BC Hydro

Transforming Our Business with Technology

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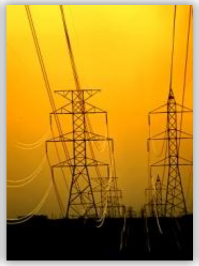
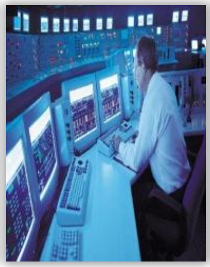

BC hydro

FOR GENERATIONS

BC hydro
FOR GENERATIONS

Outline

- About BC Hydro
- Technology Drivers in BC
- Technology Adoption
- BC Hydro Technology Planning
- Technology Solutions
- Questions

BC Hydro Snapshot

BChydro REGENERATION

General

- Crown Corporation)
- Serving about 95% of province and 1.9 million customers
- ~10,500 MW demand
- Two subsidiaries: PowerEx and Powertech

Generation

- 13,800 MW capacity
- 41 Dam sites, 30 Hydro facilities and 9 Thermal units
- > 90% renewable

Transmission

- 500kV series-compensated backbone
- 18,000 km of transmission lines, 22,000 steel towers
- 260 substations
- One primary control center + one backup
- Interconnected to Alberta and US – part of WECC

Distribution

- 56,000 km of Distribution lines
- Approx. 900K poles, over 300K transformers
- Serve 17 Non-integrated areas

Technology Drivers in BC

▶ *Our Business Environment*

- Need to deliver clean reliable electricity in safe manner
- Aging assets
- Capital constraints
- Pressure to keep rates low
- Human resource constraints – aging workforce + new skills needed
- Emergence of disruptive technologies
- Challenging energy policies

Technology Drivers in BC

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▶ *The 2010 Clean Energy Act*

CEA priority objectives	Ensure self sufficiency at low rates	Harness clean power for economic development	Strengthen environmental stewardship and reduce GHGs
Mandates	▪ Achieve electricity self-sufficiency by 2016 ▪ Replace current planning processes with a long-term Integrated Resource Plan filed every 5 years ★ Ensure rates that are among the most competitive in North America ▪ Facilitate net metering for customers ▪ Allow customers to enter into long-term purchase contracts	▪ Actively market clean power for export ▪ Create regional economic opportunities through development of the Northwest Transmission Line ▪ Connect rural residents to the grid ▪ Create First Nations Clean Energy Business Fund to enable investments in renewable power ▪ Encourage renewables development by allowing BCH to enter long-term PPAs ▪ Establish feed-in tariff and increase renewable purchases through the Standing Offer Program	▪ Increase renewables target from 90% to 93% of total generation ★ Reduce GHGs to 33% below 2007 level by 2020 ★ Meet 66% of new resource requirements from energy efficiency ★ Accelerate deployment of EV and NG vehicles ★ Install smart meters to all customers by end of 2012 ▪ Prohibit future developments of large hydro (excluding Site C) ▪ Complete objectives without consideration of nuclear power

SOURCE: British Columbia 2010 Clean Energy Act

Technology Drivers in BC

▶ *Our Business Objectives*

Developing **strong partnerships** in technology development & deployment

Technologies could provide **lower-cost alternatives** to many traditional capital investments

- SAFELY KEEPING THE LIGHTS ON
- MIND OUR FOOTPRINT
- SUCCESS THROUGH RELATIONSHIPS
- FOSTER ECONOMIC DEVELOPMENT
- MAINTAIN COMPETITIVE RATES
- ENGAGE A SAFE & EMPOWERED TEAM

Technologies could drive **significant reliability improvement**

Provincial economic benefits through use of local technology solutions

Technologies could provide **safer alternatives to** traditional field activities

Technologies can reduce **environmental impacts**

Technology Adoption

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When is the right time to invest in a new technology?

Invest too early (take the lead!)

- The technology works but there are barriers to deployment
  - too expensive to deploy on scale – have to wait for it to become commercially viable
  - Competitive technologies (perhaps better!) emerge
  - Standards!
- It fails because technology is too immature or is flawed

Invest too late (wait for others!)

- Miss opportunity to get some value from early deployment
- Commercial solution may not evolve – may be a long wait
- Exposed to risks associated with being unprepared for commercial deployment
  - No competency in technology
  - Get stuck with obsolete technology

Technology Adoption Lifecycle

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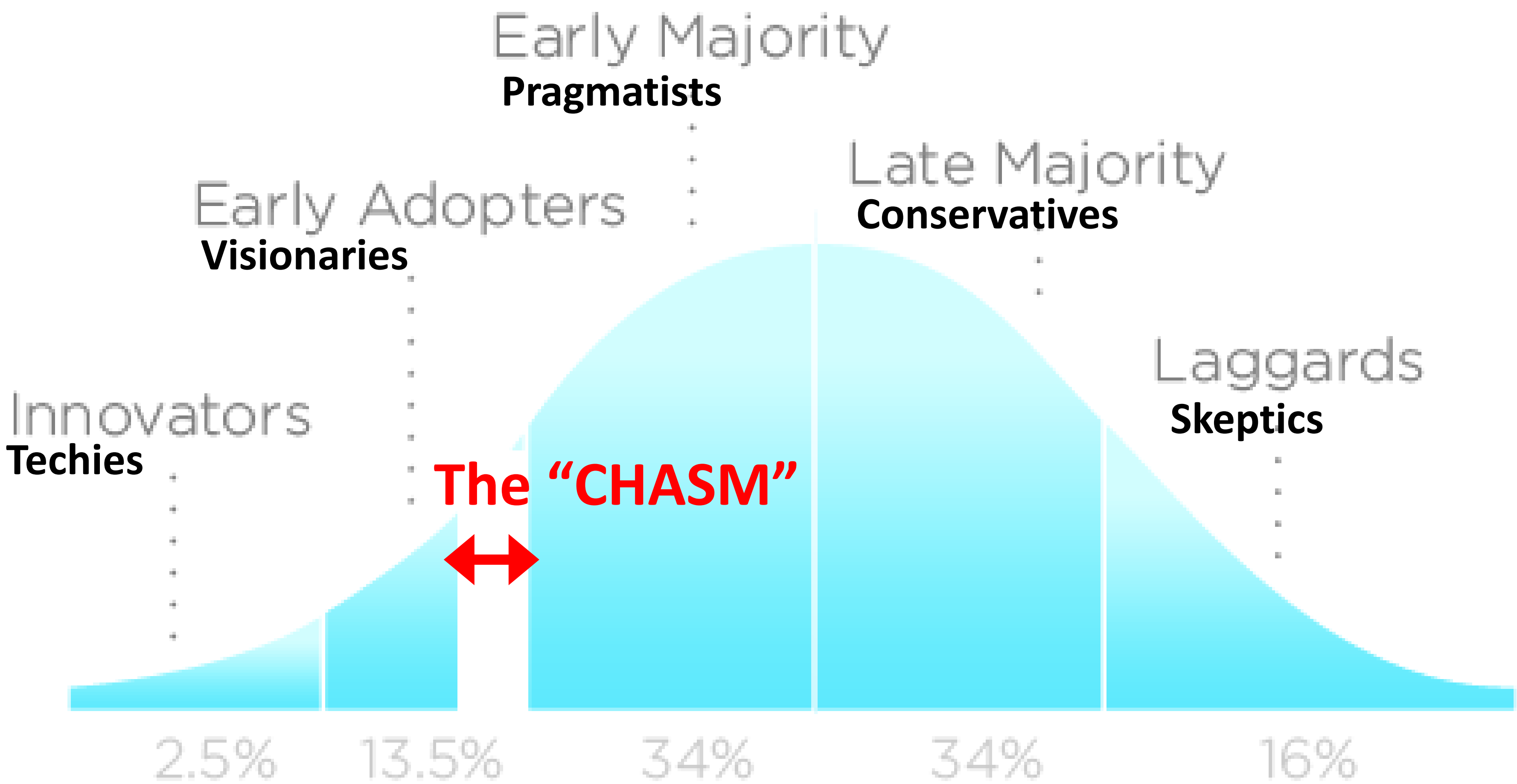
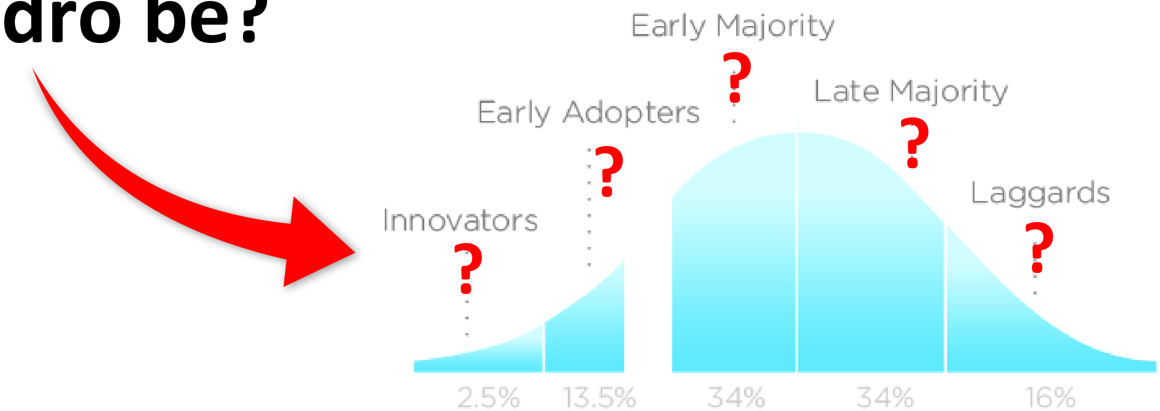
- Diffusion Model



What should BC Hydro be?



It depends,

- What are the **risks** of doing nothing?
- What **value** could the technology bring?
- What's the **cost**?
- What will it take, and how much **time**, to make it deployable on scale?
- How wide is the **chasm** (risk of getting stranded) ?
- How **unique** is our need?
- How **mature** is the technology and what is the probability it will work?
- Others?

Technology Planning

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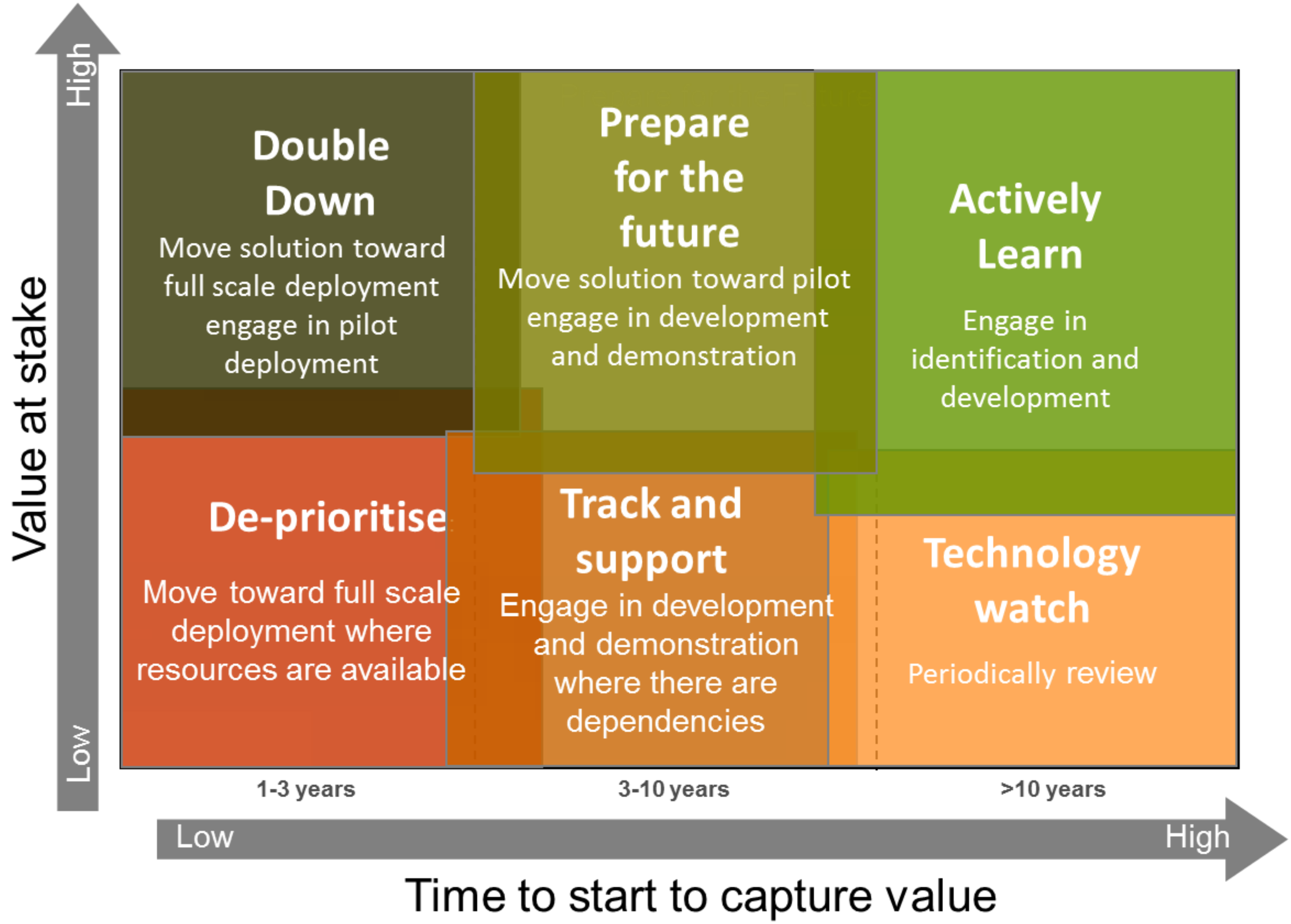
▶ Technology Value-at-Stake



Technology Planning

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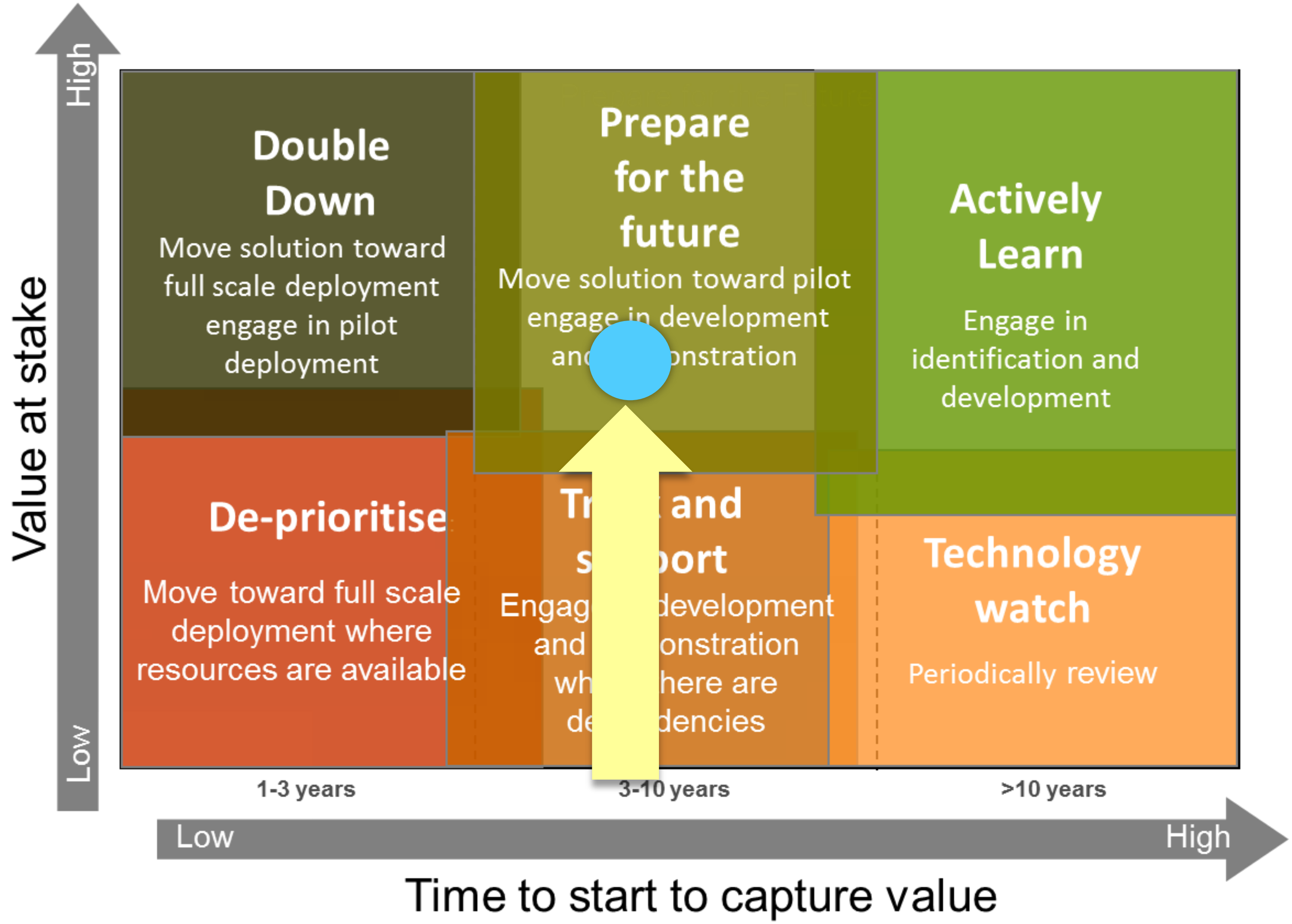
▶ Technology Value-at-Stake

Net Value
- CapEx
- OpEx
- Reliability
- Safety
- CSAT
- Environment
- Conservation
- Ec Dev
- Cost



Technology Planning

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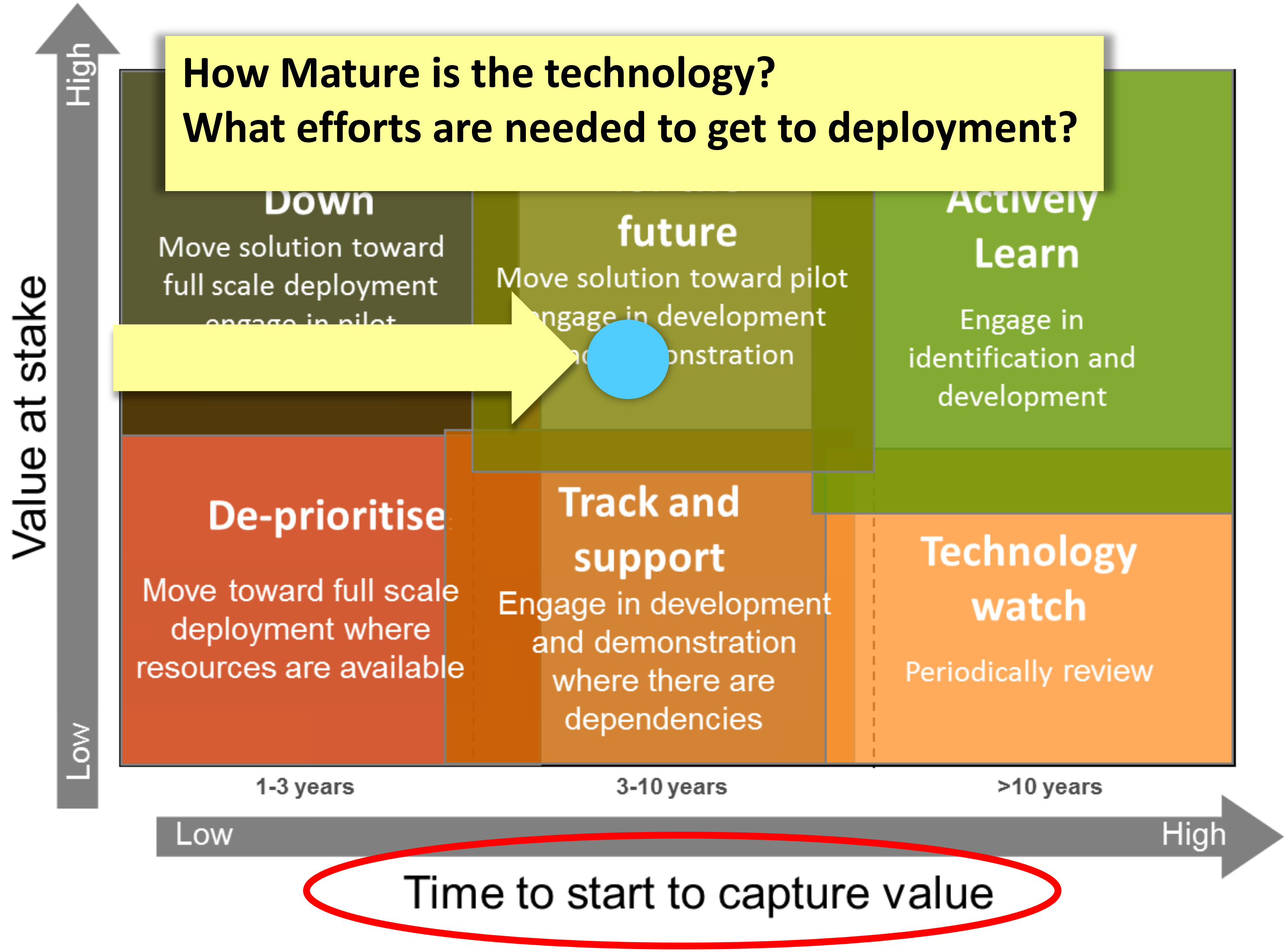
▶ Technology Value-at-Stake

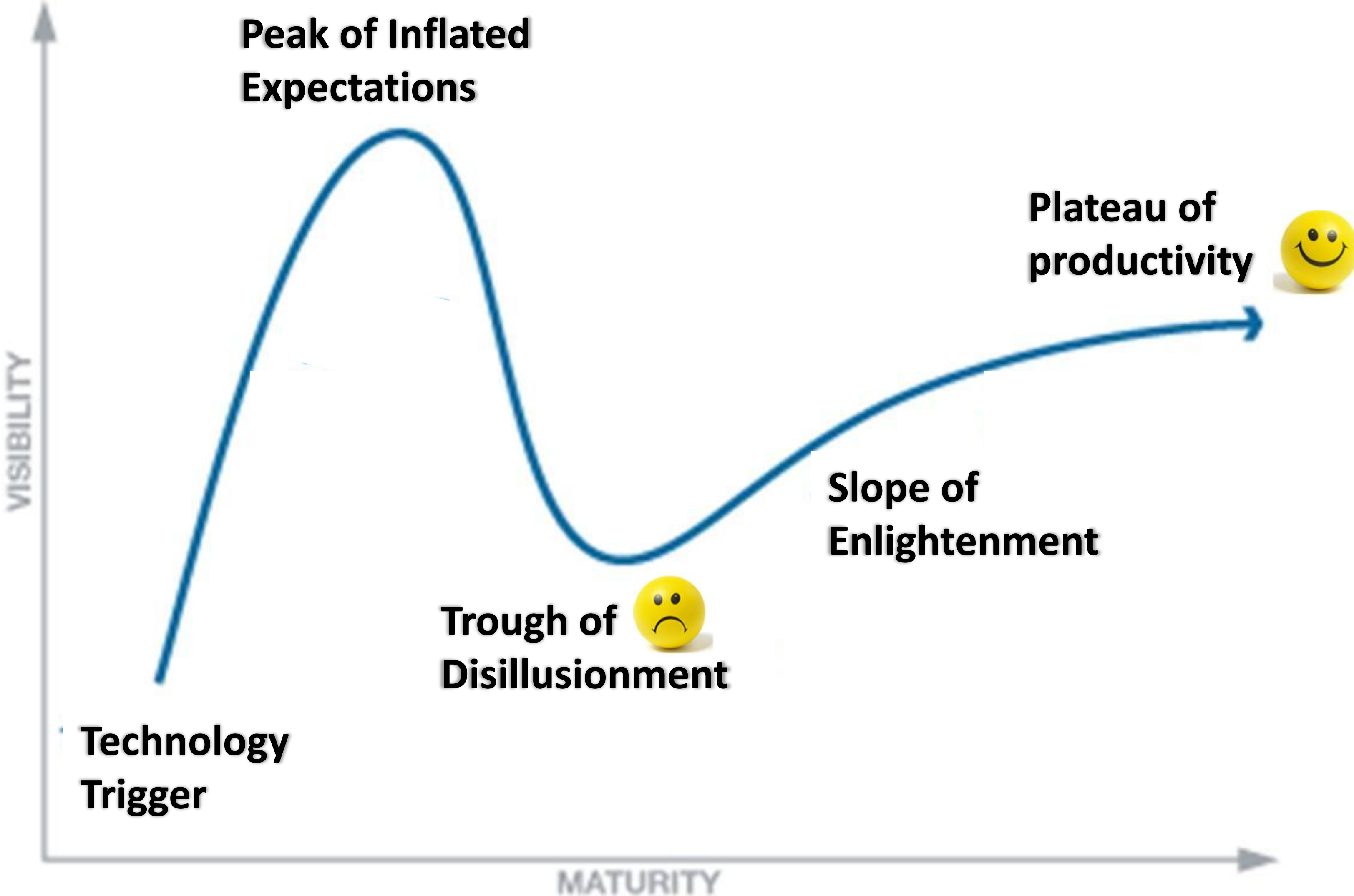


Technology Readiness Levels

Level	NASA	US DOE
TRL 1	Basic principles observed and reported	Scientific research begins translation to applied R&D
TRL 2	Technology concept and/or application formulated	Invention begins
TRL 3	Analytical and experimental critical function and/or characteristic proof of concept	Active R&D is initiated
TRL 4	Component and/or breadboard validation in laboratory environment	Basic technological components are integrated
TRL 5	Component and/or breadboard validation in relevant environment	Fidelity of breadboard technology improves significantly
TRL 6	System/subsystem model or prototype demonstration in a relevant environment (ground or space)	Basic technological components are integrated
TRL 7	System prototype demonstration in a space environment	Prototype near or at planned operational system
TRL 8	Actual system completed and 'flight qualified' through test and demonstration (ground or space)	Technology is proven to work
TRL 9	Actual system 'flight proven' through successful mission operations	Actual application of technology is in its final form

INCREASING READINESS

Gartner's Hype Cycle



Corporate Technology Roadmap

Technology theme

- Energy Resources
- Robotics & Tools
- End Use Technologies
- Automation & Control
- Modeling, Analysis & Simulatio
- Power System Components
- IT & Telecom

Net Value

- CapEx
- OpEx
- Reliability
- Safety
- CSAT
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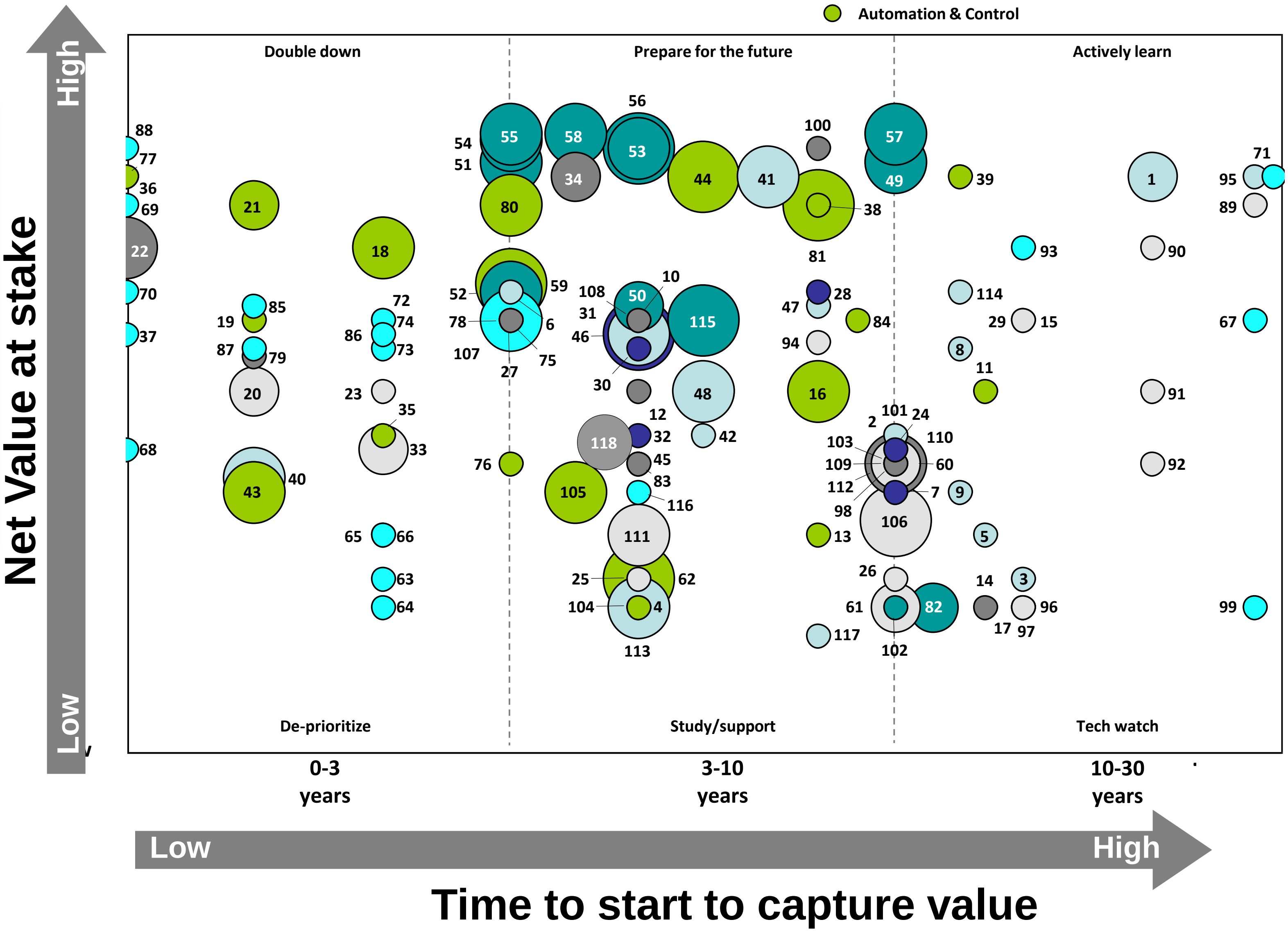
- Cost



Corporate Technology Roadmap

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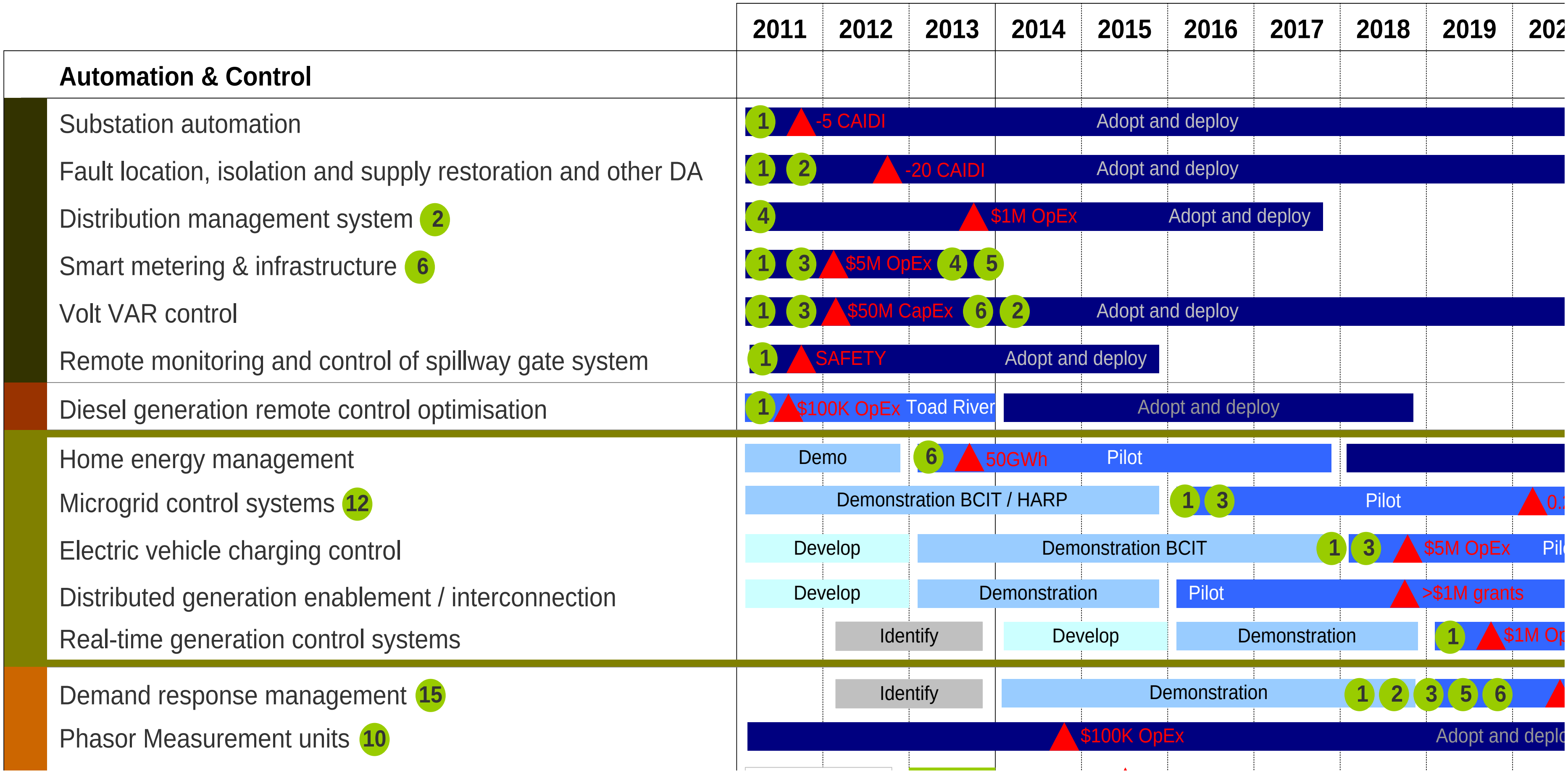


Double Down	Prepare for the future	Actively learn
De-prioritise	Track an support	Technology watch

Technology Solutions

Smart Metering & Infrastructure (SMI)

Smart meters are a key first step in modernizing our electricity system and ensuring the safe, reliable delivery of electricity to homes and businesses throughout the province.

IMPROVED OPERATIONAL EFFICIENCY

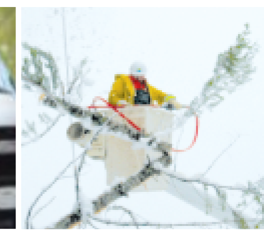
- Optimize voltage regulation to reduce electricity waste and improve power quality
- Enable long-term distribution system planning
- Automate meter reading

GREATER CUSTOMER CHOICE & CONTROL

- Enable timely access to usage information
  - Web & mobile applications
  - Energy management devices
- Introduce new conservation programs
- Enable customer generation

IMPROVE WORKER & PUBLIC SAFETY

- Pinpoint outages and restore power faster
- Discourage illegal tampering with electricity wires which cause fires and live wire dangers

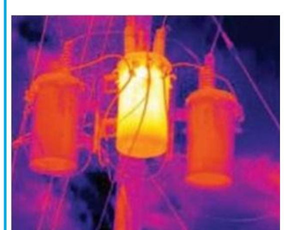


ENHANCE CUSTOMER SERVICE

- Better informed customer service
- Eliminate estimated billing
- Streamline moving procedures
- Faster outage restoration


REDUCE ELECTRICITY THEFT

- Locate and reduce power diversions that cost ratepayers over $100 Million per year

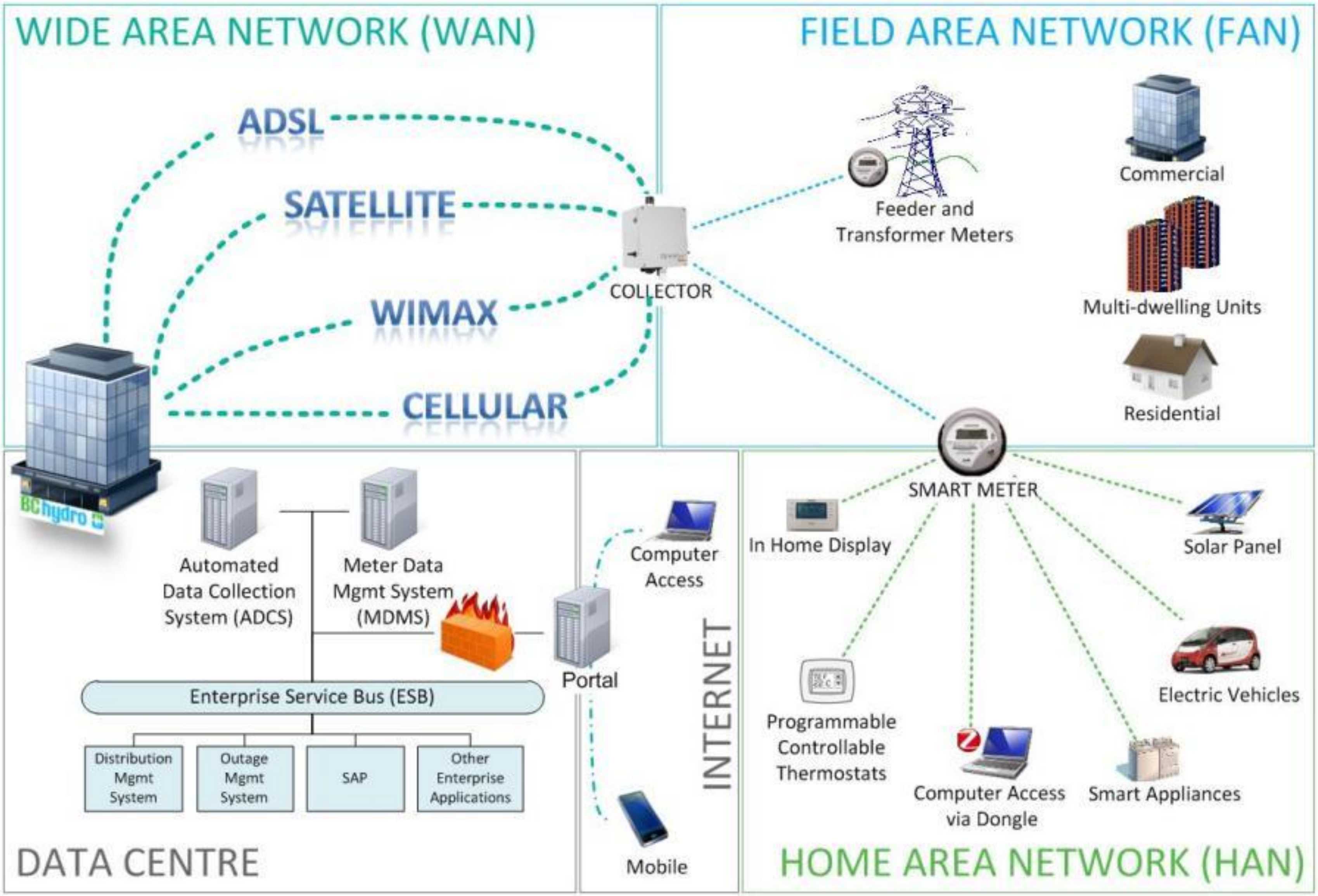



MODERNIZE BC'S ELECTRICITY SYSTEM

- Accommodate clean energy transportation
- Support micro-grids & distributed generation
- Enable an intelligent, self-healing grid that can accommodate two-way flow of electricity



SMI SOLUTION CONCEPTUAL ARCHITECTURE



Distribution Automation

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- Historically, the distribution system has not been widely monitored nor controlled

- Current direction is to use technology to optimize distribution operation → significant reliability, efficiency, and safety benefits

- Leverage SMI

- Distribution Automation Components
  - Advanced Distribution Management System (ADMS)
  - Supervisory Control And Data Acquisition (SCADA).
  - Intelligent field devices
  - Advanced analytics and control (such as VVO and FLISR)

DMS Applications:
Volt-VAr Optimization (VVO)

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What is it?

- VVO is industry recognised and adopted practice to realise reduction in energy consumption
- VVO optimises distribution supply voltage both on substation and consumer end

Principle: When VVO is enabled at a substation,

→ distribution voltage is optimised (i.e. reduced)

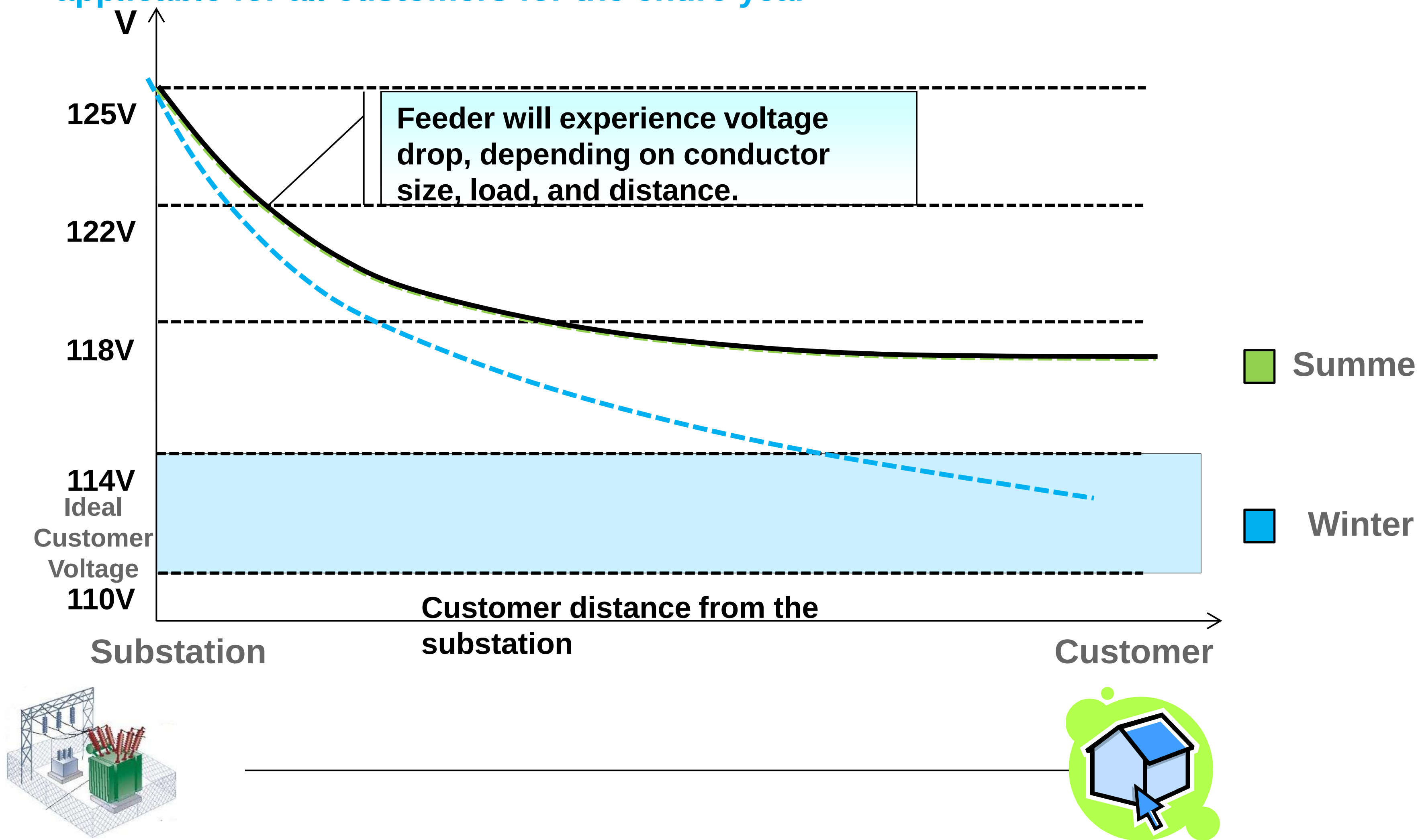
→ customers draw less power and consume less energy

Energy conservation benefits:

- Customers have lower bills
- Reduced system losses
- Decrease in BC Hydro’s cost of service leads to lower rates

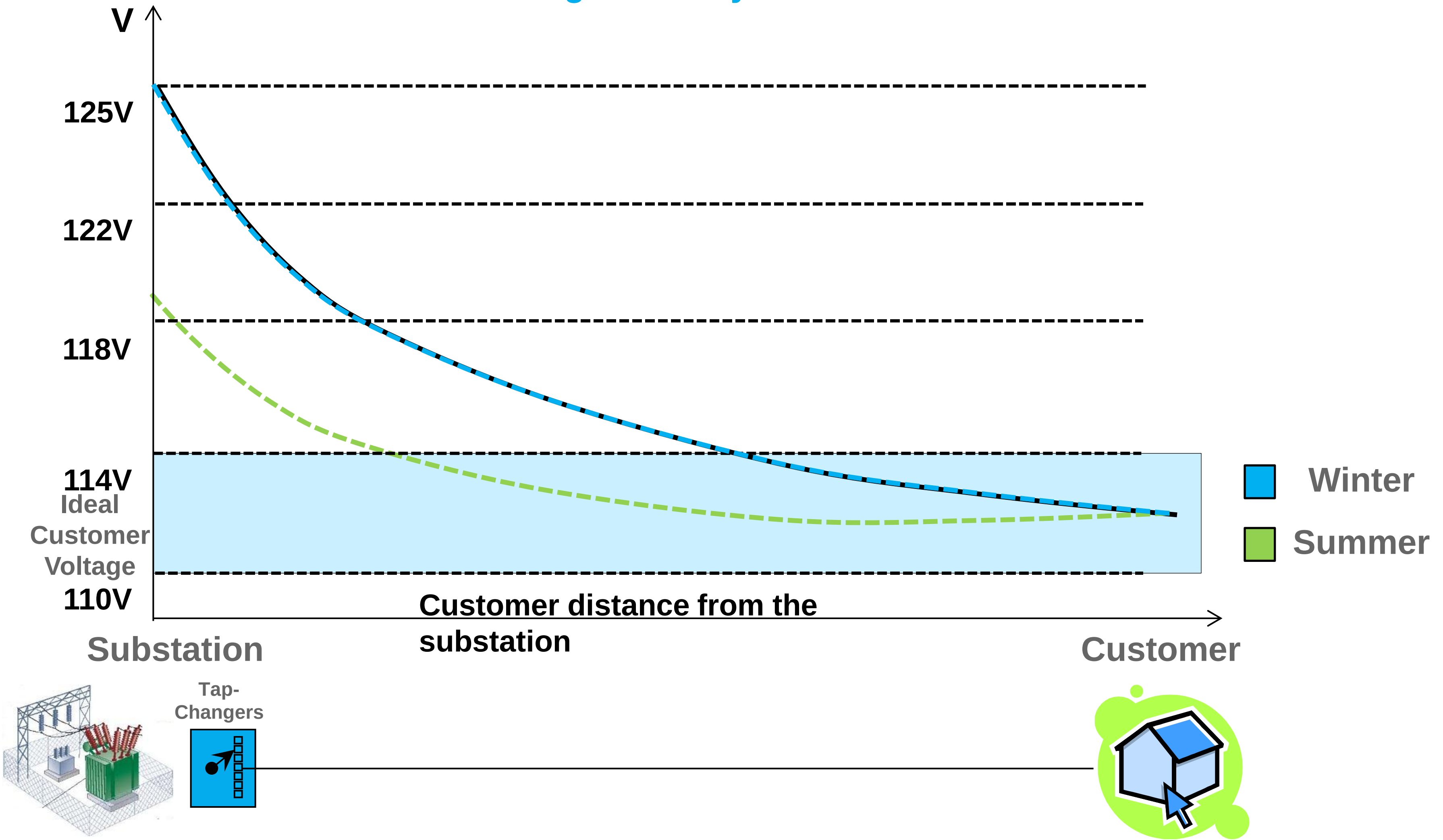
Voltage Regulation without VVO

- Substation has fixed voltage setpoint that is applicable for all customers for the entire year

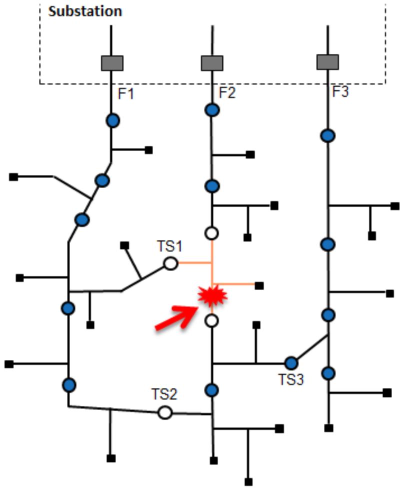


Substation Improvements & DMS

- Substation has automated voltage setpoint that considers load variations throughout the year



DMS Applications:
Fault Location Isolation and Service Restoration (FLISR)



What is it?

An application in DMS that utilizes substation and distribution automation to detect, locate and isolate fault and return service to a healthy part of the feeder effectively reducing the number of customers exposed to lengthy outages and therefore improving SAIFI and CAIDI indices.

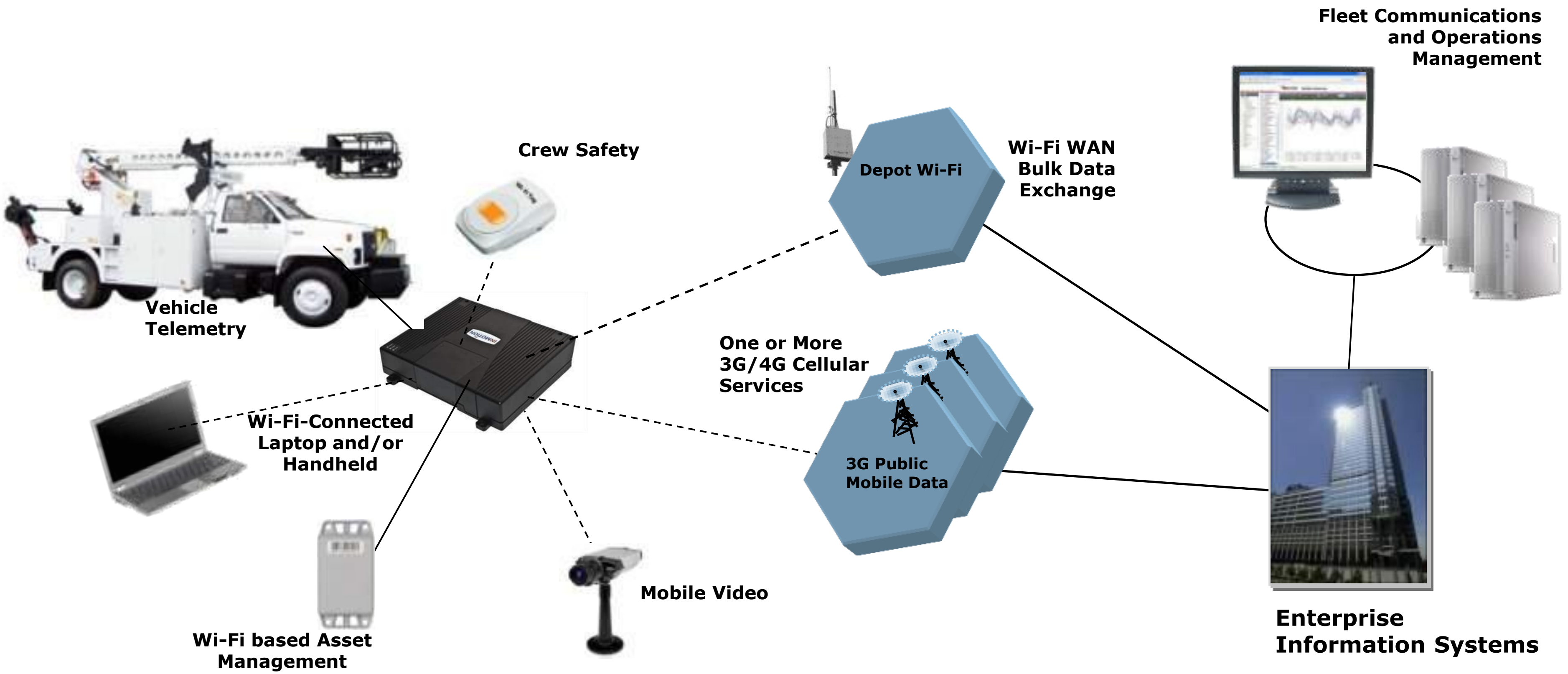
Principle

1. Use info from substation and field devices, calculate the most probable **LOCATION** of the fault.
2. Prepare and execute switching plan to **ISOLATE** faulted element by opening the closest switchable devices via SCADA
3. Automatic closing of the substation circuit breaker after the fault is isolated will **RESTORE** service to all up-stream customers.
4. Prepare and execute switching plan to **RESTORE** service to down-stream customers by closing one or more automated normally open tie switches to transfer load to adjacent feeders.

Show Me

Enterprise Field Mobility

- Reliable communications for mobile office and dispatch operations
- Automatic Vehicle Location and tracking
- Fleet health monitoring
- Track onboard assets and inventory
- Crew safety alerting and video supervision



Electric Vehicles Charging Control

- Electric vehicles are here
- If numbers become significant – charging pattern is critical to impact on transmission and distribution infrastructure.
- In BC, transportation sector accounts for ~ 38% of GHG production – CEA calls for electrification
- Challenges
  - Metering solutions
  - Smart charging
  - Business Model
  - Policy
  - Modeling and planning (mobility)

Activities

- T&D Impact study
- Demos projects
- Dunsmuir Office Tower EV Charging Pilot
- ★Government EV Infrastructure program
  - 30 DC Fast Chargers
  - > 500 Level II Chargers
  - 300 grid-aware stations

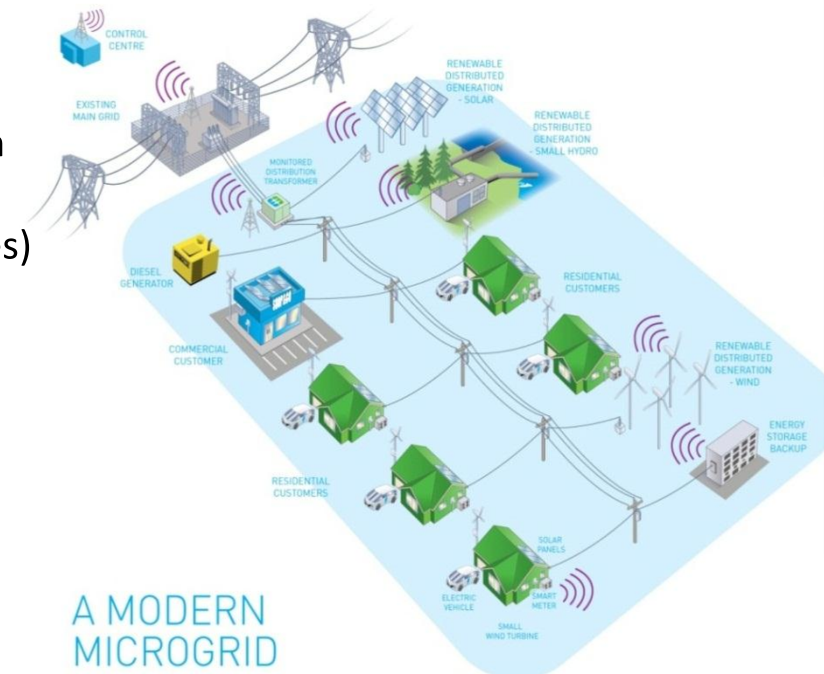
Micro-Grids

Vbine and EV Charger at BCIT smart house

- Can defer bulk transmission and generation additions
- Can improve local reliability
- Two-way power flow
- Can be green

BCIT Microgrid Project

- Renewable/efficient generation
- Smart Meters
- Loads (including electric vehicles)
- Building envelops and systems
- Storage (battery, flywheel)
- Networks (WAN / HAN)
- Software analytics
- EMS - Automation and Control



BCIT CEF Integration of Renewables and EV Charging

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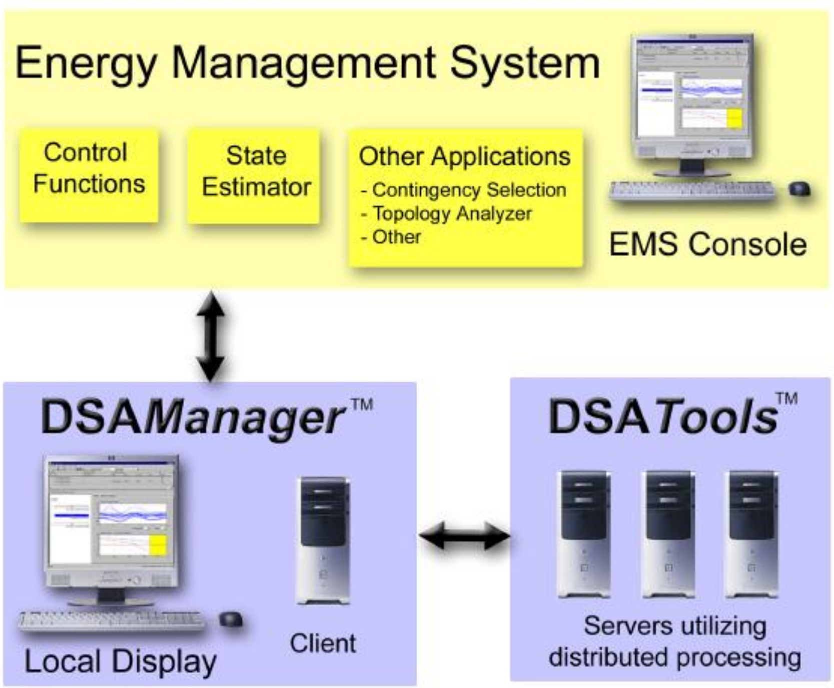
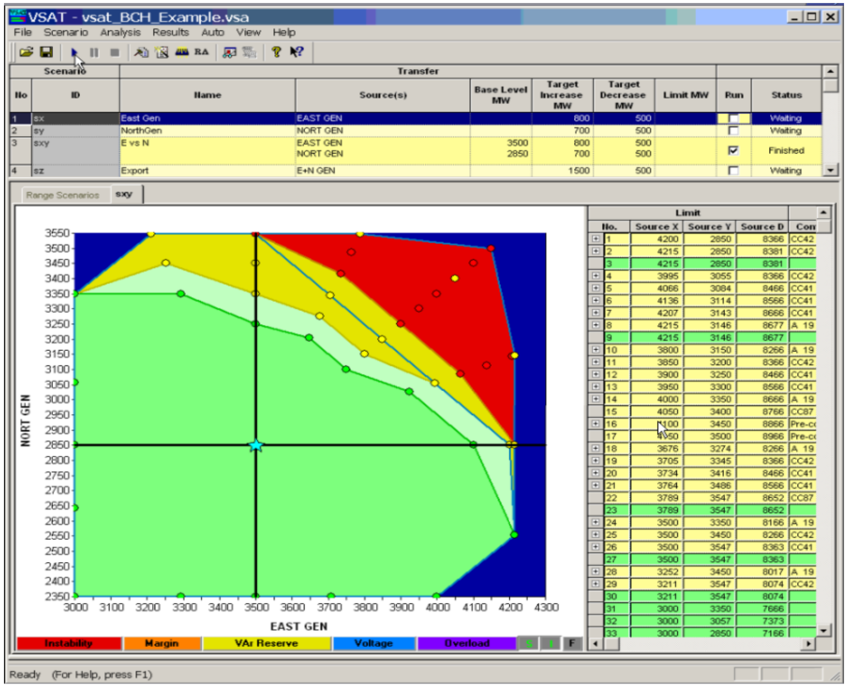
- NRCan Clean Energy Fund Project : $8M total budget - complete Q4 F14
- Integration of solar panels, battery storage, other generation, and EV Level 3charger
  - BC Hydro – co-funder
  - BCIT – co-funder and site provider
  - NRCan – CEF up to 50% matching funds ($4M)
  - Panasonic (250kw Solar panels and 500kwh lion battery),
  - Powertech – Expertise and service provider
  - Schneider (Level 3 charging station)
  - Car2Go (electric Vehicles)
  - Siemens (EMS)

Transmission Optimization

- Objective is to allows maximization of asset utilization by real-time assessment of operating limits
- Control Centre Software using models (built from measurements and state-estimator) and simulation
- Voltage security tools in-service – now implementing transient security limits
- Future - Small Signal Stability, PMU, and DMS applications





VSAT Application developed by Powertech Labs Inc.

Storage

Opportunities

- acquiring knowledge of storage integration for future BC Hydro initiatives including the support of intermittent generation from renewable sources
- supporting load capacity-constrained substations in other locations
- piloting the intelligent management of distributed energy resources
- providing an alternative backup energy source to diesel
- providing savings from deferring transformer upgrade costs – reliability improvements

Projects

- Hydrogen Assisted Renewable Power
- BCIT 500kw Lithium Ion Battery
- 1 MW NaS battery at Field

Hydrogen Storage

NaS Battery Installation

Asset Condition Assessment

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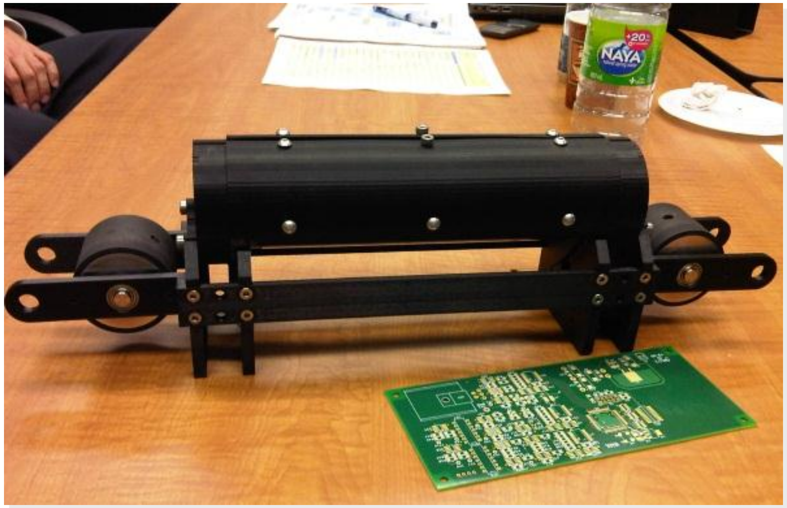
Corrosion Detection Device

- BC Hydro, HQ, and National Grid
- Deliverable is portable corrosion detection device suitable for use on range of live lines
- Seen as high value solution
- Prototype delivery and BCH Testing at Powertech in early 2014



Dynamic Line Rating (DLR)

- Maximum capacity of conductors is a function of many factors – ultimately limited by sag
- Vision – wide-scale deployment
- Extends to virtually all assets (generators, transformers, switchgear, structures, etc.)
- Components include sensors, communication and software
- Several devices field tested
- Challenges
  - Business value
  - Device Reliability
  - Communications
  - Deployment
  - Sustainment

Installation of DLR Equipment

Phasor Measurements

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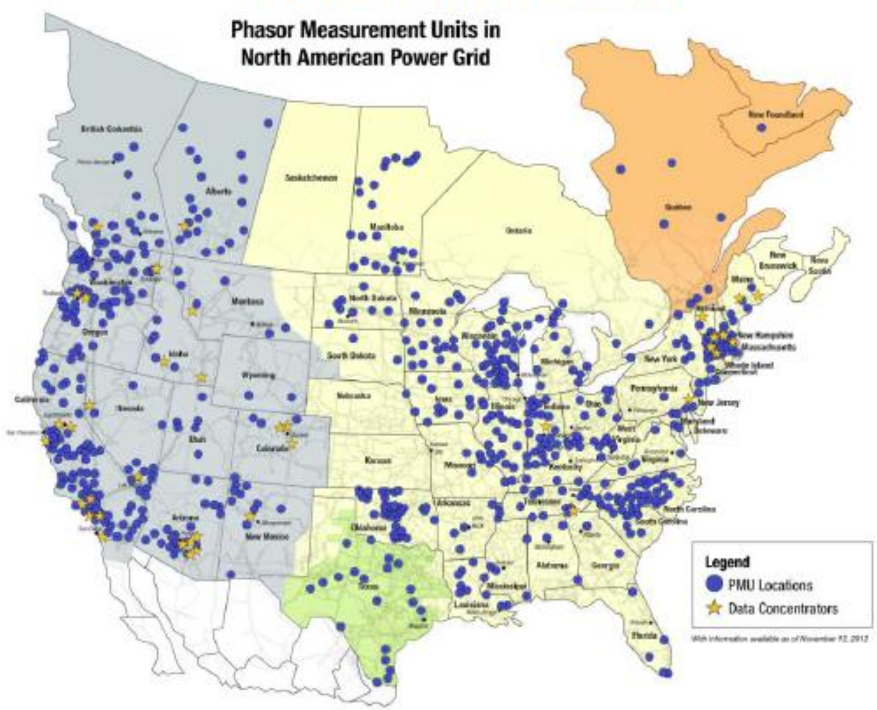
- BC Hydro has several PMUs installed (many relay based-PMU available for conversion)
- First to use PMU measurements in State Estimation
- Added facilities needed for connectivity to WECC
- Business case is not clear – draw on learnings and tools developed by WISP, NASPI, and others
- Investigation into real-time security assessment tools using PMUs



Summary

- There exists many drivers motivating us to pursue modernization toward the smart grid → technical, business, policy

- Use value-at-stake approach in prioritizing technology solutions.

- Focus on technology solutions that can deliver high value in terms of BC Hydro's strategic objectives.

- Take programmatic approach to delivering solutions.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