances and see how much each contributes to the energy bill. Bidgely takes this one step further. Their universal disaggregation algorithm uses machine learning and a database of over 50 billion meter readings from smart meters to extend the appliance profiling to homes without smart meters.

Cyber security

- **December 2015 Ukraine power grid cyberattack** is considered to be the first known successful cyberattack on a power grid. Hackers were able to successfully compromise information systems of three energy distribution companies in Ukraine and temporarily disrupt electricity supply to the end consumers.
- Cyber attacks followed in 2016 and 2017.
- The world is gearing up to meet this challenge. **Computer Emergency Response Teams** (**CERT**) have been formed in each country since early 1990s. CERT is an expert group that handles computer security incidents. CERT-IN has also been formed in 2004, but its activities have picked up in the last few years.

Thank you