

AUTOMATION for Energy Utilities

**Gurunath Gurrala
Associate Professor,
Department of Electrical Engg.
Indian Institute of Science
Bangalore-560012
gurunath@iisc.ac.in**

I am a Layman

What I know about Electricity

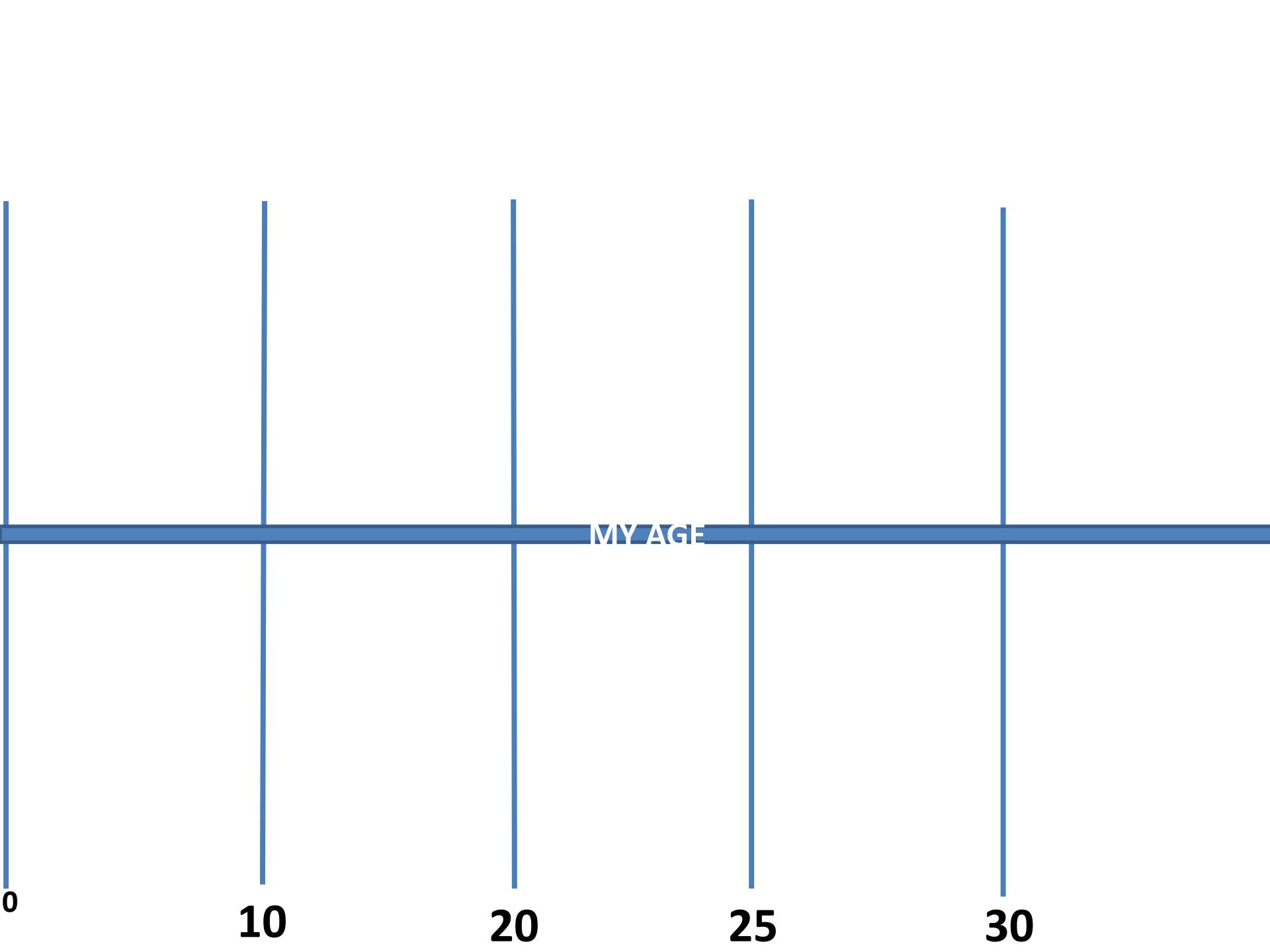
What I know about Communication

What I know about Information

**When I born
To
Till Day**

**When I born
To
Till Day**

What Changed and What not changed



0

10

20

25

30

MY AGE



Very few

MY AGE

Born

10

20

25

30



Very few

MY AGE



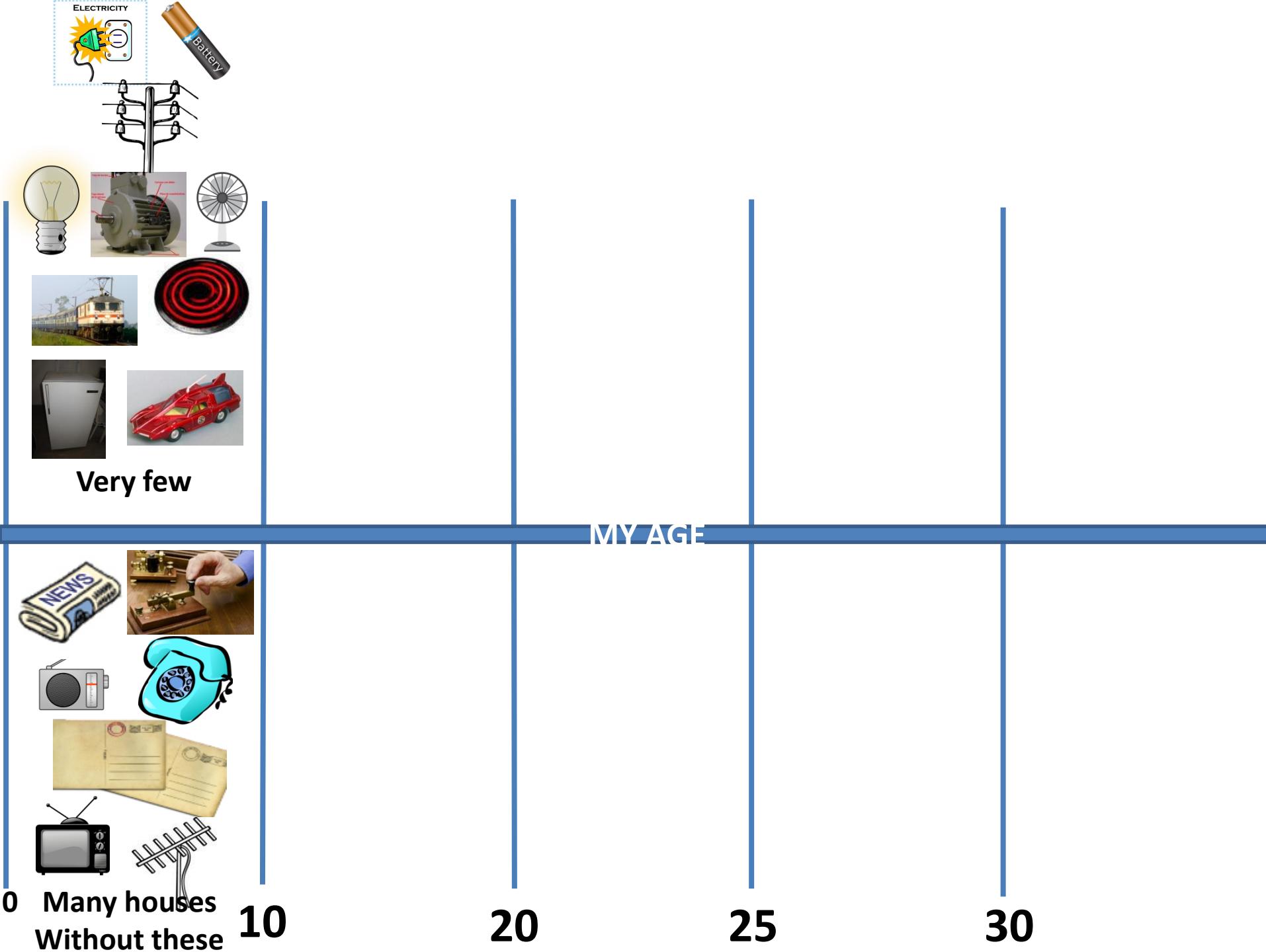
**0 Many houses
Without these**

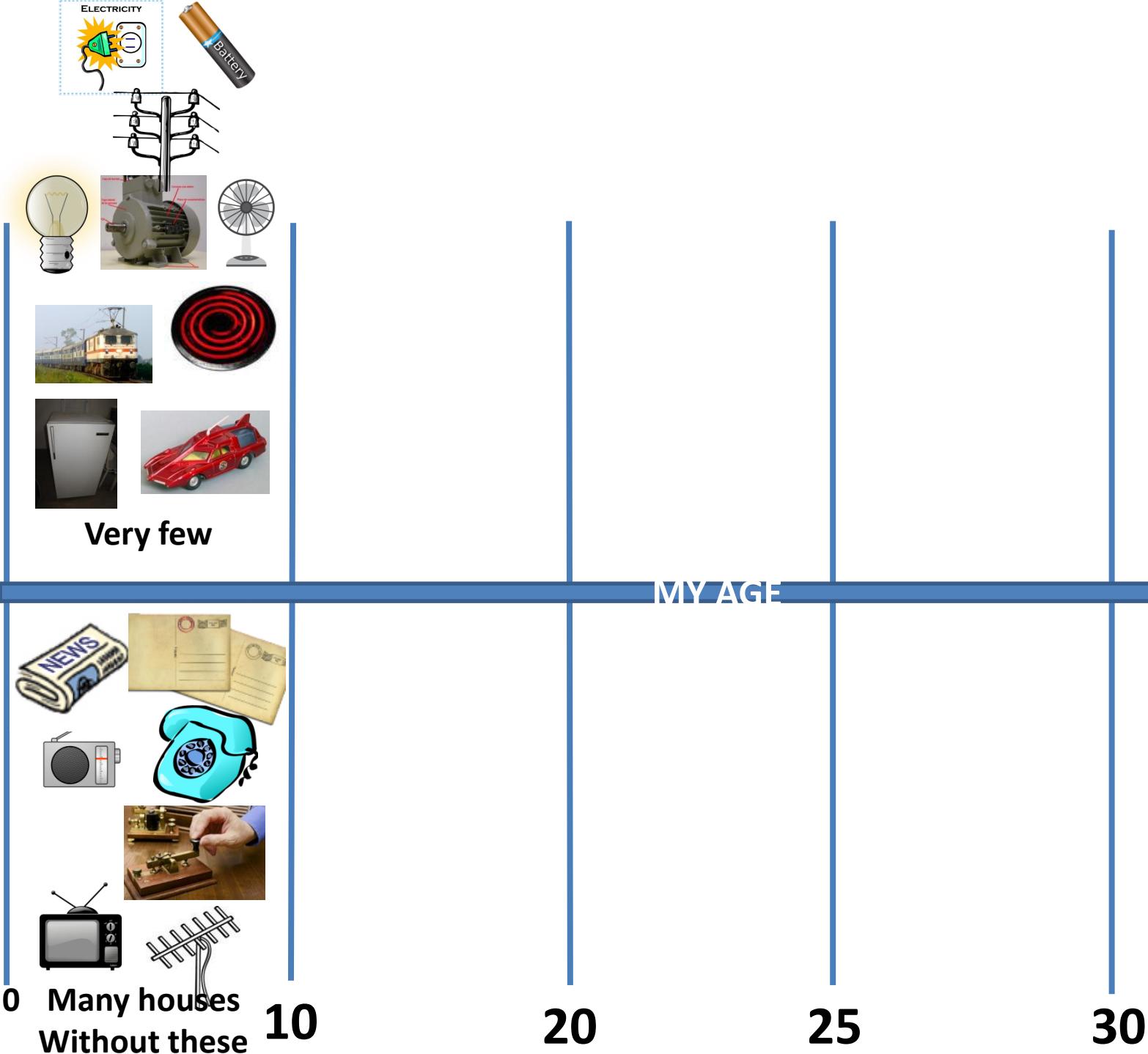
10

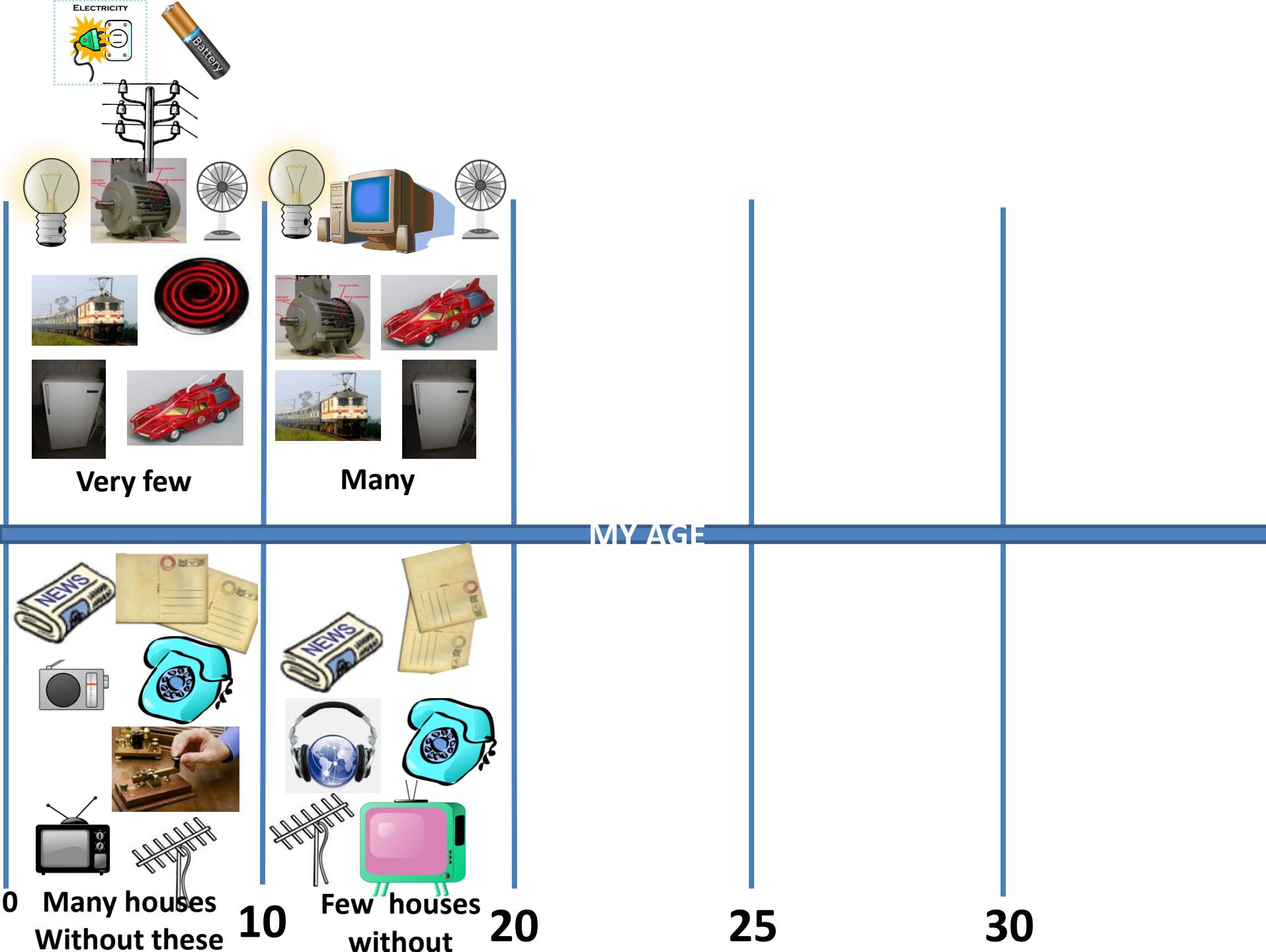
20

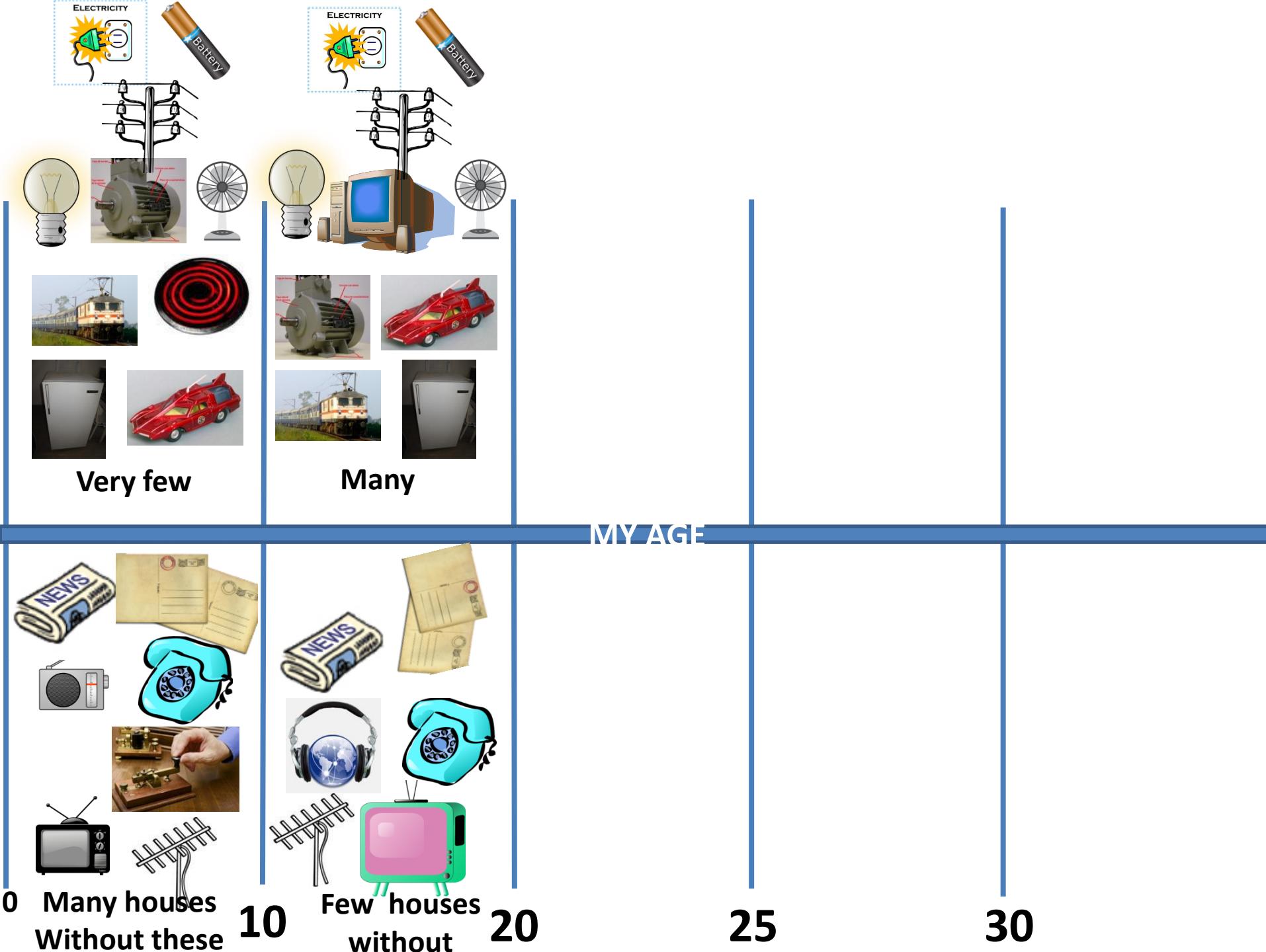
25

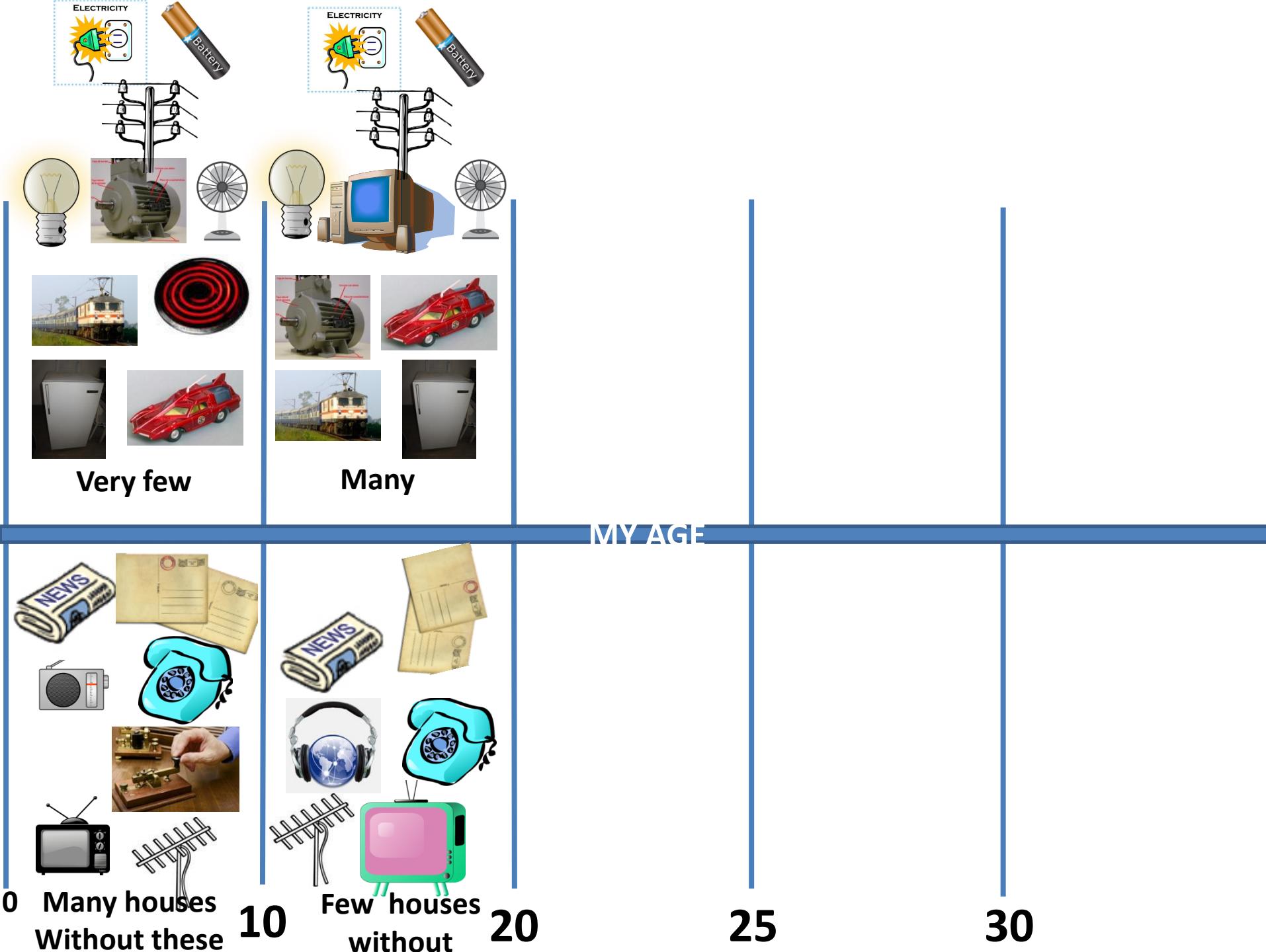
30

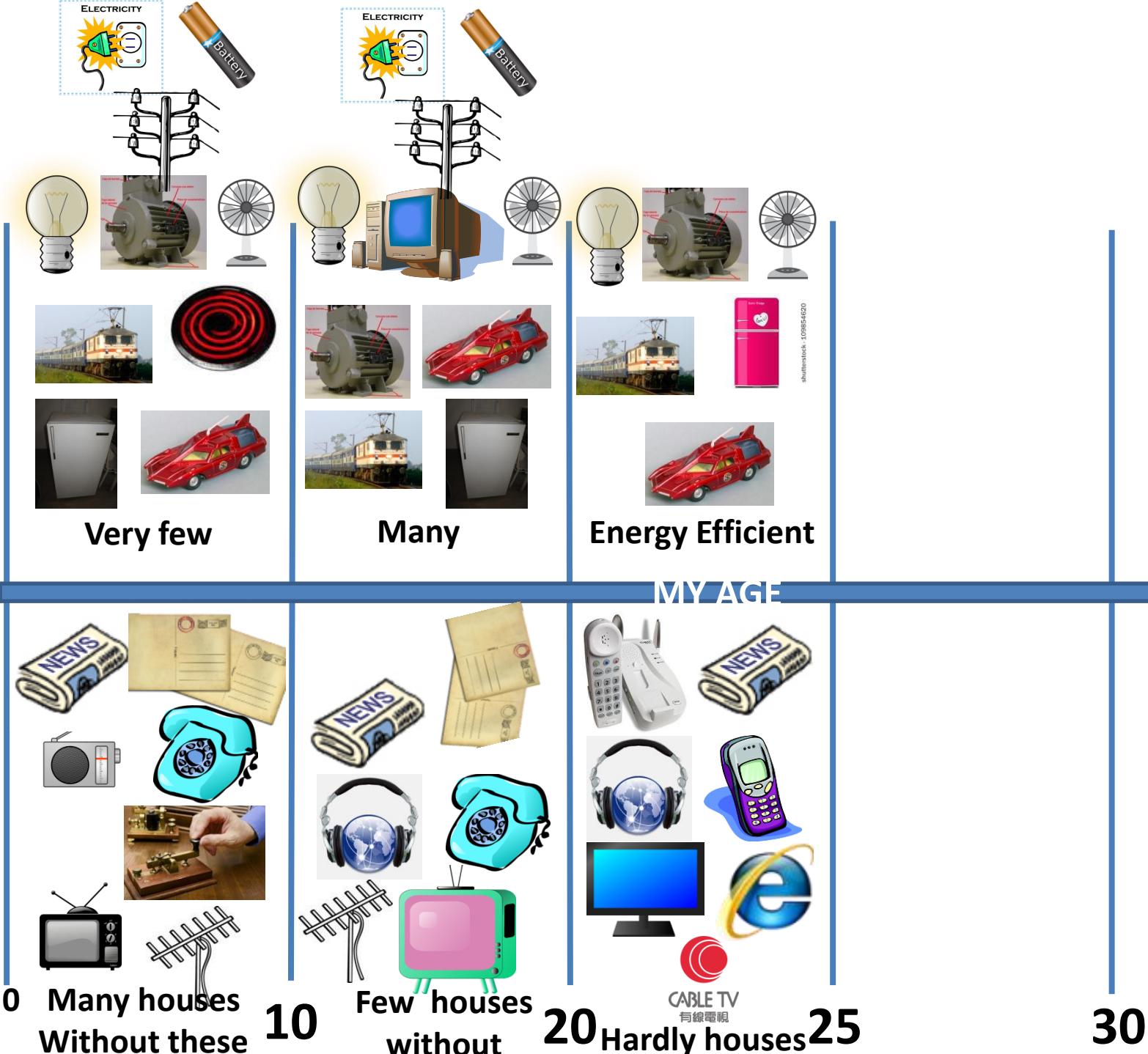


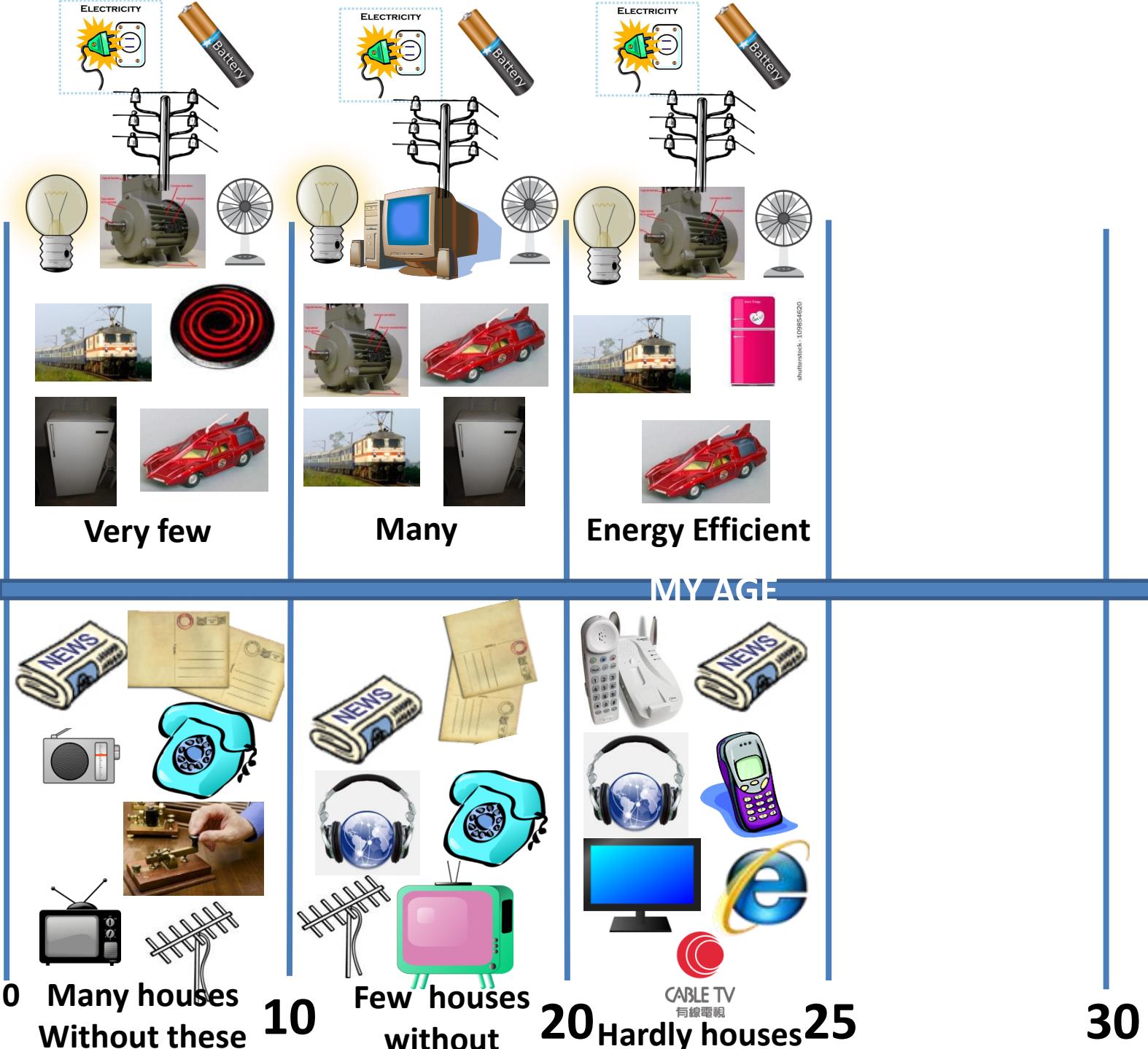


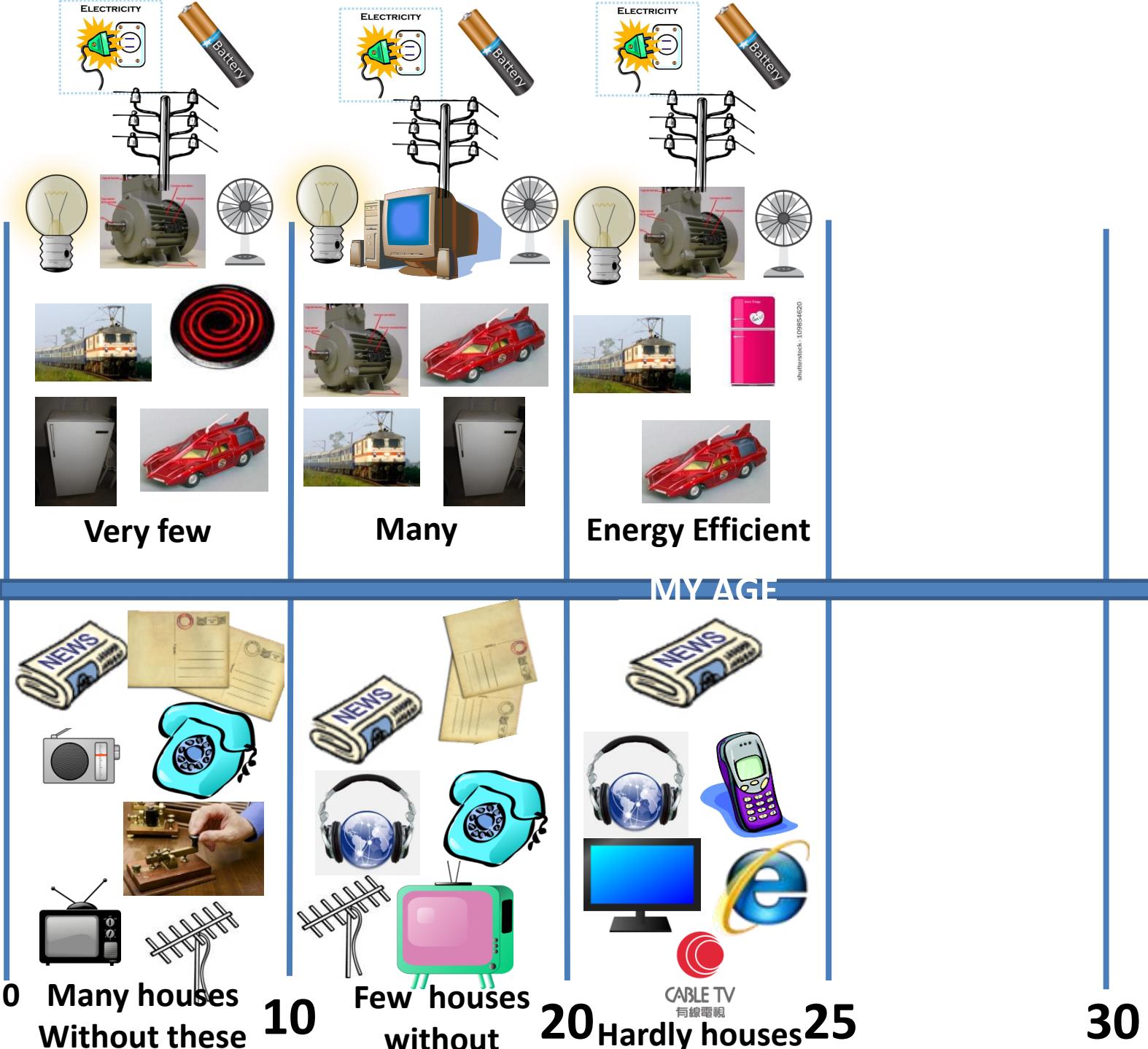


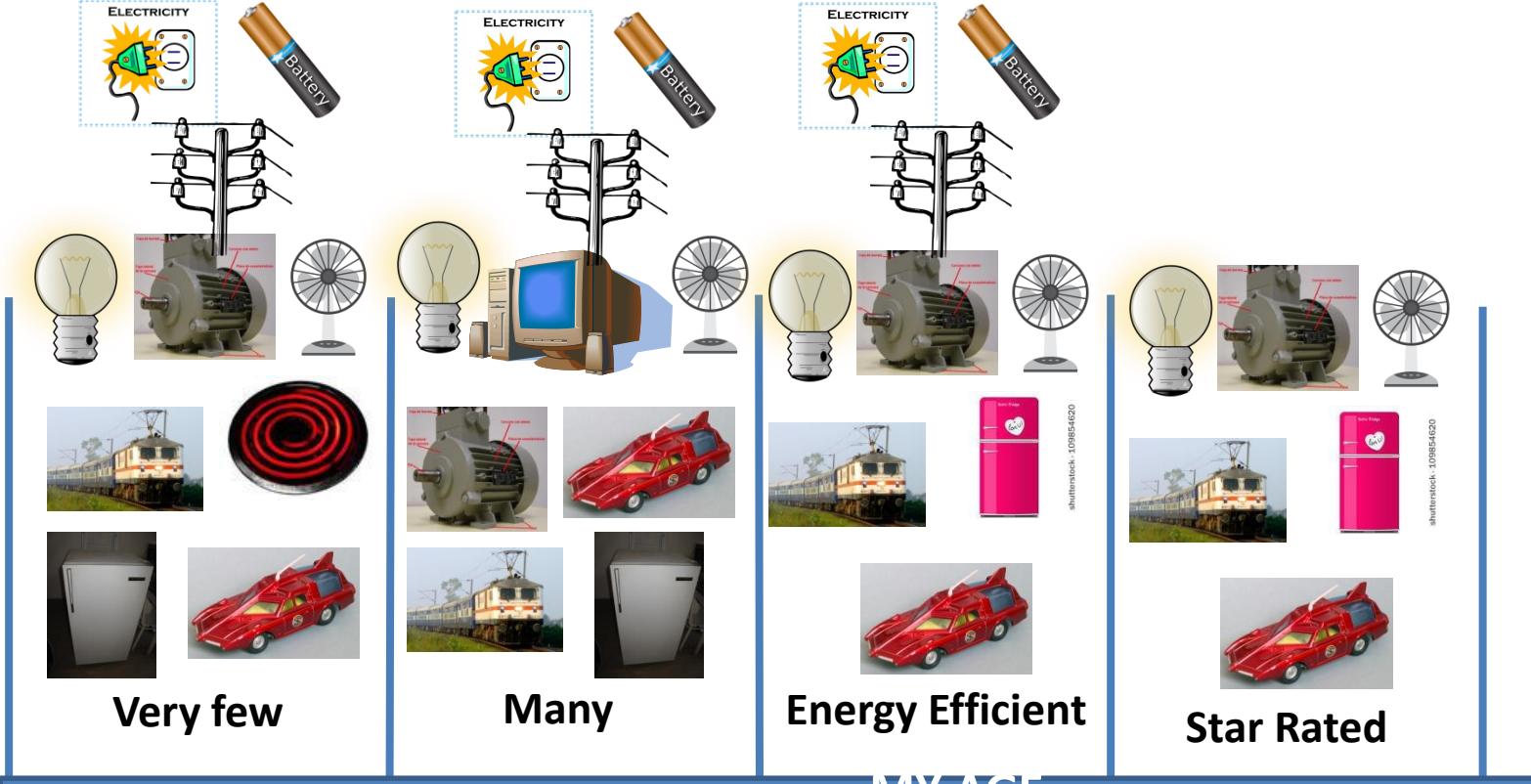




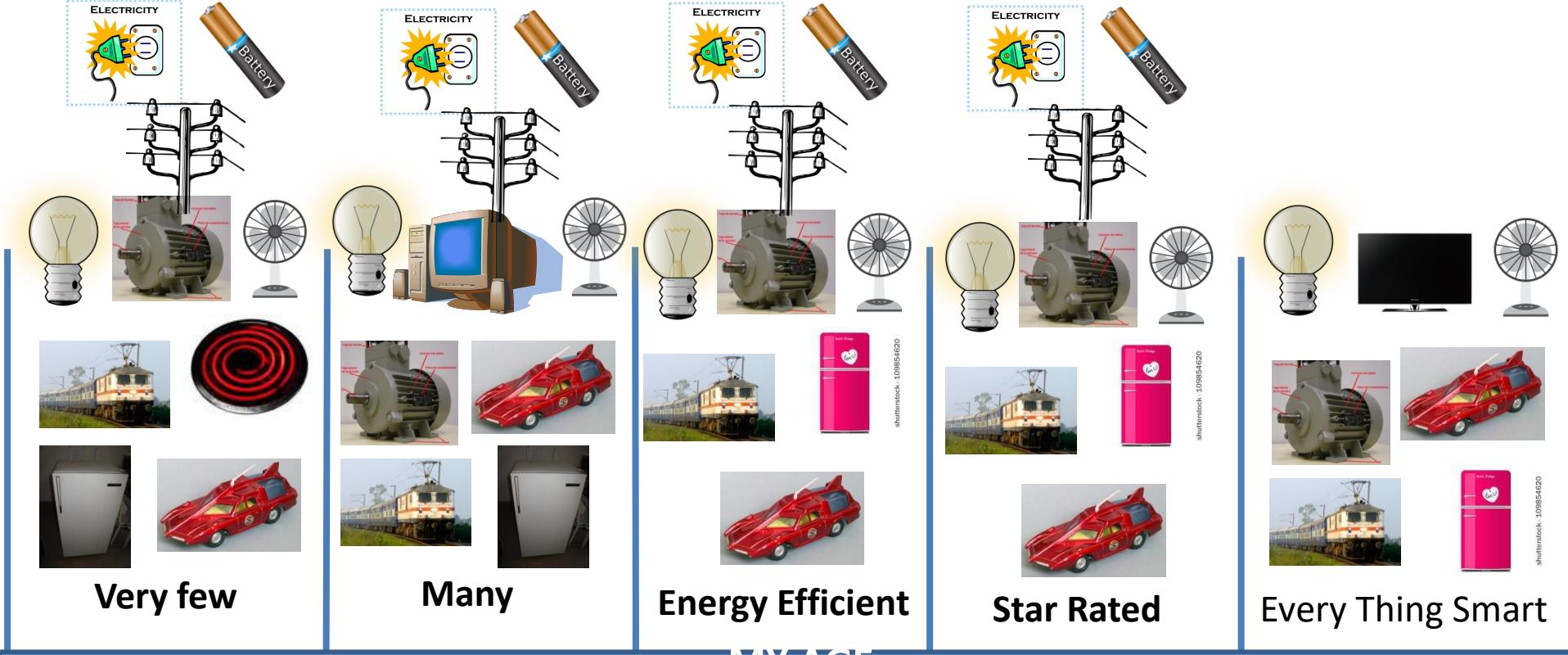


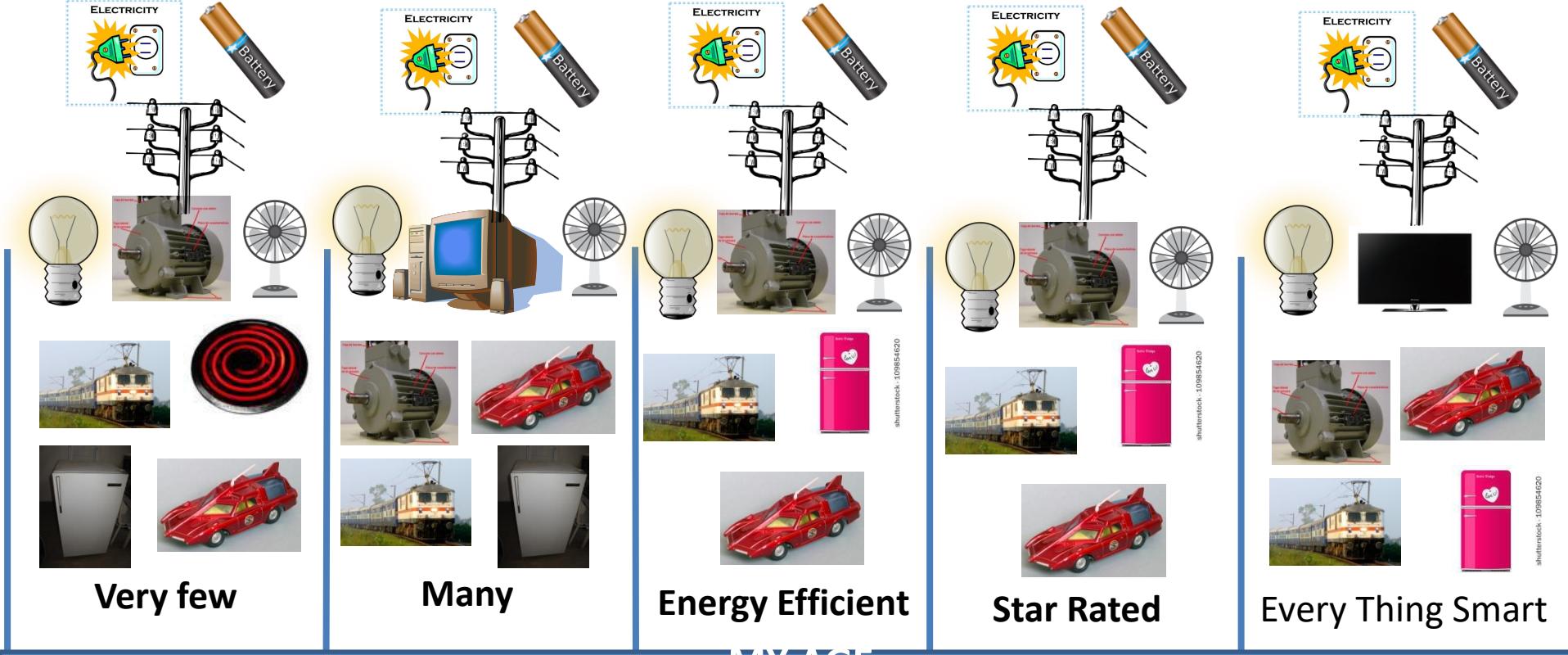






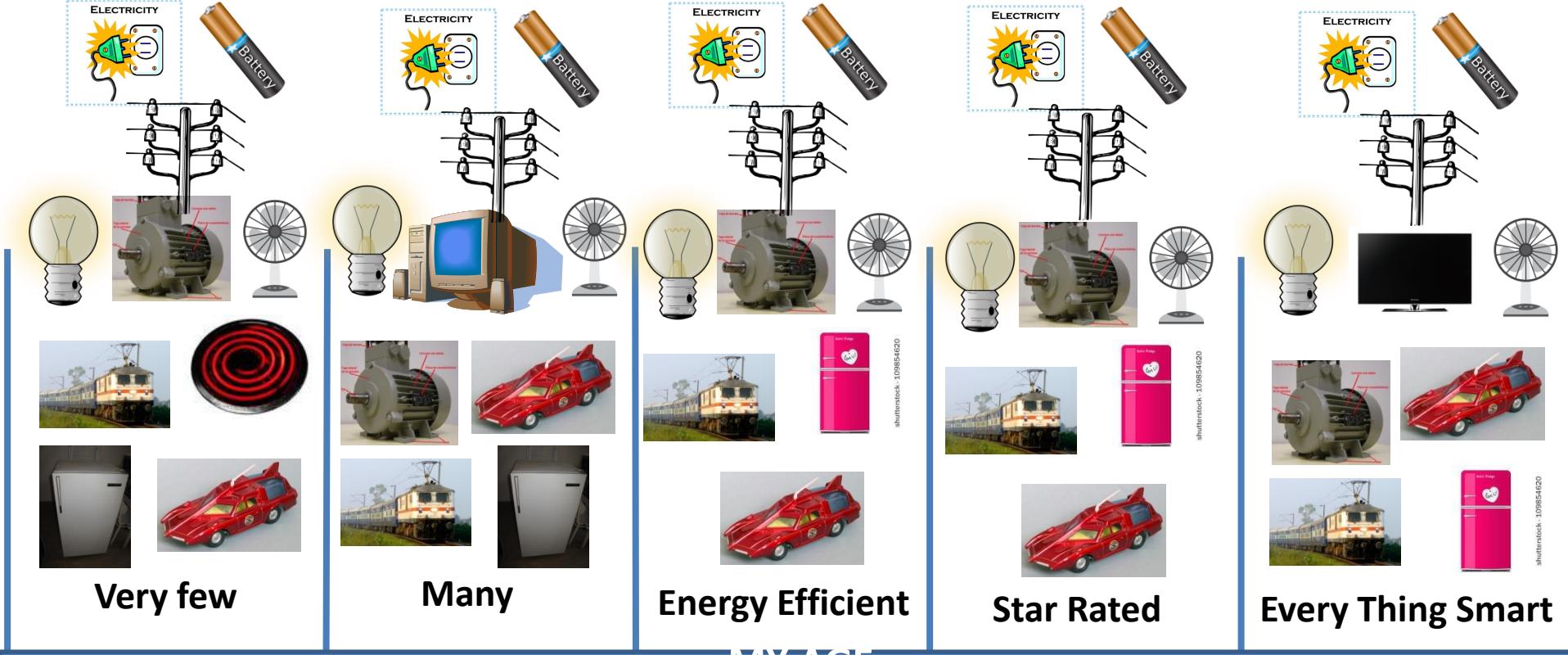






MY AGE





MY AGE



MY AGE

I could live without all these

MY AGE

**I could live without all these
Very Few, Long Life, Repairable**

MY AGE

**I could live without all these
Very Few, Long Life, Repairable**

MY AGE

**I could communicate
Without Electricity**

**I could live without all these
Very Few, Long Life, Repairable**

MY AGE

**I could communicate
Without Electricity
Very Few, Many Options, Slow**

Fresh



Beautiful



I could live without all these gadgets

Very Few, Long Life, Repairable

MY AGE

I could communicate
Without Electricity

Very Few, Many Options, Slow

Fresh



Beautiful



I could live without all these

Very Few, Long Life, Repairable

I could still live without all these

MY AGE

I could communicate
Without Electricity

Very Few, Many Options, Slow

Fresh



Beautiful



I could live without all these
Very Few, Long Life, Repairable

I could still live without all these
All, Very Short Life, Use and throw

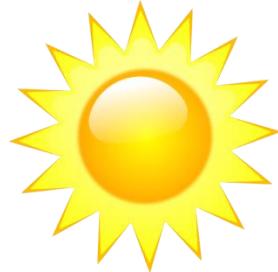
MY AGE

I could communicate
Without Electricity
Very Few, Many Options, Slow

Fresh



Beautiful



I could live without all these
Very Few, Long Life, Repairable

I could still live without all these
All, Very Short Life, Use and throw

MY AGE

I could communicate
Without Electricity
Very Few, Many Options, Slow

I cannot communicate
Without Electricity

Fresh



Beautiful



I could live without all these
Very Few, Long Life, Repairable

I could still live without all these
All, Very Short Life, Use and throw

MY AGE

I could communicate
Without Electricity
Very Few, Many Options, Slow

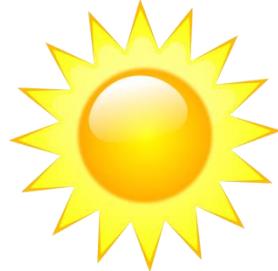
I cannot communicate
Without Electricity

Many people cannot live
Without Phone

Fresh



Beautiful



I could live without all these
Very Few, Long Life, Repairable

I could still live without all these
All, Very Short Life, Use and throw

MY AGE

I could communicate
Without Electricity
Very Few, Many Options, Slow

All, Largely one option, Fast

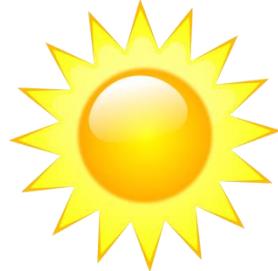
**I cannot communicate
Without Electricity**

**Many people cannot live
Without Phone**

Fresh



Beautiful



I could live without all these
Very Few, Long Life, Repairable

SMART



CAPTURE



USE



MY AGE

I could communicate
Without Electricity
Very Few, Many Options, Slow

I could still live without all these
All, Very Short Life, Use and throw

All, Largely one option, Fast

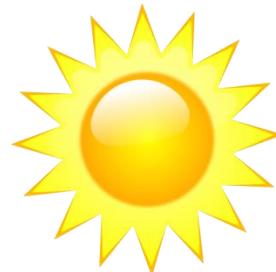
I cannot communicate
Without Electricity

Many people cannot live
Without Phone

Fresh



Beautiful



I could live without all these

Very Few, Long Life, Repairable

SMART



CAPTURE



USE



I could communicate
Without Electricity

Very Few, Many Options, Slow

I could still live without all these

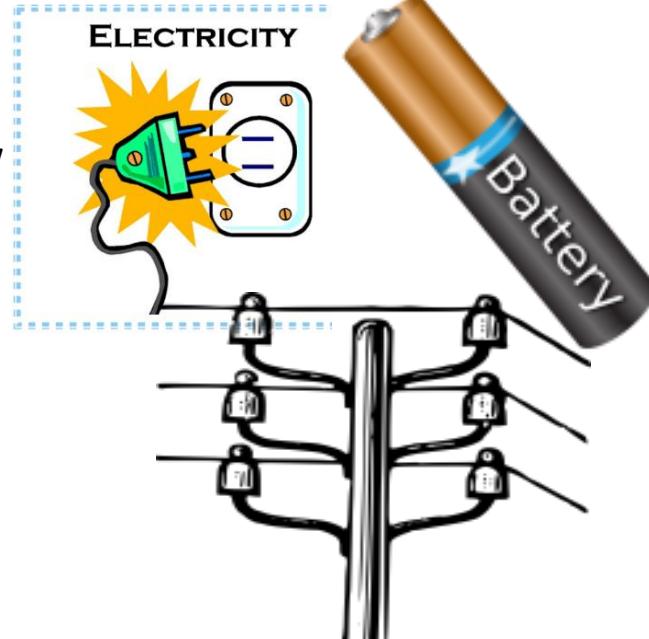
All, Very Short Life, Use and throw

MY AGE

All, Largely one option, Fast

I cannot communicate
Without Electricity

Many people cannot live
Without Phone



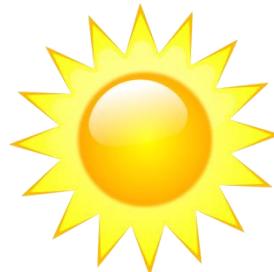
The Plug- The Socket – The Battery – The Wire – The Pole

OHM'S LAW and KIRCHOFF's Law unbreakable threads of ELECTRICITY does not change

Fresh



Beautiful



I could live without all these

Very Few, Long Life, Repairable

SMART



CAPTURE



USE



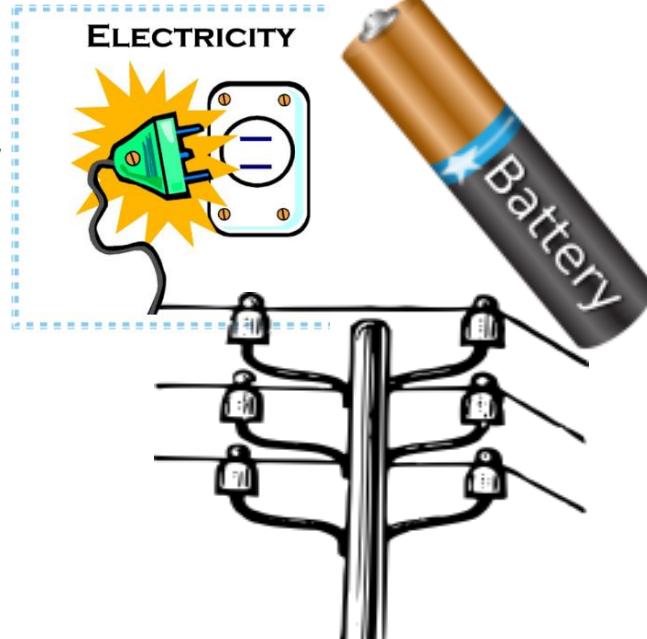
I could communicate
Without Electricity

Very Few, Many Options, Slow

I could still live without all these

All, Very Short Life, Use and throw

MY AGE

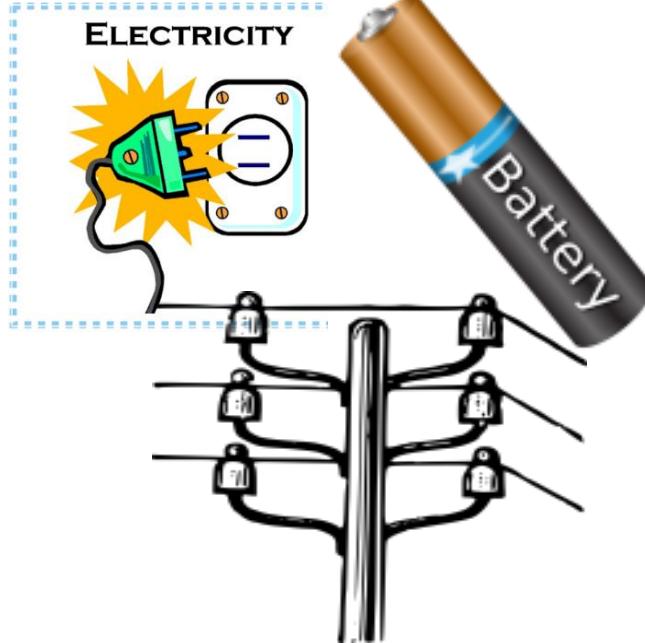


All, Largely one option, Fast

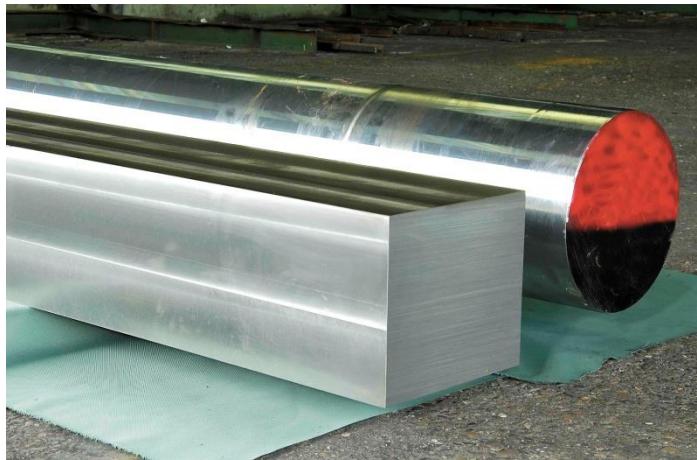
I cannot communicate
Without Electricity

Many people cannot live
Without Phone

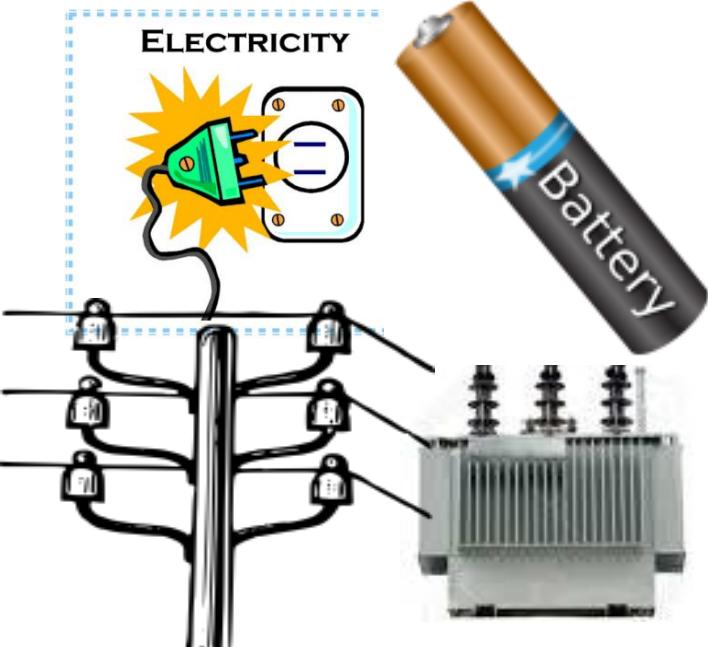
The Plug- The Socket – The Battery – The Wire – The Pole
NOT CHANGED



The Plug- The Socket – The Battery – The Wire – The Pole



THEY BECAME LIKE HARDENED STEEL

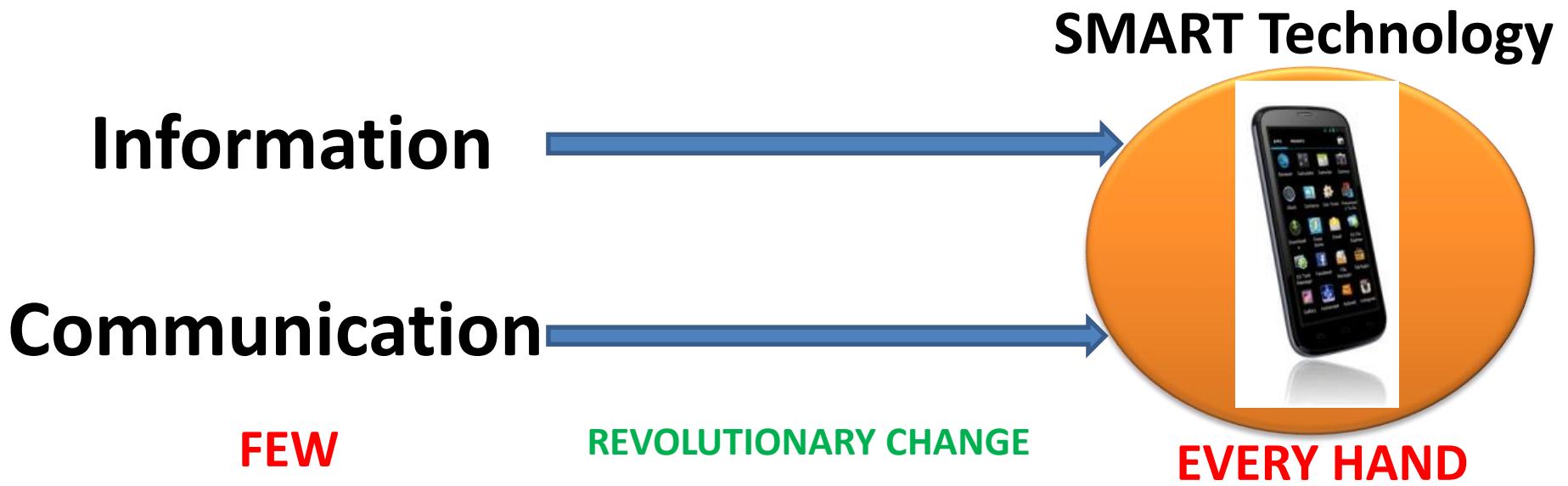


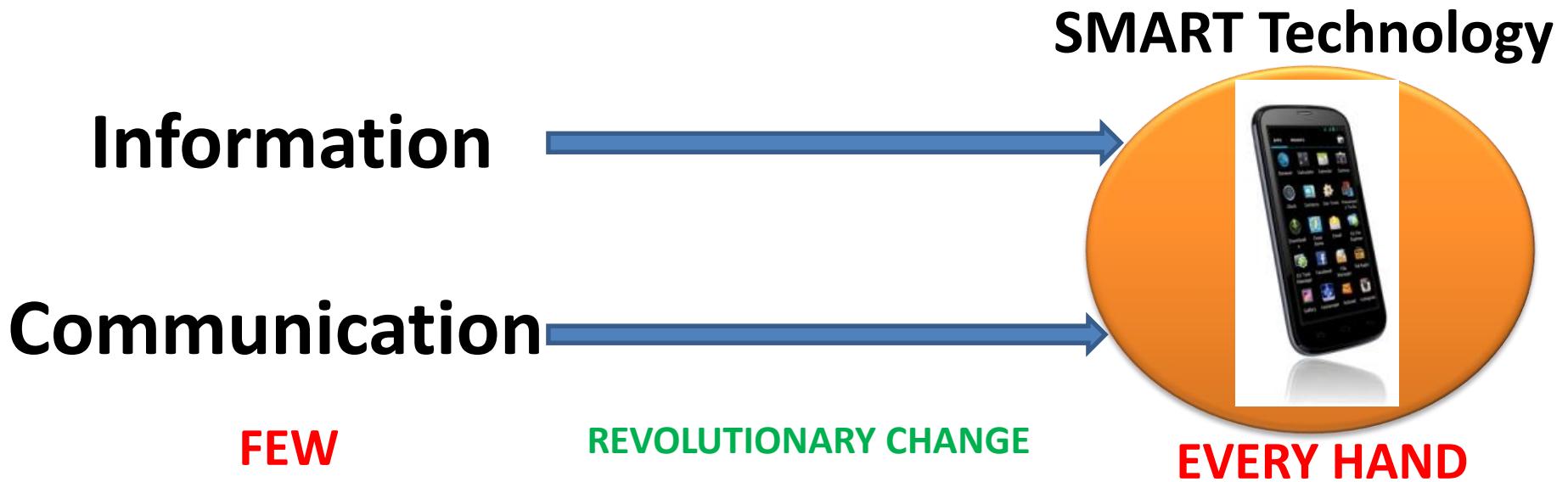
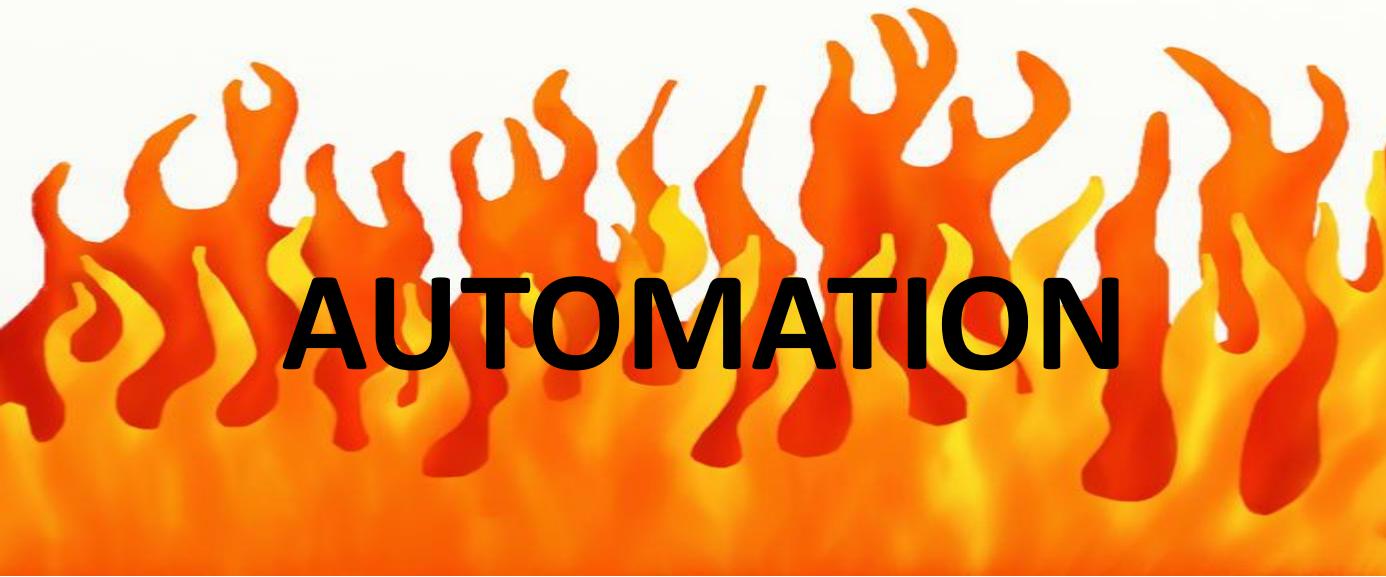
NOT CHANGED

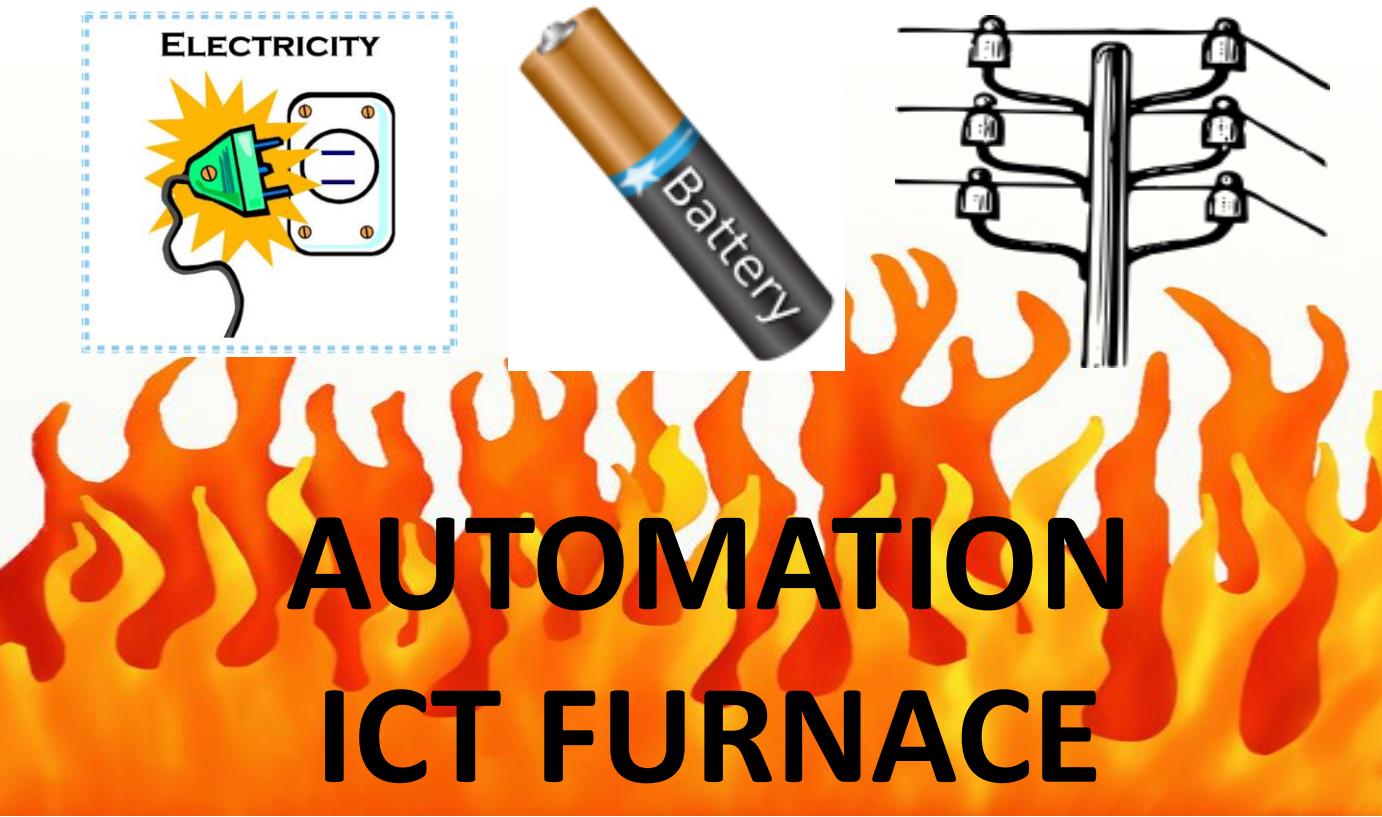
**When I born
To
Till Day**



Revolutionary







AUTOMATION ICT FURNACE

SMART Technology

Information



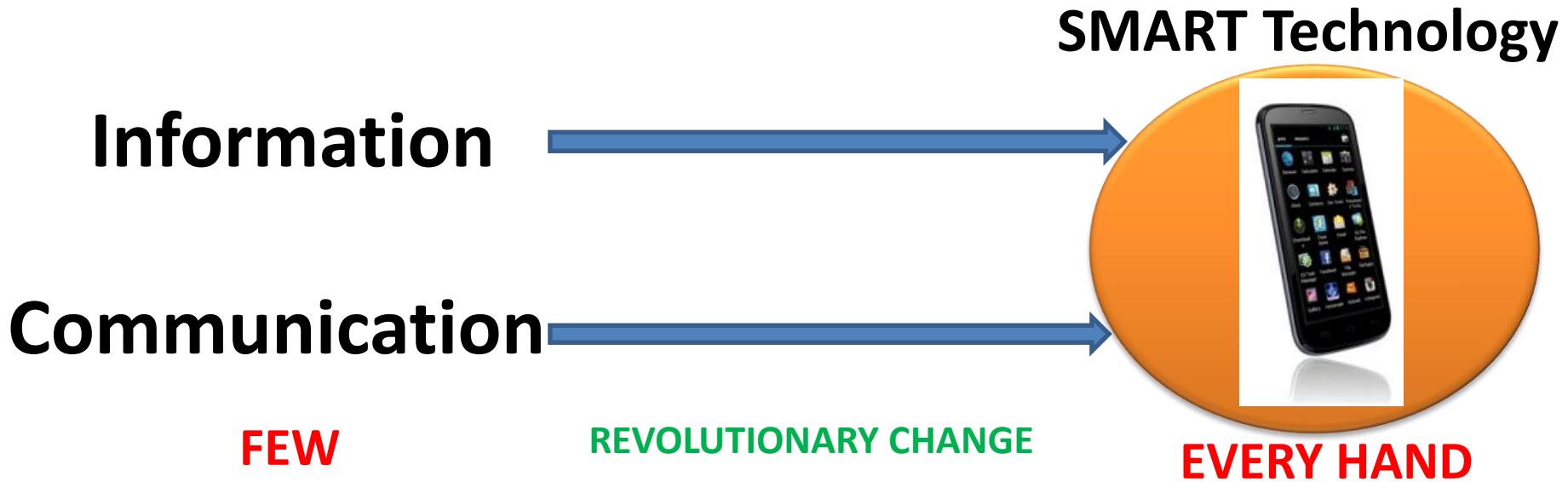
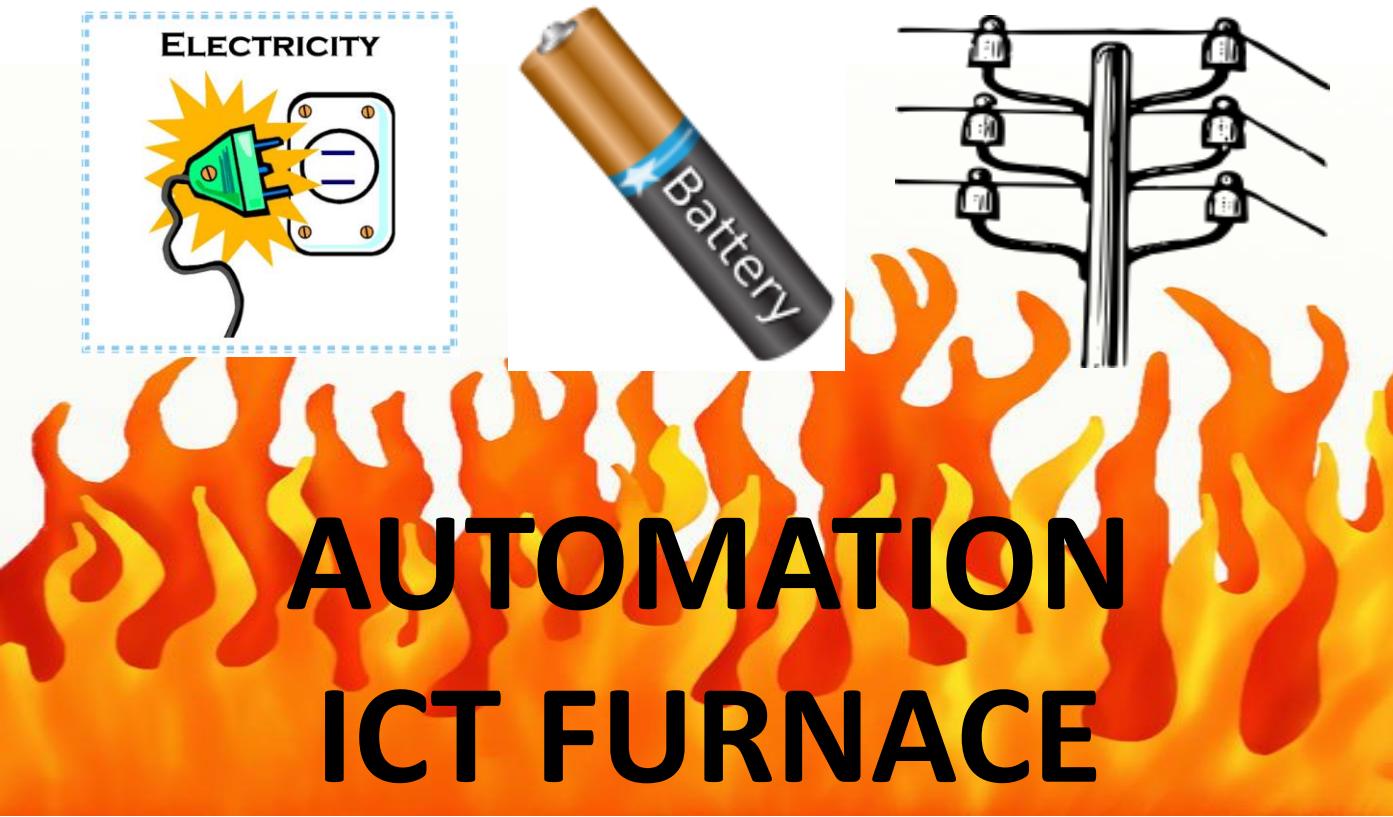
Communication



FEW

REVOLUTIONARY CHANGE

EVERY HAND



GENCOs - NTPC



Power Generation

Generator Transformer

TRANSCOs – POWERGRID, KPTCL

765
kV
400
kV

220
kV

Transformer

SUB-TRANSMISSION

11kV

33kV



240V/415V
Residential /
Commercial
buildings

Small & Medium
Industries



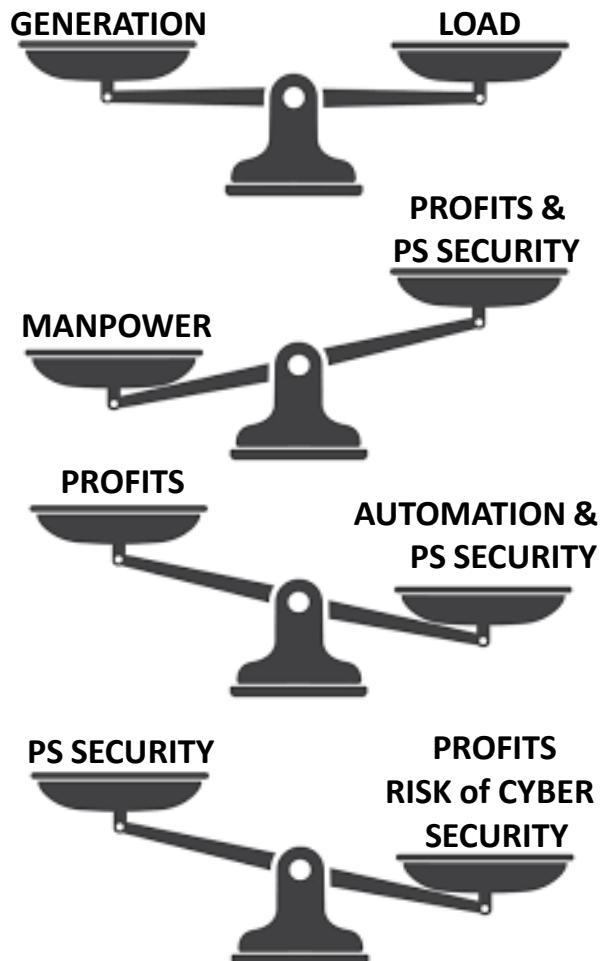
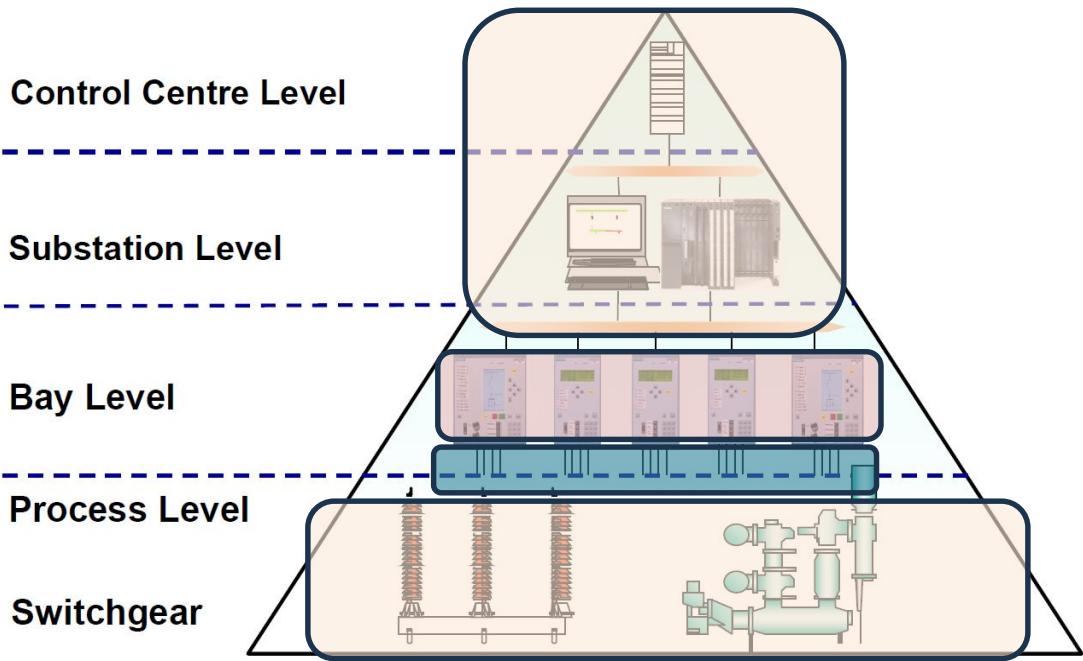
Heavy Industries

DISCOM - BESCOM

132 kV, 110 kV, 66 kV

Transformer

POWER SYSTEM AUTOMATION AND CONTROL



<https://drive.google.com/file/d/1ZNEQBg57D7TAYvc8yrgu5G8pQ2Nb1EKa/>

UNIQUE CHARACTERISTICS OF INDIAN DISCOMS

- Density of their service regions are high
- Directly affect the lively hoods of masses
- Directly influenced by POLITICS
- HAUNTING non-technical losses
- STARVING Balance sheets

Today's Energy Society Needs

Everything Smart

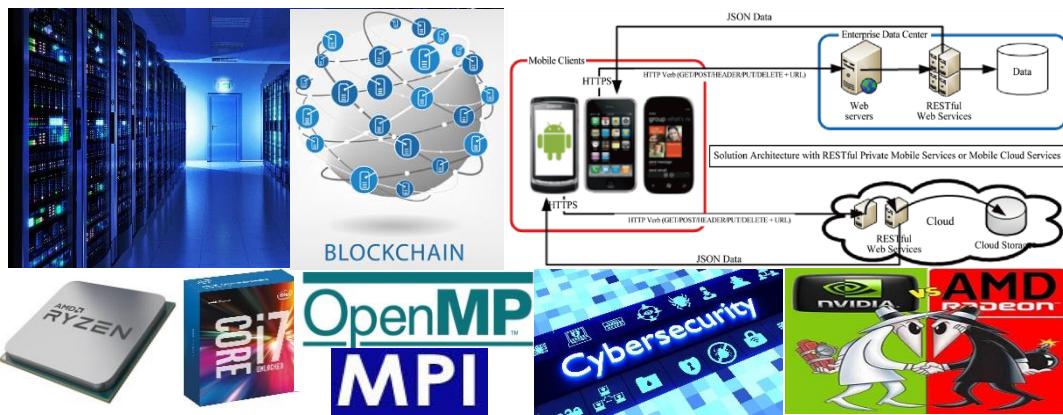
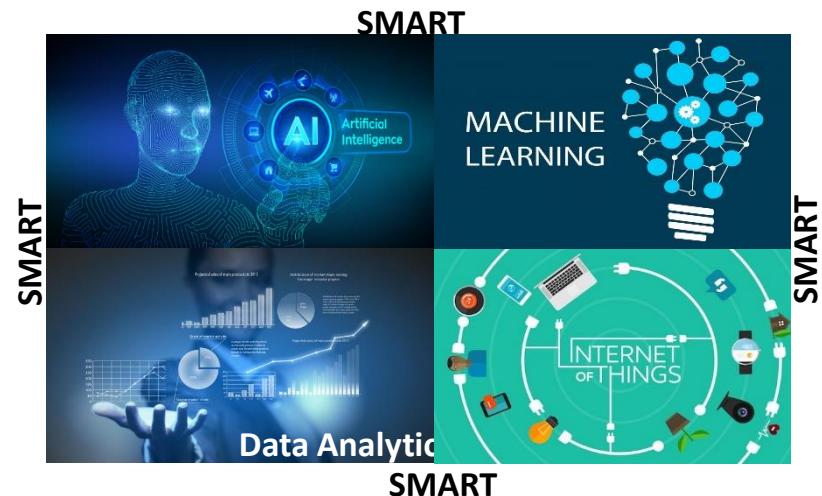


Renewables



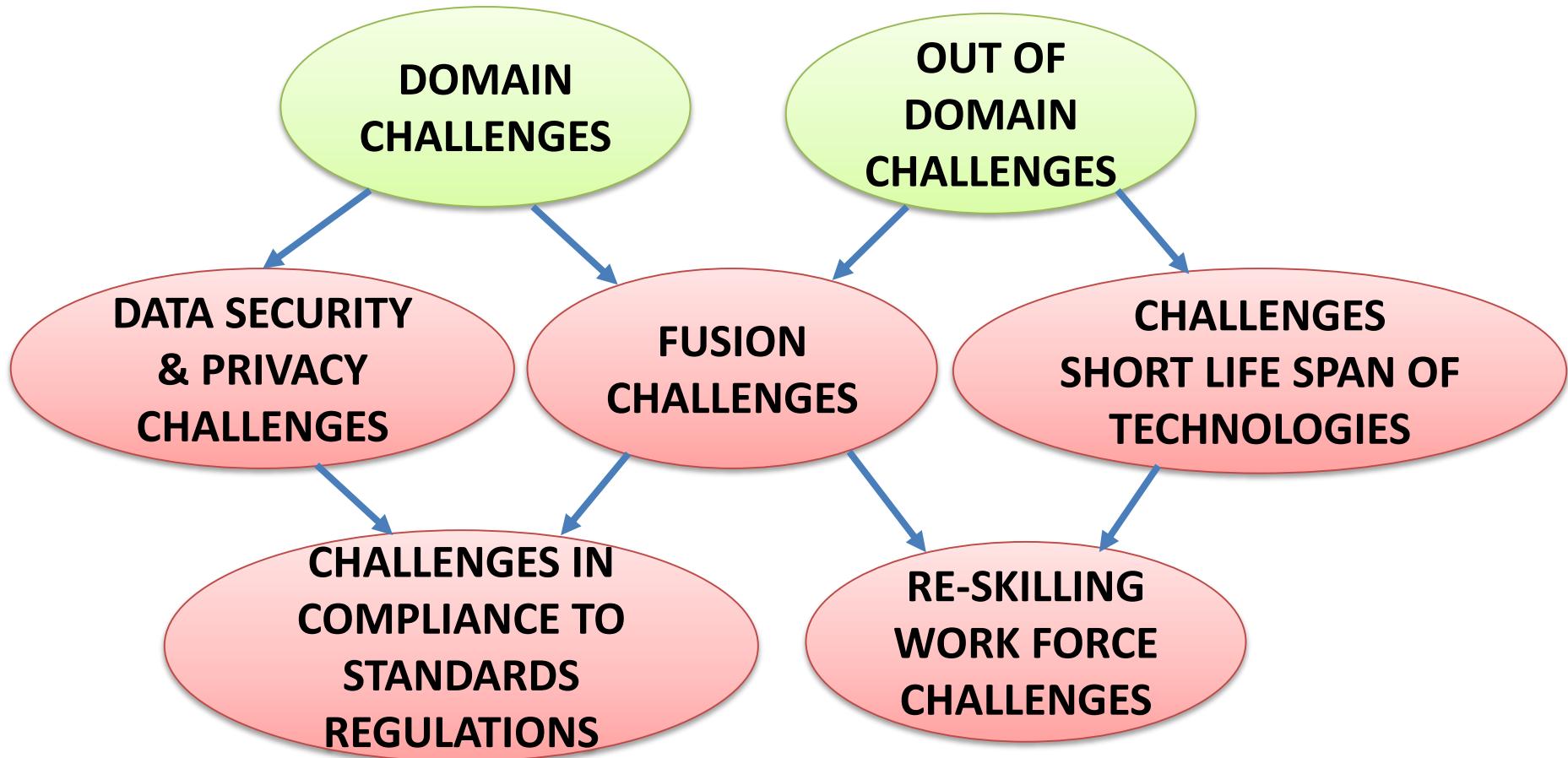
Electric Vehicles

**ELECTRICITY
MARKET**

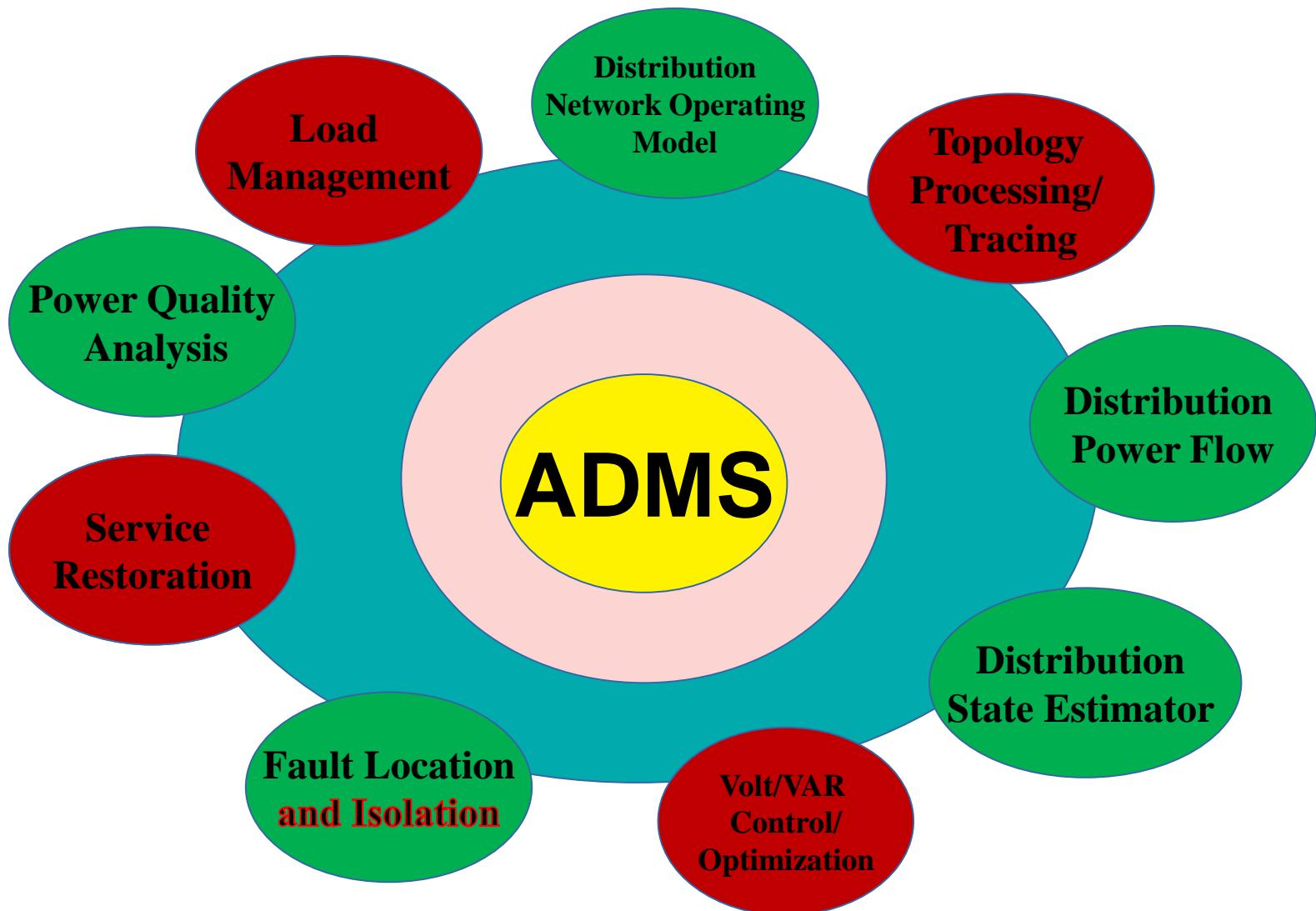


Many utilities need helping hand to Catch the T-BUS

CHALLENGES AUTOMATION BRINGS

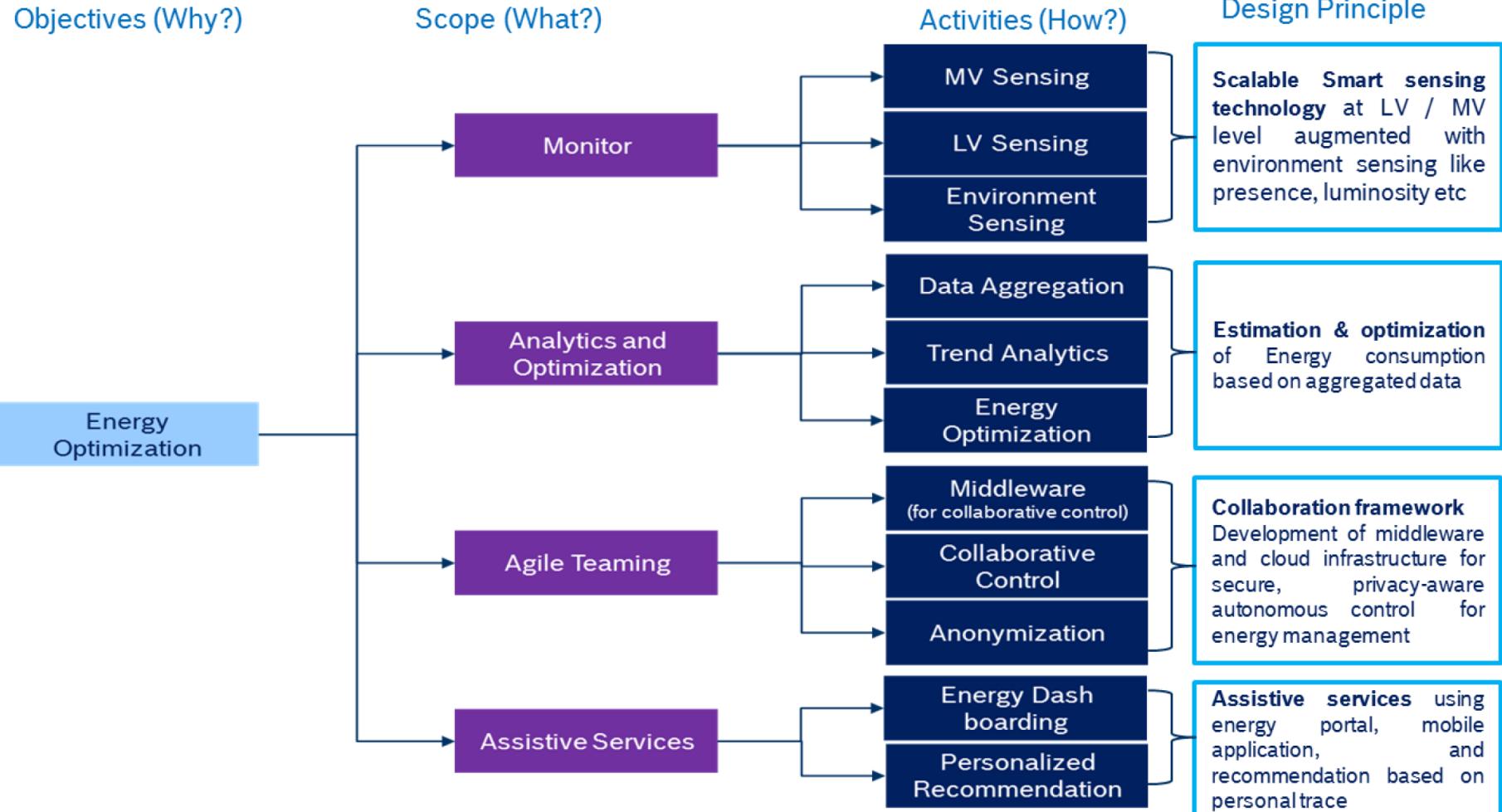


INDIGENOUS Utilities Stack for DIGITAL TRANSFORMATION

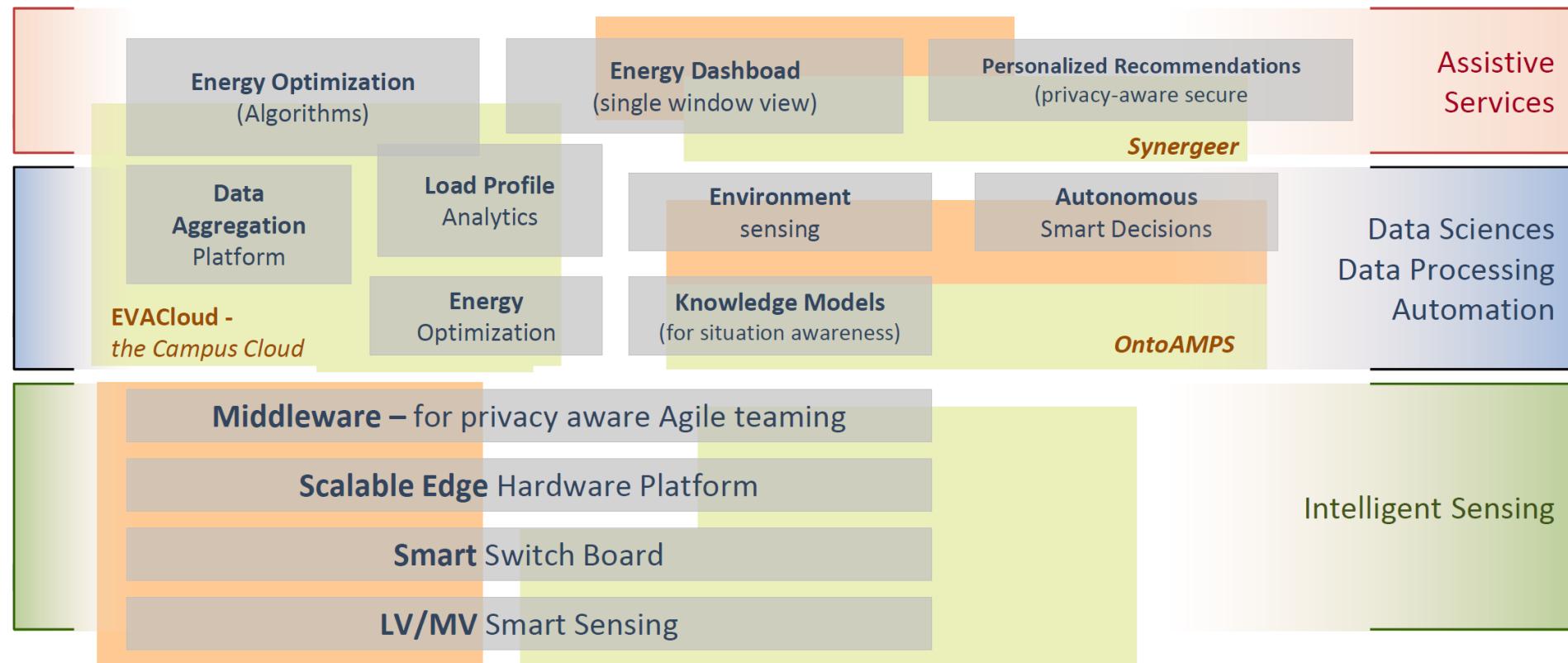


CDACs, CPRI, Academics + Public & Private Utilities + SW experts

BUILDING BLOCKS



BUILDING AN OPEN TECHNOLOGY STACK For STARVING DISTRIBUTION UTILITIES

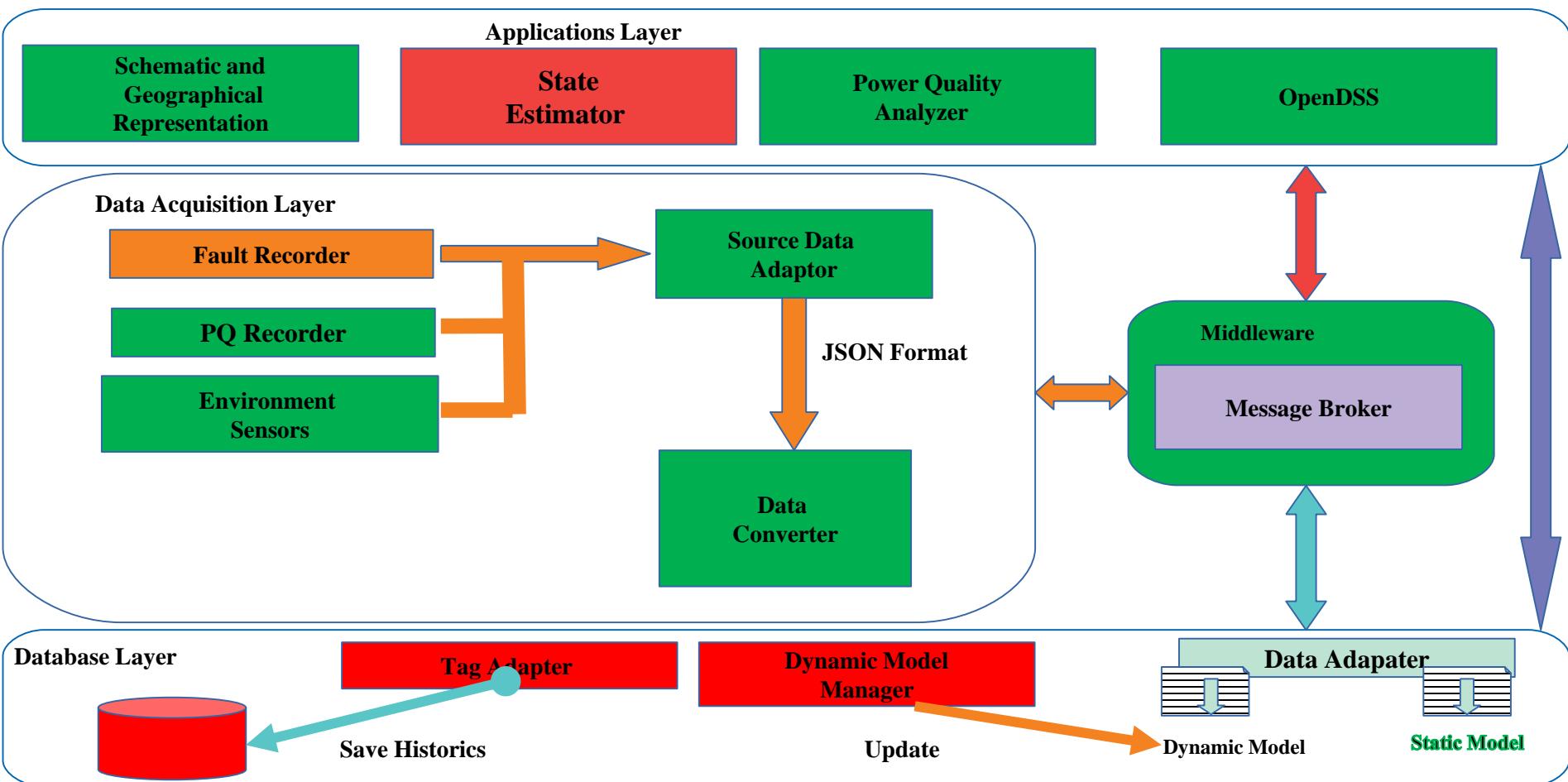


- Distribution Service Areas
- Large Campuses
- Large Commercial Establishments
- Security Driven Architecture

E-Sense: Sensing and Analytics for an Energy-Aware Smart-Campus

- **A open hardware based Power Quality Analyzer + Micro Phasor Measurement Unit (Micro PMU)**
 - Sampling at 32kHz
 - GPS time stamping
 - More than 200 phasors per second reporting
 - Power Quality analysis at the edge
- **An open Visualization portal**
 - Hosts Campus Network Diagram
 - Open Source System Analysis software Open-DSS integration
 - GIS mapping of the Substation Locations
 - Display of Data from Hardware
 - Database for hosting Raw Data

E-Sense - Architecture



CIM Based Open-ADMS

OPEN-ADMS IISc ADMIN

DMS-HOME DMS-MAIN Forms UI Fitures Widgets Charts Tables Pages

SCHEMATIC/GIS

IISc / GIS

IISc-SCHEMATIC

```
graph LR; LBS1[LBS IN SS-5] --> SS3[SS-3]; SS3 --> SS1[SS-1]; SS1 --> SS2[SS-2]; SS2 --> SS6[SS-6]; LBS2[LBS SWIM POOL] --> SS11[SS-11]; SS11 --> SS4[SS-4]; SS4 --> SS13[SS-13]; MUSS11[MUSS SS-11] --> RMU(RMU); RMU --> NVH[NEW VISITOR HOSTEL]; RMU --> NS[NANO-SCIENCE]; RMU --> BS[BIO-SCIENCE]; RMU --> PS[PHYSICAL SCIENCE]; RMU --> AS[AERO-SPACE];
```

View SLD | View SLD Editor | Run Simulation | View CIM Editor

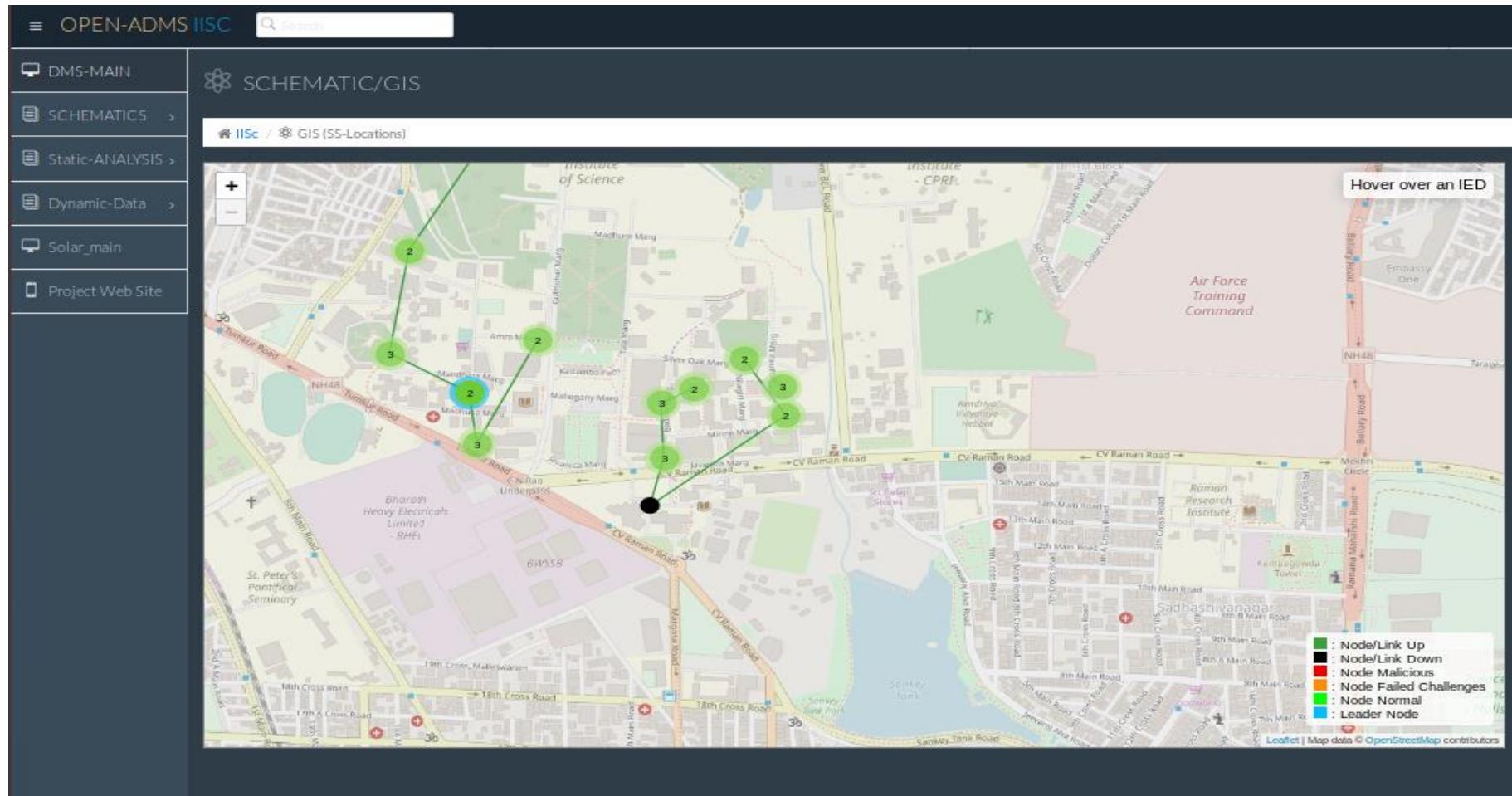
IISc-GIS

OpenStreetMap contributors CV Raman Road 15th Main Road Sri Balaji Stores Indian Javaniya Marg C N Rao Underpass Kadamba Park Mandhara Marg Amra Marg Guincha Marg Madhura Marg Tala Marg Silver Oak Marg Javaniya Marg Mirini Marg Sade Marg OpenStreetMap contributors CV Raman Road 15th Main Road Sri Balaji Stores Indian Javaniya Marg C N Rao Underpass Kadamba Park Mandhara Marg Amra Marg Guincha Marg Madhura Marg Tala Marg Silver Oak Marg Javaniya Marg Mirini Marg Sade Marg

View Larger Map | Parallela Display | streaming Data Display

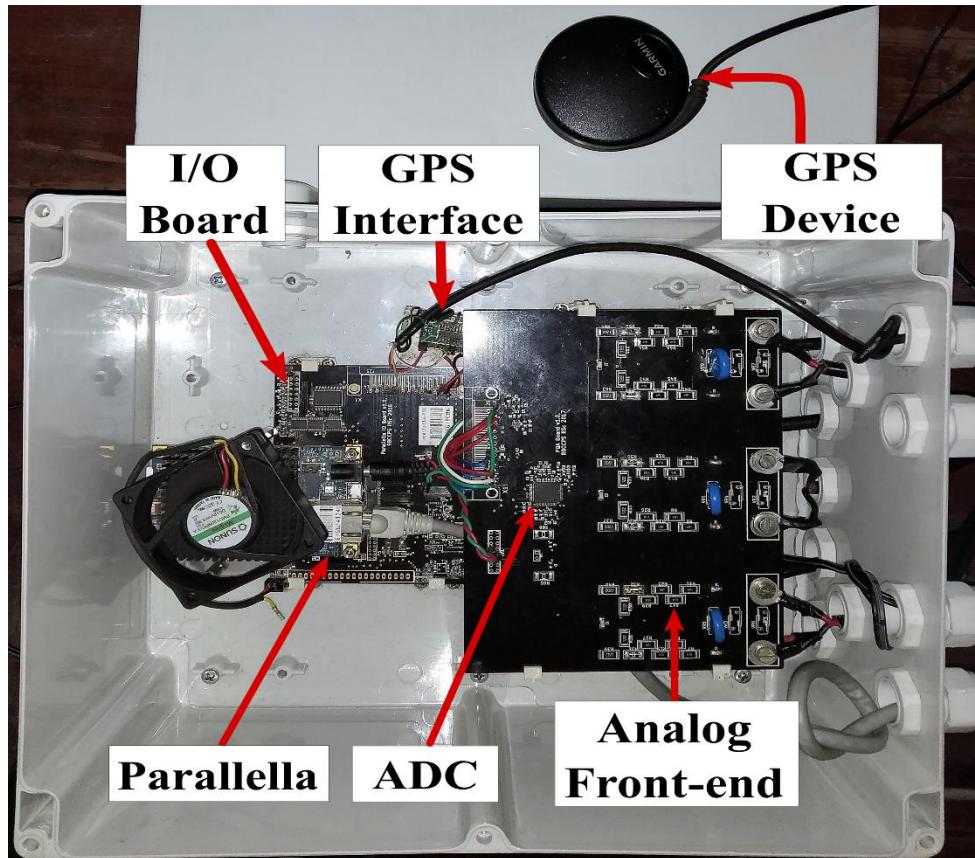
OADMS-Solutions by IISc, Bengaluru

Visualization : Open-ADMS



- **Cyber security Features**
 - Osquery
 - Challenge Response Mechanism
 - Network Booting
 - Freestyle Algorithm
- **Analytics on Parallelia**
 - Fault aware compression algorithm
 - PLL based PMU algorithm
 - Power Quality Implementation as per IEC standard
 - Flicker Meter Implementation
 - Decentralized State estimation Algorithm
 - Fault Classification and Detection using AI
 - Event Detection using Symbolic Dynamic Filtering

Micro PMU + Power Quality Analyzer for Distribution Systems

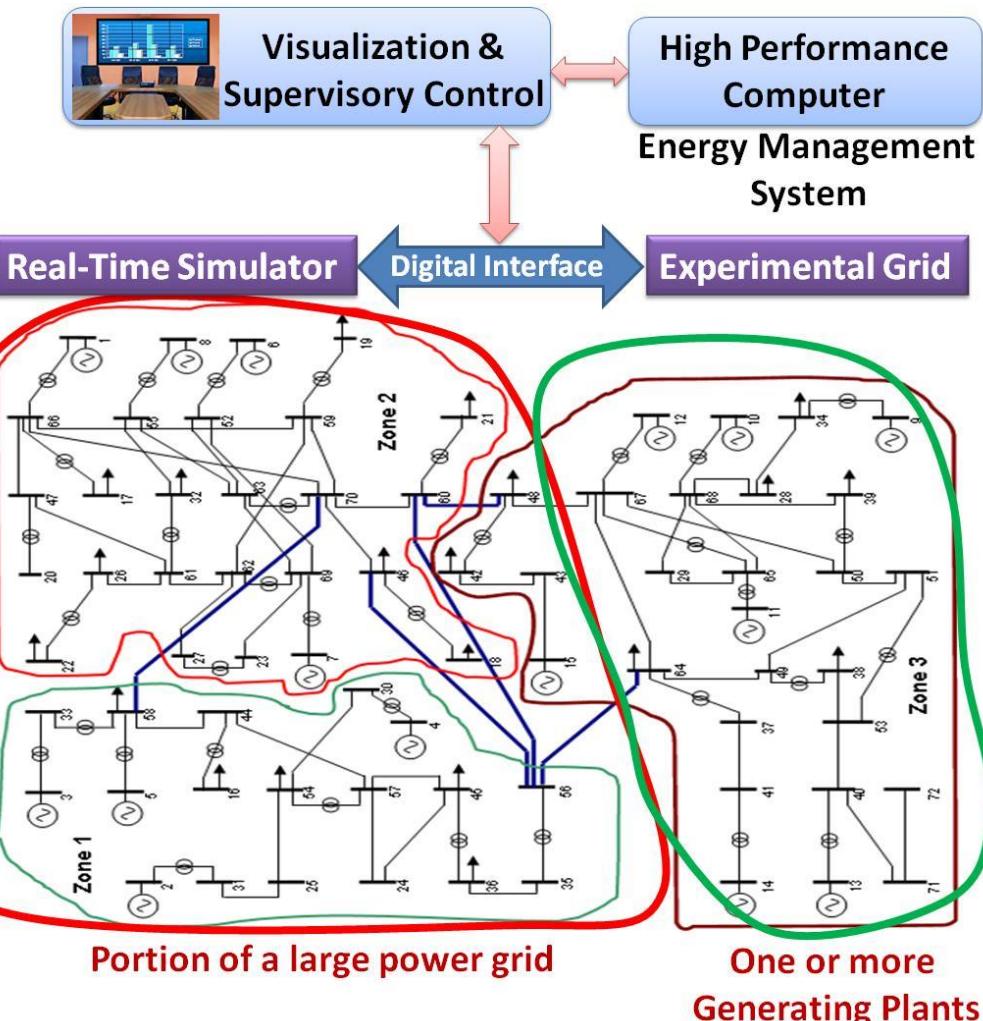


Finds application wherever continuous Waveform recording with high sampling rates are needed.

Especially in Power Quality analysis, Fault recording

Phasor Estimation for System Operational view and analysis in normal operation

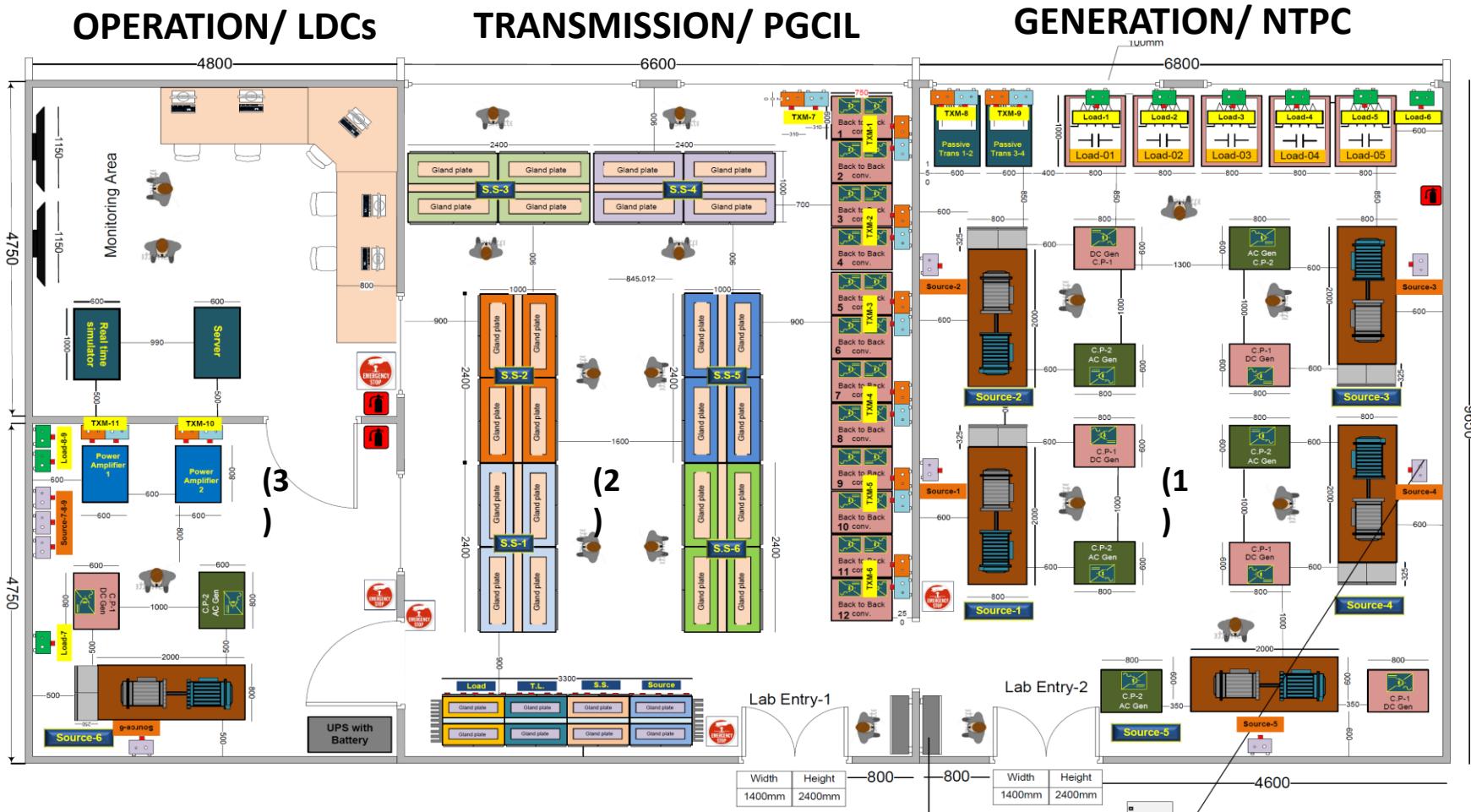
Smart Energy Systems Infrastructure - Hybrid Test Bed (SESI-HTB)



Parallel algorithms:
Power flow, Transient stability
state estimation etc.

- Real-time simulator for simulating a large, complex power grid
- Power Amplifier for interfacing Physical and Real-time power systems

SESI-HTB LAB Layout (3-rooms) – 18.2m*9.65m



ROOM-1 SOURCE EMULATION LAB

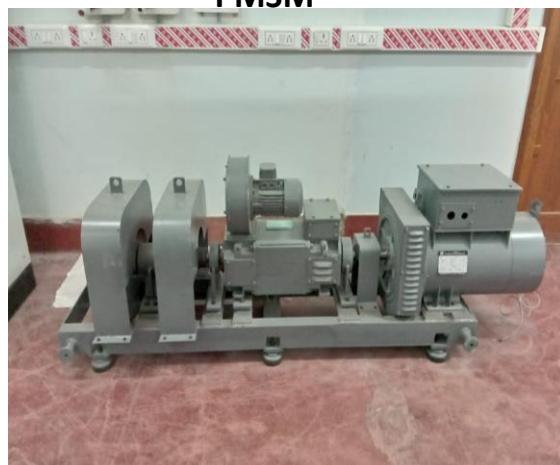


- **4 Synchronous Machine Sets**
- **1 DFIG, 1 PMSM**
- **6 custom Load Banks, +/- 0.6pf, 5 kVA**
- **Synchronization Trolley**





PMSM



DFIG



SYNCHRONOUS MACHINE



CONTROL PANELS



ROOM-2, TRANSMISSION EMULATION: Generalized Substation Panels



SIX RECONFIGURABLE GENERALIZED SUBSTATIONS



TOPOLOGY CONNECTION PANEL

Designed to Mimic a Practical Substation
Seven Practical Station Arrangements, IEC61850 Protection and Fiber
Optic Communication Systems

Room-2, Passive and Power Electronic Emulated Electrical Lines



The transmission line emulates transients up to 5 kHz.
230 kV line scaled to 220 V.



Realtime Digital Simulator

❖ An Indigenous Realtime Digital Simulator for Power system and Power Electronics
“Capable of doing SiL, HiL and PHiL simulations ; Rapid prototyping of Systems”

Motivation

- Commercially available (Foreign Vendors) Real-time Simulators cost starts around 50 Lakhs
 - ✓ Proprietary technology
- The software costs from 1.5 L to 20 L; any software updates 15% to 20% extra
- Limited access for testing new simulation algorithms



Features

- Generic Motherboard based design
- Custom ported Realtime Linux
- Indigenous system Simulation software
- Automatic parallelization
- 10 μ s time step
- High speed I/Os with 1 μ s DAQ time

Specification

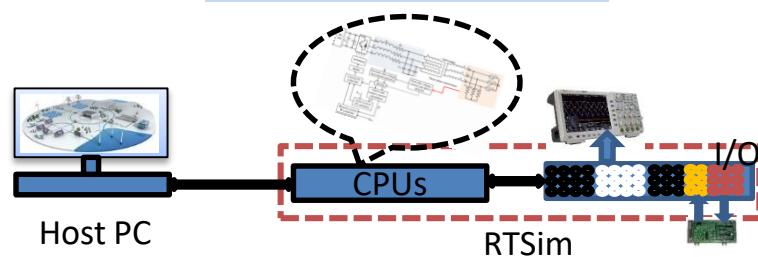
Intel Xeon 4210 R 2 CPUs , 20 Dual Cores, Virtually 40 Cores

Analog Outputs 38 Channel, 16-bit resolution, $\pm 10V$

Analog Inputs 16 Channel, 16-bit resolution, $\pm 10V$

Digital I/Os 24 Channel , 0 – 10V range

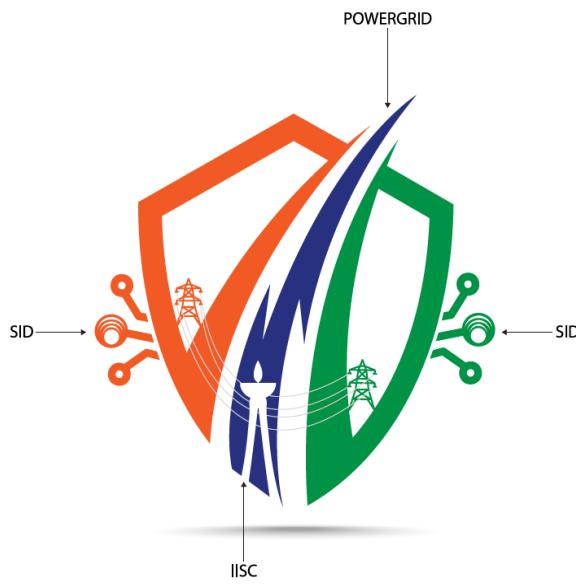
Simulation Environment





POWERGRID

CENTER OF EXCELLENCE IN CYBER SECURITY



पावरग्रिड
POWERGRID

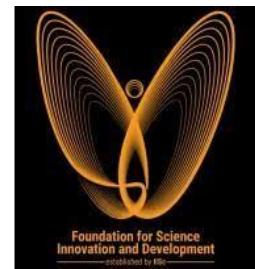


Shri K. Sreekant

Chairman & Managing Director



Division of EECS
Electrical, Electronics, and Computer Sciences
Indian Institute of Science, Bangalore



Foundation for Science
Innovation and Development
(FSID)

119 Crores for a Period of 10 Years – Established -- October 2022

The PGCIL Team



Shri. R. K. Tyagi



Dr. Subir Sen



Anand Shankar



Abhishek

Governing Board Members

Executive Committee Members

Project Coordinators

- 15+ PGCIL Employees at various levels working with faculty members

Green Energy

Coal – Free Nature's Gift

Wind – Free

Nuclear – Uranium – Free

Solar – Free

Natural Gas – Free

Do not extinct

Diesel – Free

All these extinct at one time or other

**Is that the driver for Green
Energy**

Green Energy

The Fossil Fuelled Plants which Helped Transforming the Human Life to Phenominal Growth, Urbanization and Sophistication



Non-Green Today

WHY ??

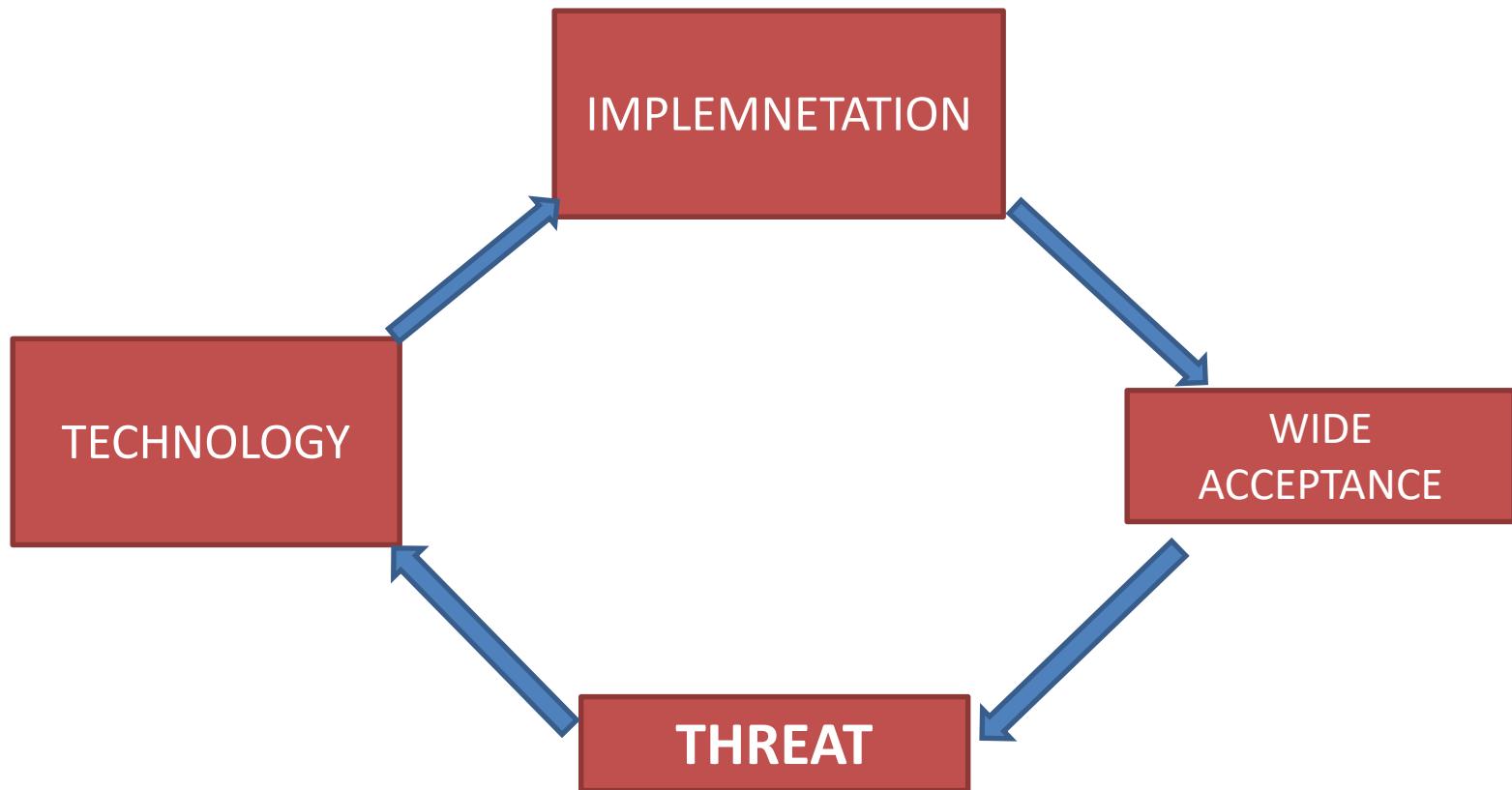
After more than 100 years of existence ----- ENVIRONMENTAL IMPACTS REALIZED

WIND – SOLAR



Green Today

Green Energy



After some years of existence --- HOPE THEY DON'T BECOME OBSELETE

Green Energy

