Session 4: Communication Technologies for Utility Operations

Session Contents

- Telecommunication Options for Electric Utilities
- What to consider before strategic investment.

Speaker:

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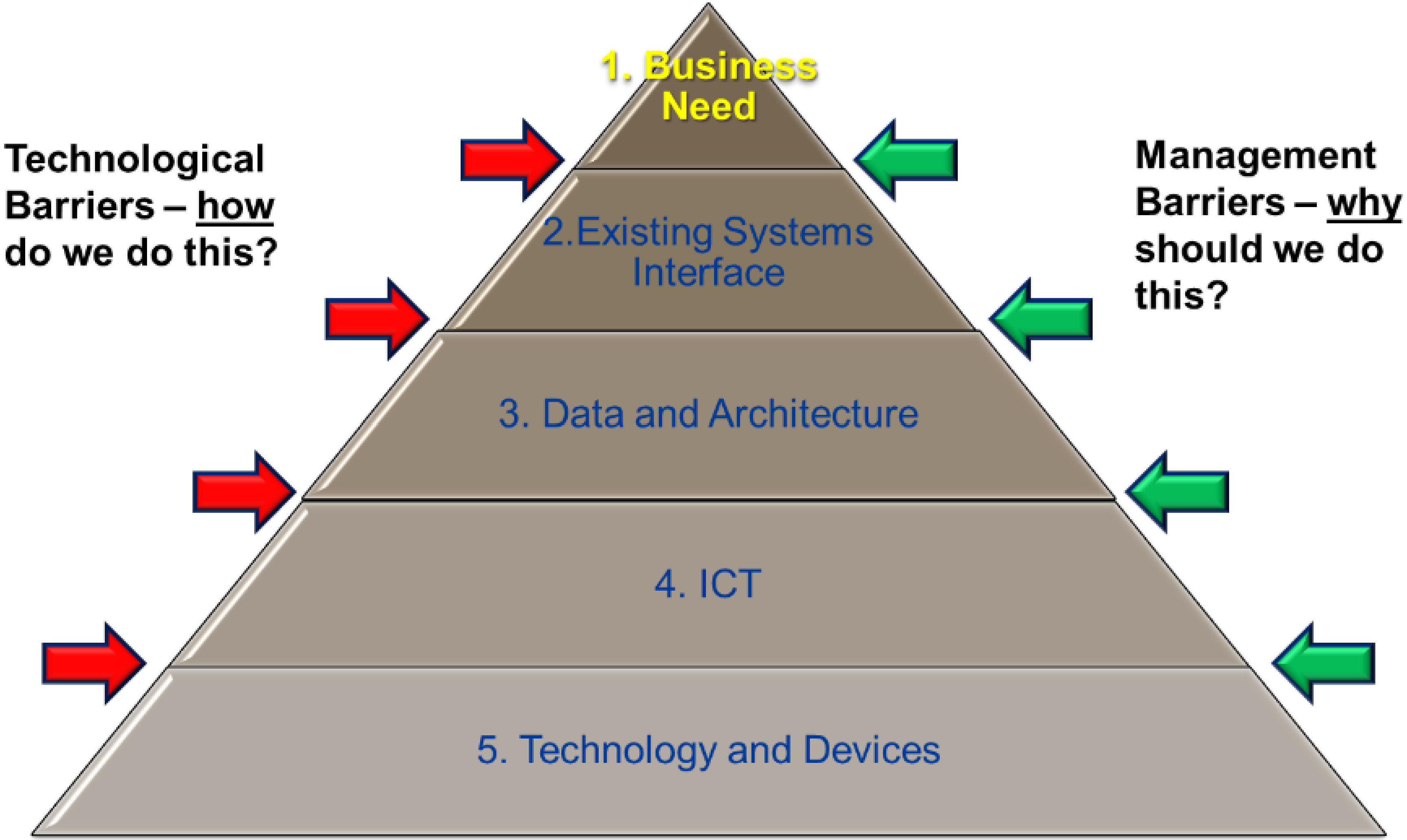
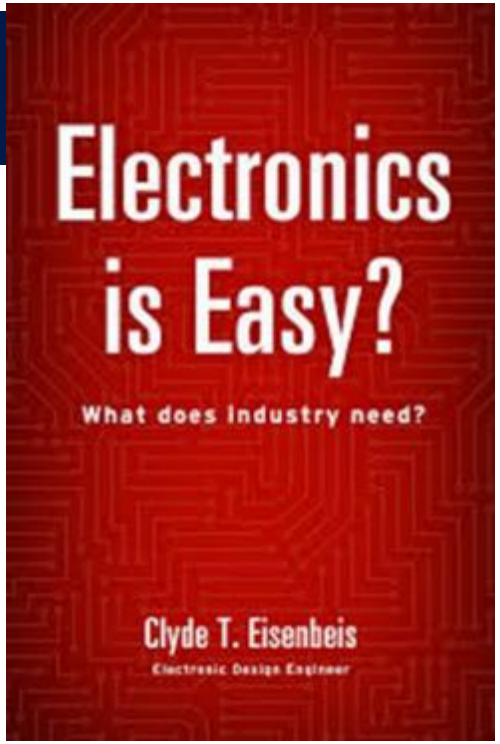
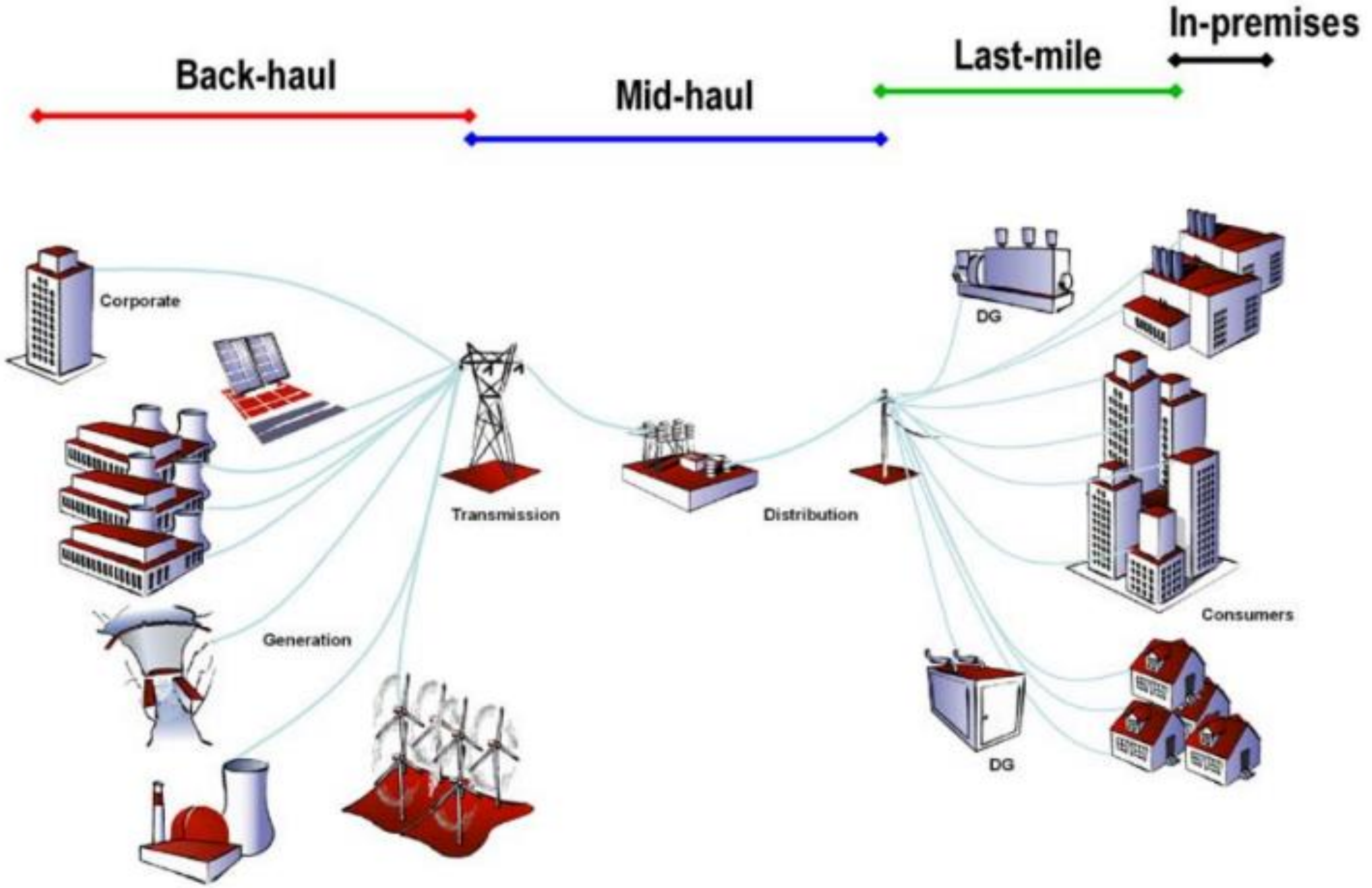
Technology Options and Business Needs





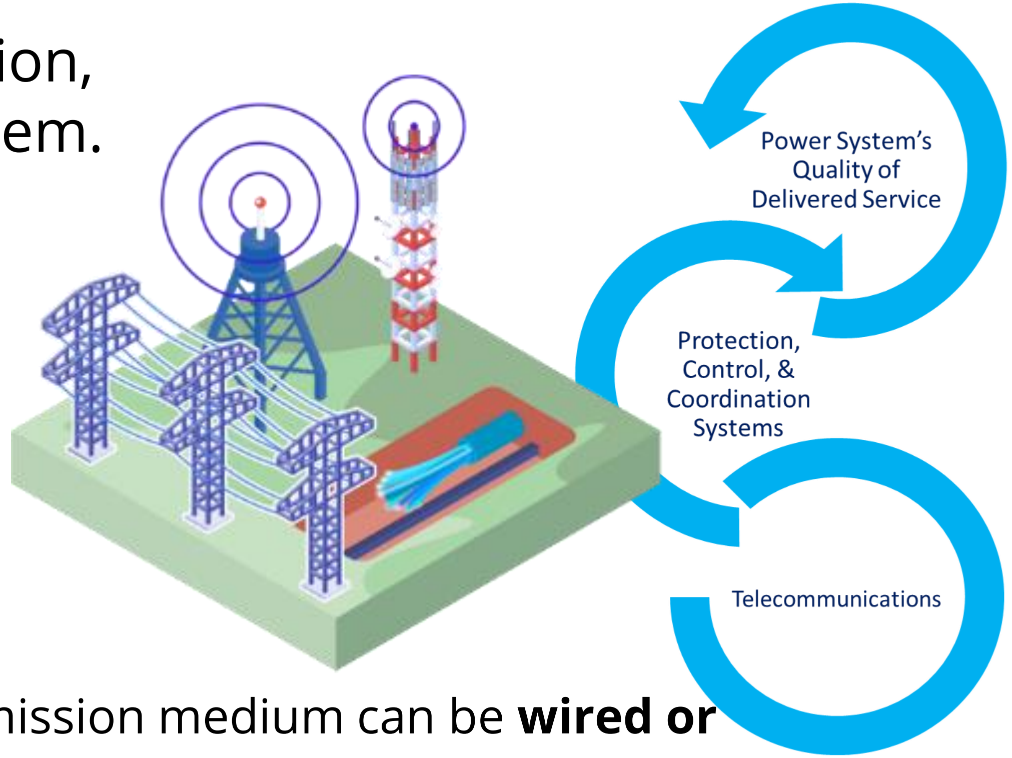
Physical Communication Media

- No single communication technology is expected to meet the needs for supporting the grid modernization vision.
- The utility will likely have a hybrid solution for its communication platform, trying to design the best match for their long term needs based on the geography of the communicating devices.
- Technology options generally break down into four categories: Power line carrier (PLC); Broadband over Power Lines (BPL); Hard wired such as fiber or copper; and Wireless or radio frequency (RF).

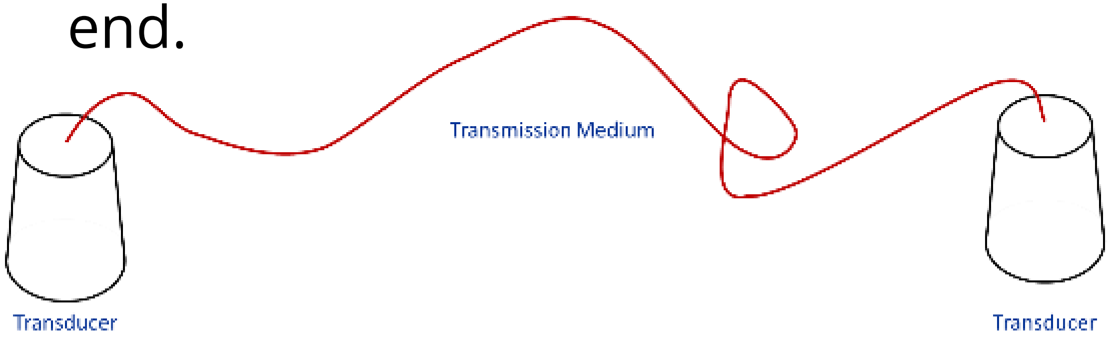


Telecommunications for Power System

- Telecommunications system are critical for protection, control, and coordination of the electric power system. And increasingly for modernizing the grid and customer communications.



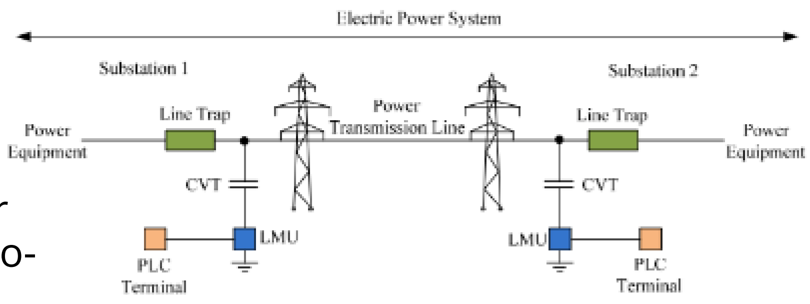
- A typical telecommunications system consists of a signal energy transmission medium, with a pair of transducers at each end.

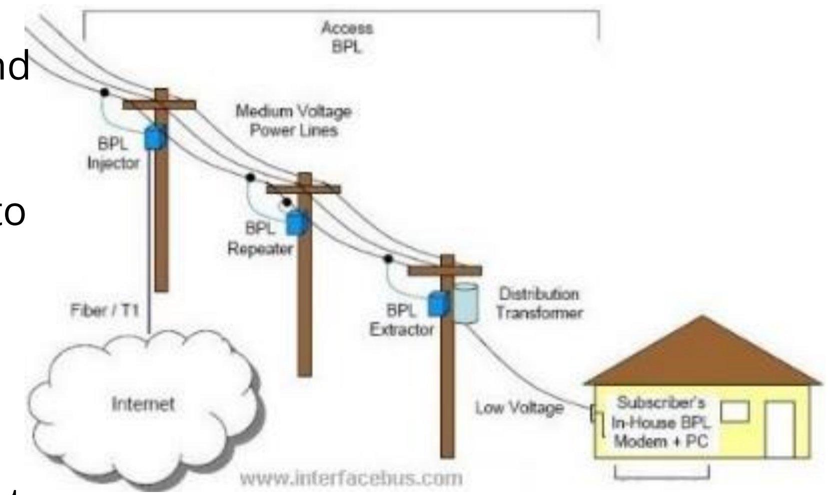


- The transmission medium can be **wired or wireless.**
- The transducers perform two functions:
  - Convert energy signal into a form suitable for transmission medium
  - Coordinate / manage the shared use of the transmission medium

Wired Communications Systems

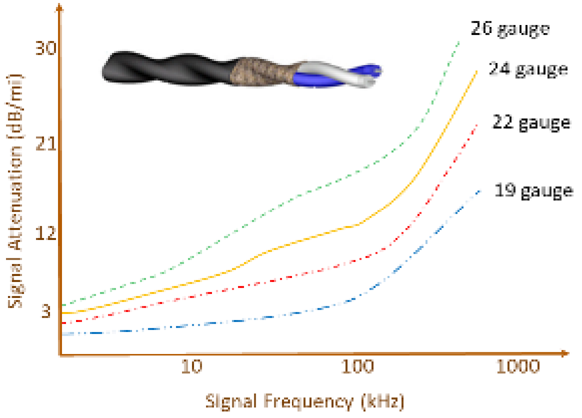
- There are five major types of ‘wired’ transmission media.
  - Power Line Carrier PLC technology
    - Has been in use for many years in the utility industry. PLC communicates over electric power lines and provides low-cost, reliable, low- to medium-speed, two-way communications between a utility and its customer or point to point (protection schemes). PLC is almost always proprietary to a single vendor.
  - Broadband over Power Lines BPL
    - A variety of approaches to communicate over the power and energy cables and equipment that supply electric energy to the customer.
    - Challenges include getting messages through utility equipment other than wires, including transformers, splices and other equipment. It can be subject to interference from both terrestrial and extraterrestrial sources of interference.
    - Initially, application of BPL typically focused on Internet access and voice over Internet protocol for consumers. This has shifted to a focus on using BPL to meet utility needs for AMI
    - A common criticism of BPL and PLC is that they are by definition, communications technologies that are vulnerable to power outages. This is not critical for traditional meter reading and billing, but can become an issue if the metering (communication) system is used to augment distribution automation or enable demand response.



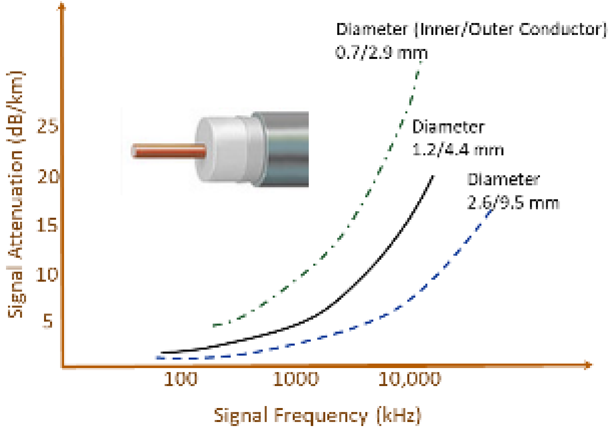


Wired Communications Systems cont.

- Twisted Pair
  - A pair of insulated conducting wires are used to carry the communication signal through one wire and the ground reference through the other.
  - The two wires are twisted together to reduce susceptibility to interference.
  - Typical example is a category 5 cable used for Ethernet connectivity.



- Coaxial Cable
  - In this metallic cable, a solid conductor is coaxially surrounded by a cylindrical outer conductor. The two are separated by a dielectric medium.
  - Coaxial arrangement provides better immunity to interference than a twisted pair, resulting in support for significantly higher frequency signals and hence a higher information carrying capacity.

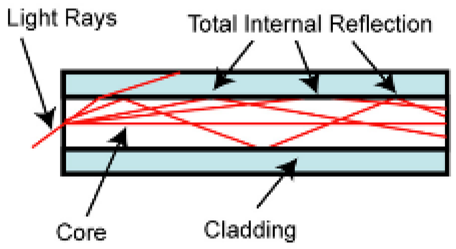


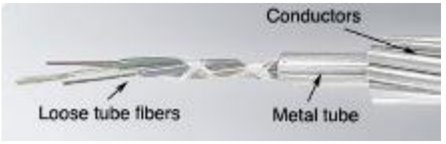
Wired Communications System

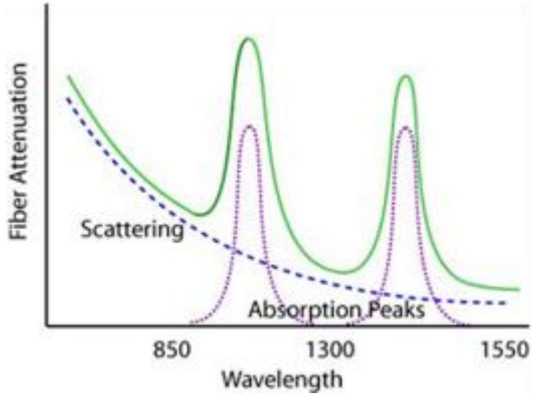
– **Optical Fiber**

- The go-to transmission medium in telecommunications system, where feasible.
- Preferred for its immunity to interference and high information carrying capacity.

- An optical fiber consists of a core – a thin cylinder of glass surrounded by a concentric layer of glass that acts as a cladding.
- This arrangement takes advantage of the phenomenon known as "total internal reflection" to carry signals across large distances.
- Optical signals traveling through an optical fiber cable at these wavelengths can travel hundreds of miles and simultaneously carry millions of conversations.
- Utilities have been using optical fiber since the 1980s. For example, in transmission systems, optical fiber is often installed on transmission towers in the form of optical ground wire (OPGW).



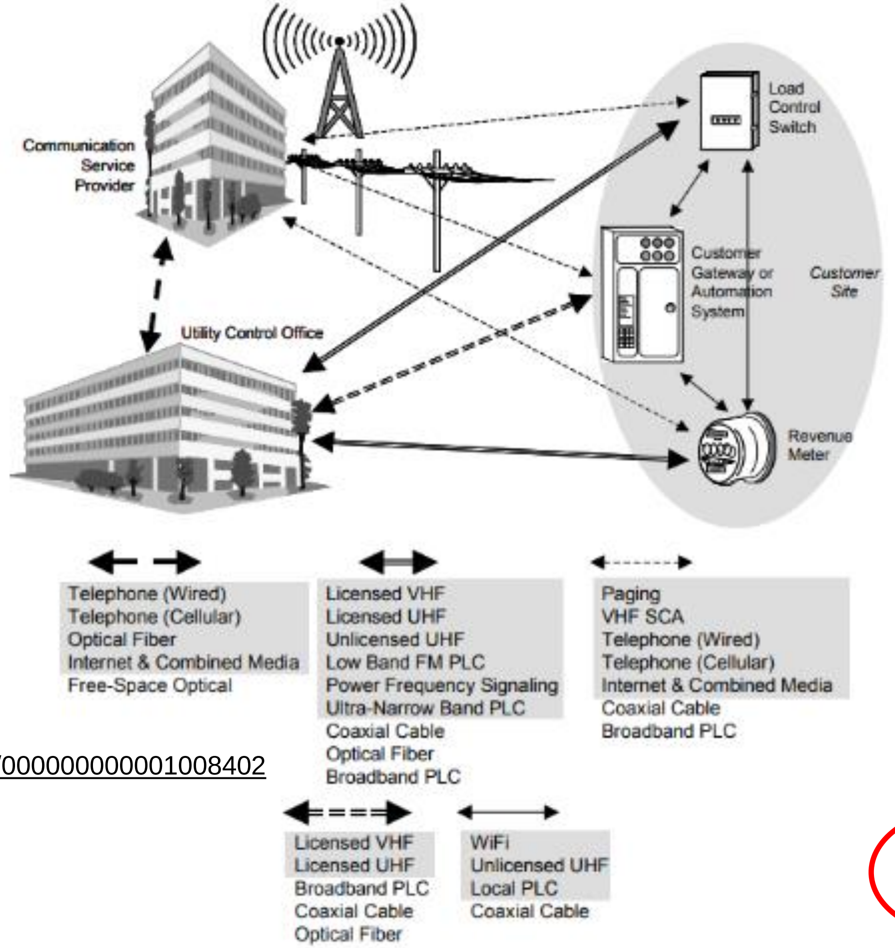




Wireless Communication Systems

- Satellite Communication
- Broadcast Radio (HF/UHF/VHF)
- Microwave Communication
  - Satellite Microwave Communication
  - Terrestrial Microwave Communication
- *Wi-Fi*
- *Bluetooth Technology*
- *Infrared Communication*
- *Mobile/Cellular Communication Systems*

Utility Customer Communication Options



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Legend

● Technology is entirely suitable, economical and capable of meeting one or more important application requirements.

◉ Technology is capable, but others are generally better in performance or cost for meeting one or more application requirements. This technology will be effective if the preferred technologies are inappropriate for some reason.

○ Technology is a poor choice for economic or technical reasons, but can perform the function.

Blank – Technology is functionally unsuitable for the application and can make no contribution, at any price.

	Connectivity Applications						
Technologies	**Critical Pk/Real Time Pricing**	**Utility Direct Load Control**	**Auto Bldg. Control**	**Customer Generation Dispatch & Control**	**Demand Side Bidding**	**Outage Detection/ Customer Notification**	**Interactive Energy Information Kiosk**
Paging	●	●	●	●	●	●	
VHF SCA	●	●	●	●	●	●	
WiFi	○	○	●	●			
Licensed VHF	●	●	●	●	●	●	
Licensed UHF	●	●	●	●	◉	◉	◉
Unlicensed UHF	○	○	○	○		◉	
Broadband PLC	○	○	○	○	○	○	○
Low Band FM PLC	◉	●	◉	◉	◉		
Power Frequency Signaling	◉	●	◉	◉	◉		
Ultra-Narrow Band PLC	◉	●	◉	○	◉		
Local PLC	○	◉	◉	◉			
Telephone (Wired)	●	○	●	●	●	●	●
Telephone (Cellular)	●	●	●	●	●	●	●
Coaxial Cable	◉	◉	◉	◉	◉		◉
Optical Fiber	◉	◉	◉	◉	◉	◉	◉
Free-Space Optical	○	○	○	○	○	○	○
Internet & Combined Media	●	◉	●	●	●	○	●

Wireless Communication Technologies Comparison

Few

Use Cases

All

Technology	Throughput	Latency	Range	Duplex	Spectrum
LoRaWAN	0.25 – 11kbps	Seconds	1-10 km (tower)	Half	Unlicensed sub-1GHz
NB-IoT	50 – 150 kbps	100 ms to seconds	~15 km (tower)	FDD /half	Licensed
Wi-SUN	50 – 300 kbps (w/ FAN 1.0)	Variable (mesh)	~ 1 km node-to-node (mesh)	Half	Unlicensed sub-1GHz
LTE-M	100 – 500 kbps	100 ms	~10 km (tower)	FDD / half	Licensed
700 MHz UAB	50 kbps – 1 Mbps	25 – 100 ms	5 – 20 km	Half or Full	Licensed
3 x 3 PLTE	Up to 15 Mbps	25 – 80 ms	5 – 20 km	Full	Licensed
Commercial LTE	Up to 150 Mbps	40-80 ms	1 – 10 km (tower)	FDD or TDD	Licensed*
5G	Up to 1 Gbps	As low as 1 ms	Depend on band	FDD or TDD	Licensed*

Performance

* LTE and 5G may operate in unlicensed spectrum

Benefits and Challenges for Utility Private LTE/5G

Long-term evolution (LTE) is a standard for wireless broadband communication for mobile devices and data terminals, based on the GSM/EDGE and UMTS/HSPA standards. 5G's main differentiator from 4G LTE is its speed, reliability, higher bandwidth and lower latency.

Benefits

- Resilience and Reliability – network is built to utility's standards
- Replacement for 20+ unsupportable, separate communication networks
- One network infrastructure supports almost all FAN use cases
- Scalable bandwidth and density
- Interoperable standards, strong ecosystem
- Cyber Security – data never leaves utility control
- Option to roam onto commercial cellular (dual SIMs, eSIM)
- Future path to replace LMR and move all voice to VoLTE
- Roadmap to migrate to 5G

Challenges

- Cost and availability of licensed spectrum
- Cost of required infrastructure (towers and sites) to provide coverage across territory (capital)
- Skill set to deploy and manage the LTE network and core

FAN: Field Area Network
SIM: Subscriber Identity Module
LMR: Land Mobile Radio
VoLTE: Voice over LTE

Private LTE/5G Challenges and Opportunities

- Many variables and deployment options

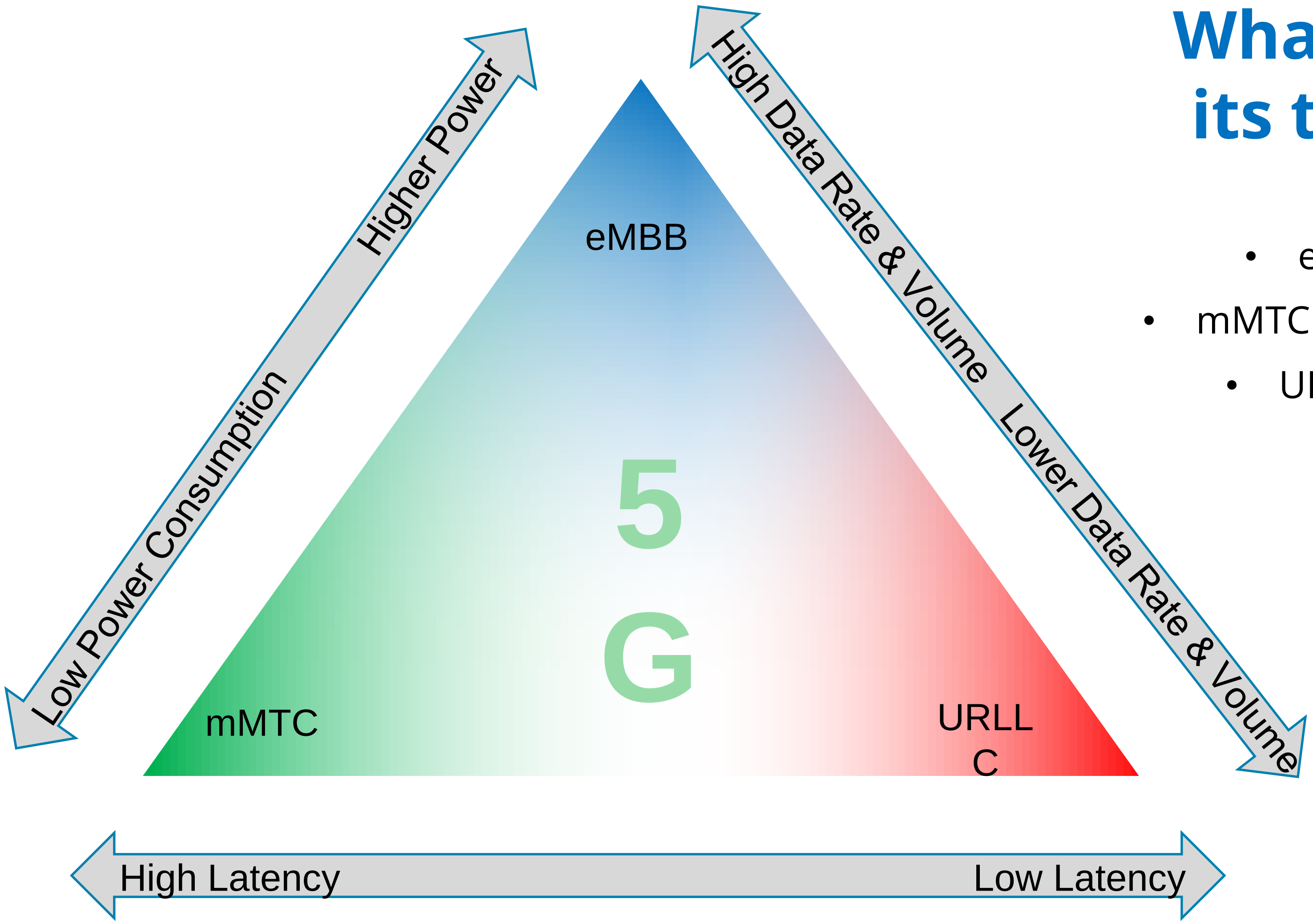
- Ownership: Private network vs commercial operator's network
  - Cost implications, cyber security implications, reliability implications…

- Spectrum is key – low band, mid band, millimeter wave
  - Licensed spectrum is purchased or leased
  - Unlicensed spectrum is possible with MultiFire (LTE) or NR-U (5G)

- Generations: LTE provides evolution path to 5G

- Spectrum band and LTE vs 5G choice affects device compatibility

Why Private LTE? 5G is here now…

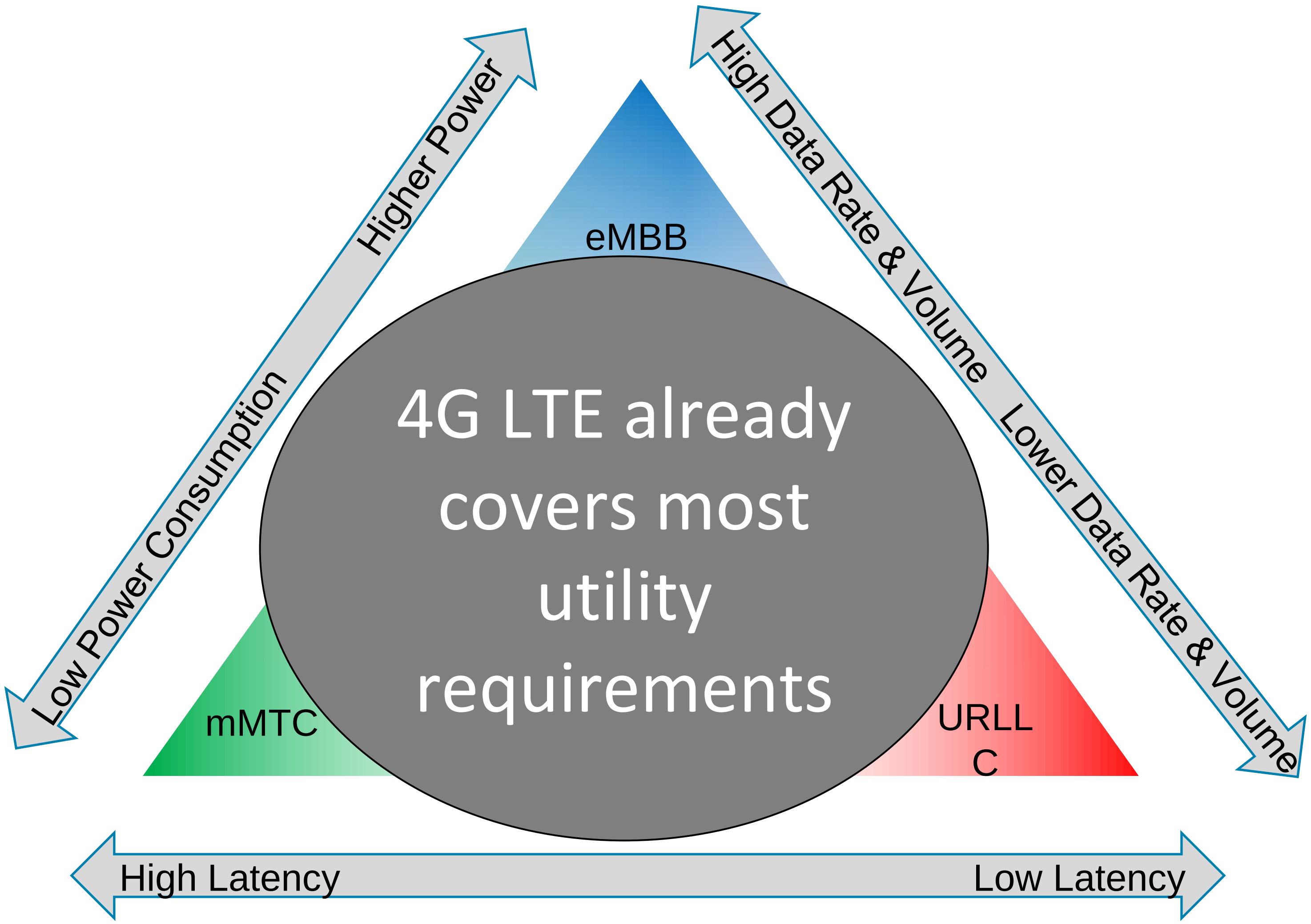


What does 5G offer with its three differentiated services?

- eMBB: enhanced Mobile Broadband
- mMTC: massive Machine Type Communications
- URLLC: Ultra-Reliable and Low Latency Communications

(Also known as Critical MTC)

Where and when is 5G needed for grid use cases?



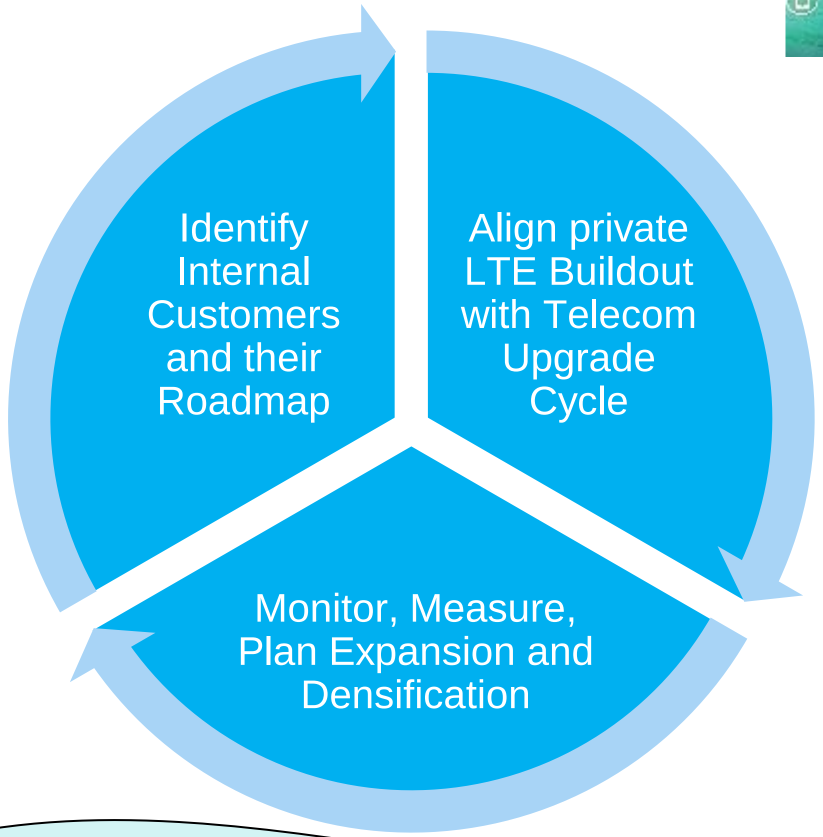
5G "pushes the limits" in these three directions

The tips of the triangle represent utility use cases where *only* 5G can serve

Building the Business Case for Private LTE/5G

Establish a Full Suite of Use Cases

- Field Devices (SCADA)
- Security / Situational Awareness / Wildfire
- Digital Worker
- Voice
- Sensors, cFCI
- Real-time, Low Latency (Opportunity for 5G)
- Customer / Prosumer (behind the meter)



Evaluate potential for network sharing:
Smart City, bordering Munic, Water, Gas, etc.

Some examples of what utilities are doing

New York Power Authority (NYPA) Private LTE Testing and Performance Assessment

A testing platform for Field Area Networks (The FAN Testing Platform) has been developed as part of the Information and Communication Technology project set 161G on Telecom to assist utilities. NYPA applied the FAN Testing Platform to perform an assessment of the performance of the Private LTE pilot that was in operation at the Blenheim-Gilboa pumped hydro facility.

The research revealed the detailed performance characteristics of the Private LTE system, enabling NYPA to better understand the capabilities of the prototype system at the pilot, and plan for future deployments. The testing also revealed new learnings about the overall network architecture that will be essential for integrating the PLTE network into the overall NYPA operational network.

Ameren

EPRI Field Area Network Research Project – Private LTE Guidebook and FAN Testing Platform

Results from the Private LTE Guidebook provided insights on technology, spectrum options, and use cases to support business case development and investment decisions. Once the pilot project was underway, EPRI's FAN Testing Platform provided quantitative results to asses and verify the network performance.

EPRI's in-depth research helped us not only to make a decision to pursue private LTE, but during our pilot provided above and beyond support for doing unbiased bandwidth and latency testing that was critical for us to understand.

Implementation Experiences in Electric Utilities

Best Practices and Lessons Learned

"Select Utility" Insights

- Interest from reliability and planning groups for more devices on the line has rapidly increased.
  - The need to utilize the grid more effectively is driving the need for devices such as Reclosers, IntelliRuptors, Fault Current Indicators etc.
  - Connectivity via public cellular on a per device/SIM basis, can became financially prohibitive.

Select Utility's Telecom Project Lead

"We have come to realize that telecom infrastructure modernization is an absolute necessity. Public safety and energy security for our state mandates grid modernization. Which means tens of thousands of new devices will soon be communicating out on the lines. The amount of telecom we are going to need requires different types of technologies, which are all part of our telecom transformation work".

EPRI

Implementation Experiences in Electric Utilities

Best Practices and Lessons Learned

Importance of Project Management and Execution in ICT Projects (including Private Communications Networks)

ICT projects fail at a higher-than-average rate across all industries.

Approximately 70% of projects completed under the ARRA funded Smart Grid Investment Grant Program reported Project Management as a key challenge; When unaddressed, these challenges can lead to schedule delays and missed objectives.

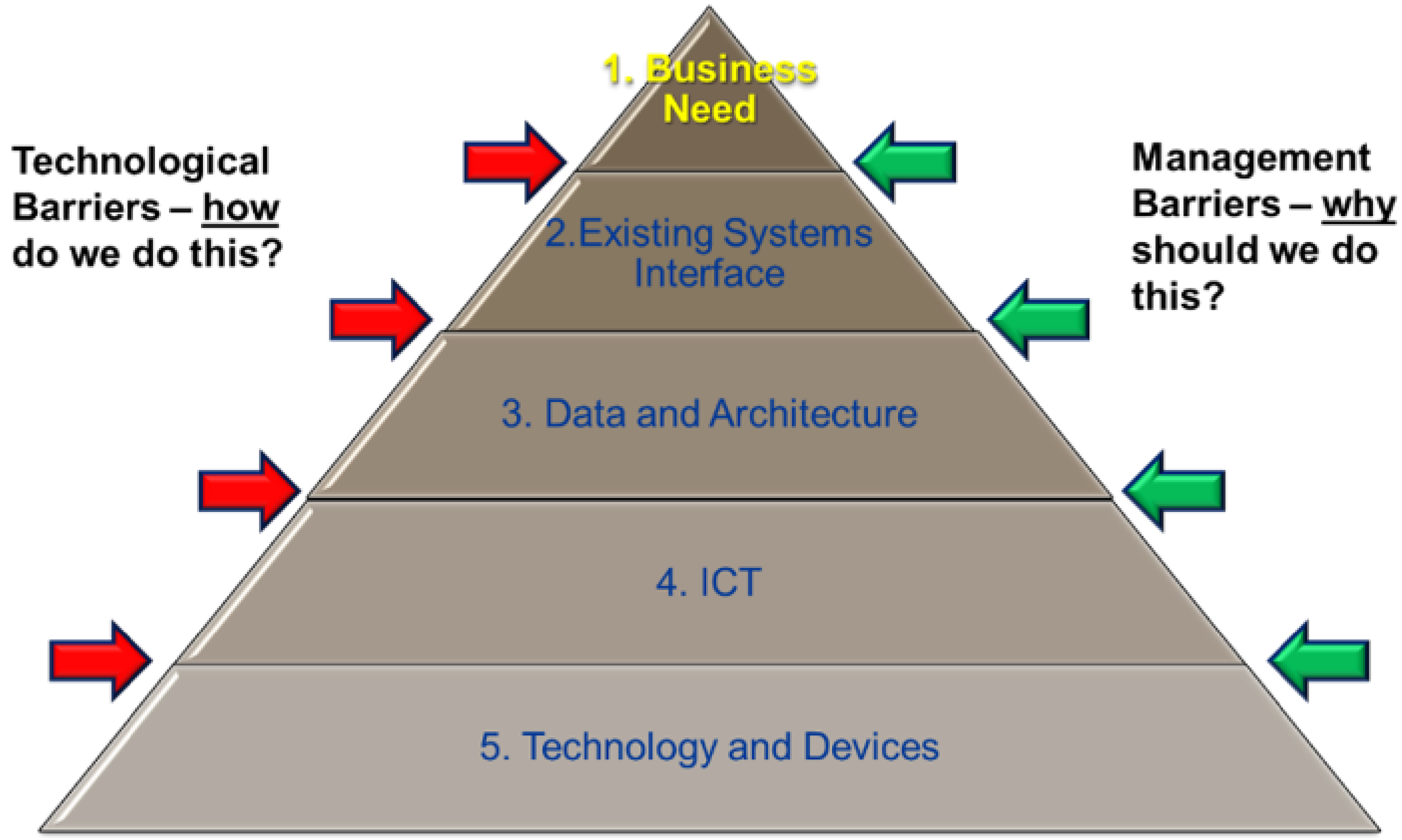
>70%

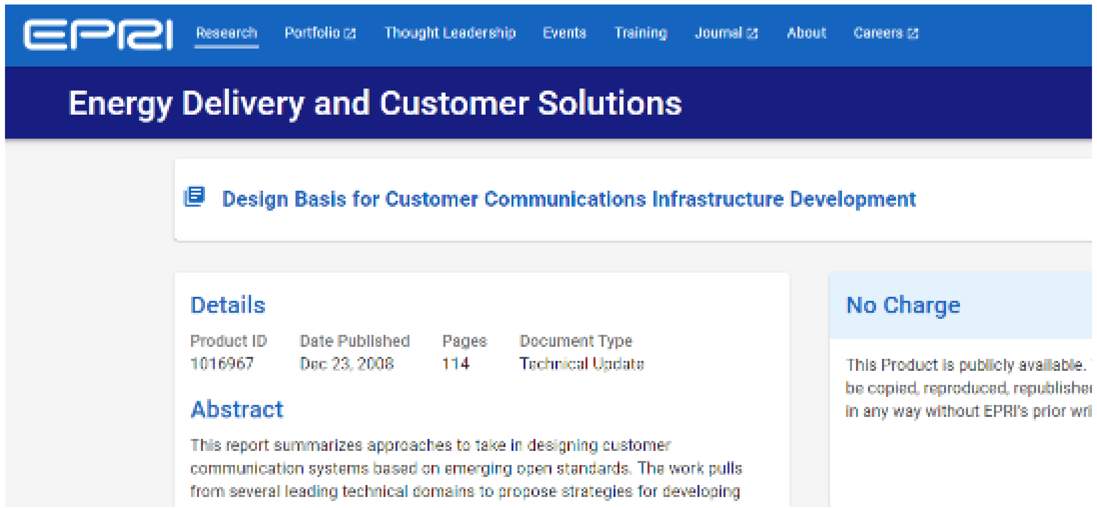
A large number of projects suffered from schedule delays, cost overruns & scope reductions.

Recommendation from U.S. DoE:
Invest in Project Management & Governance

- Sources:
- https://www.smartgrid.gov/document/smart_grid_website_data_summary_20150501.html
- https://www.energy.gov/oe/arra-smart-grid-investment-grant-sgig-projects

In closing, remember this? Start with the end in mind.





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ESMAP
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APUA ASEA

ISGF
India Smart Grid Forum

Thank you

Any questions?

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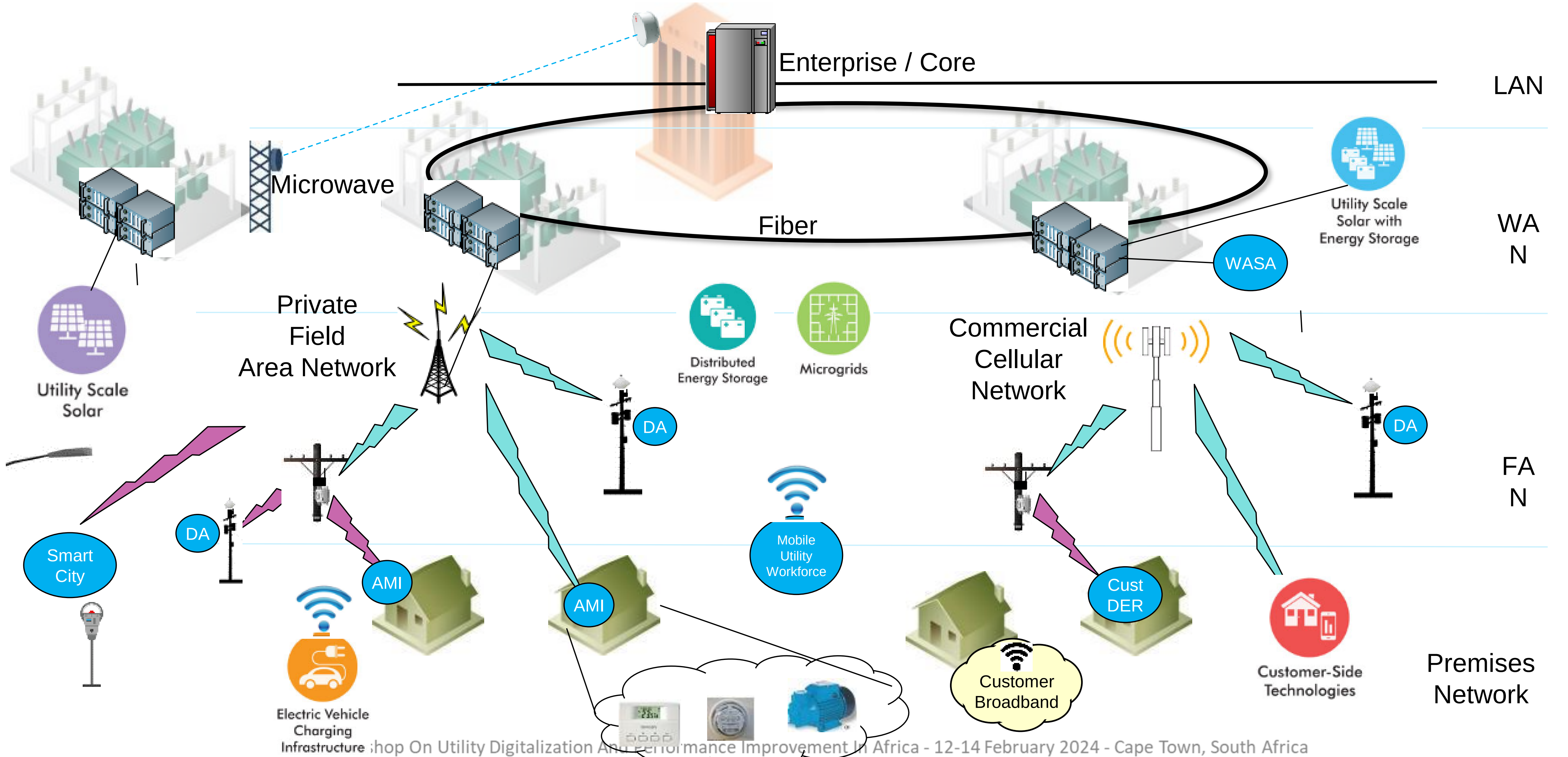
Annexes

Utility Telecom Hierarchical Architecture



A very wide suite of standards

Figure 1-1
Standards development organizations and societies

Communications System Transducers

(Transmit/Receive Communications Equipment)

- The transducer, the fundamental telecom network element, performs two basic functions:
  - Ensure the information signal is in a form and at a level of energy that can be transmitted across the desired distance via the selected medium (e.g., in the form of pulses of light transmitted via a glass fiber at a certain power level).
  - Coordinate access to the shared medium for information-generating and -receiving users in a manner that fulfills user requirements. Two basic mechanisms:
    - Static medium sharing: achieved via channelization schemes where the transmission medium is allocated based on time division multiplexing (TDM) and/or frequency division multiplexing (FDM).
    - Dynamic or on-demand medium sharing:
      - Such resource allocation schemes are more efficient as they provide on-demand access to the transmission medium.
      - Examples include networks consisting of routers and switches based on technologies such as IP (Internet Protocol) and MPLS (multi-protocol label switching).

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July 12, 2010

Department of Energy
Office of General Counsel
1000 Independence Avenue, SW., Room 6A245
Washington, D.C. 20585

RE: NBP RFI: Communication Requirements

Dear Sir or Madam:

https://www.energy.gov/gc/articles/re-nbp-rfi-communication-requirements

Below, is a more detailed mapping of networks and associated communication requirements.

Categories	Throughput	Latency	Burstiness*	Geographical Coverage
1. Inter-Utility Network	10-100 Mbps	< 50 ms for now < 8 ms in the future	High	Western Electric Coordinating Council (WECC)
2. High-Speed Backbone Network	~ 3.3 Gbps	< 150 ms	High	Data centers, Transmission substations, generation stations, major office buildings
3. Tele-protection & Other Low-Latency Network	< 1 Mbps	< 8 ms	High	Transmission and many distribution stations
4. Substation Bus Network	10 – 20 Mbps	< 8 ms	High	All substations
5. Field-Area Communication	1 Mbps downstream / 384 Kbps upstream; Total > 375 Mbps	< 150 ms	Medium	Entire SCE service area
6. Premise Area Network	4 Gbps	< 50 ms	Medium	Entire SCE service area