VELCO & Transmission 101

vermont electric power company

VELCO

September 6, 2018

ABOUT VELCO

Mission, vision & values

Our mission

VELCO's mission is to serve as a trusted partner

Our vision

…to create a sustainable Vermont through our people, assets, relationships and operating model

Our values

VELCO values people, safety, sustainability, creativity and great work

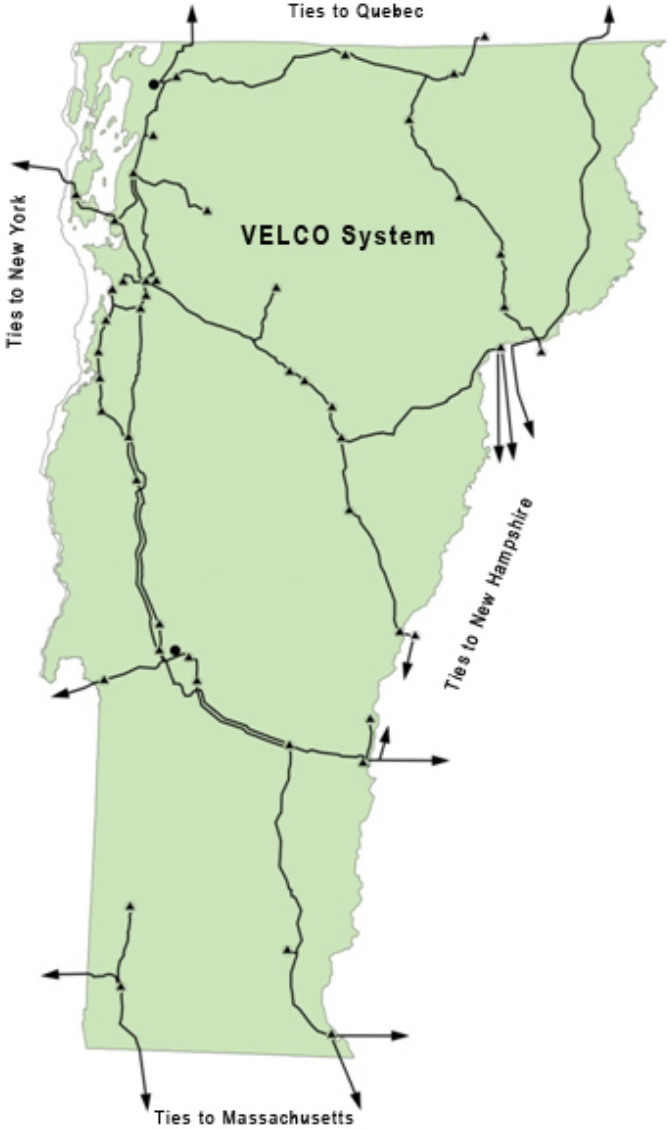
To live our values we...

- Treat everyone with respect
- Respond with urgency and care
- Unconditionally support and empower one another
- Share information
- Think outside the box

Quick facts on VELCO

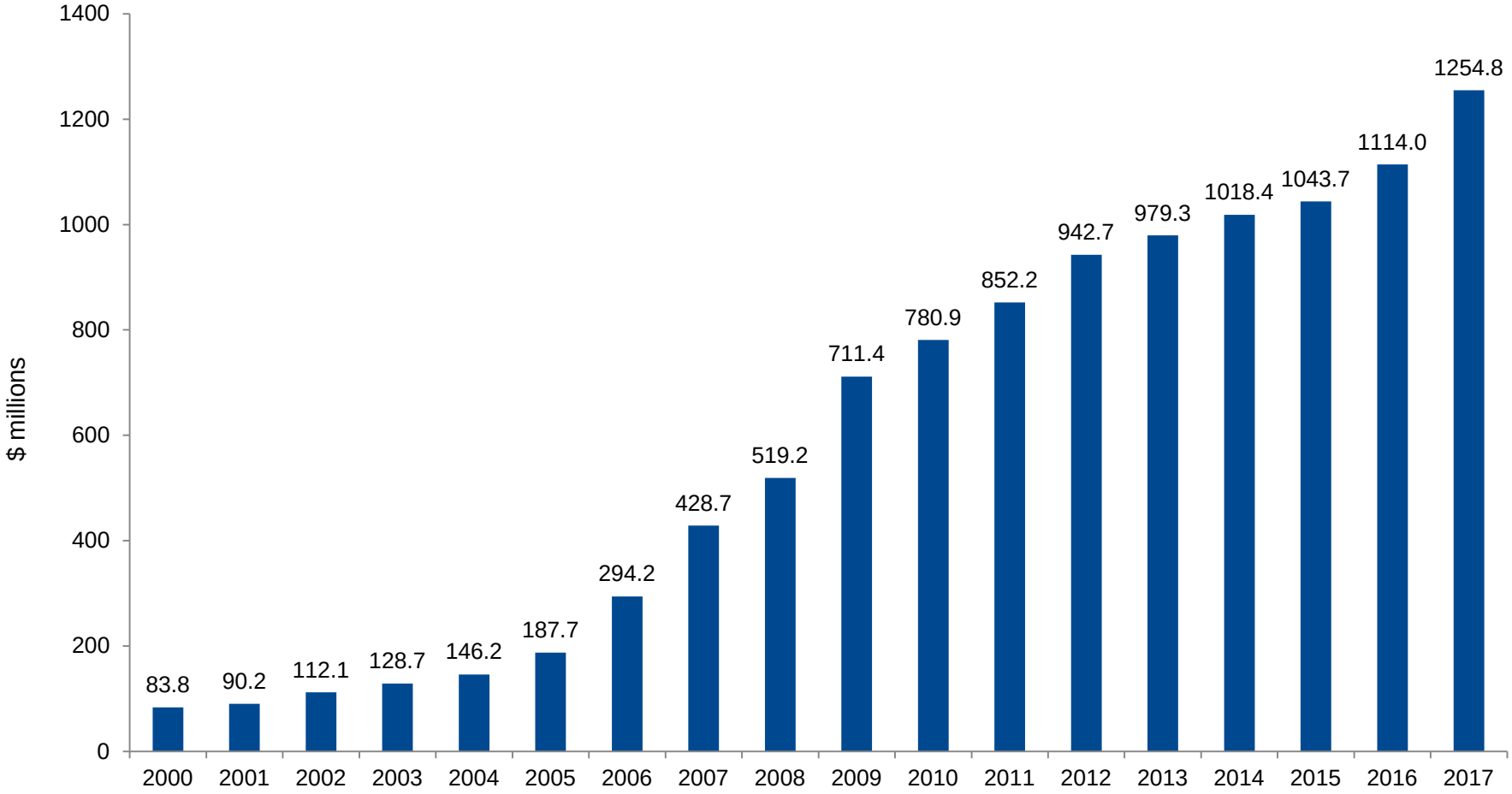
- Founded in 1956 as Vermont corporation
- 152 employees; HQ in Rutland; office in Montpelier
- Builds, operates, maintains facilities owned by VT Transco LLC
  - 738 miles of transmission lines; 1,500 miles fiber; 14,000 acres of ROW; 55 substations, switching stations, terminal facilities
  - $1.3B in assets; $21.6M in annual property taxes
- Ownership—17 distribution utilities, Vermont Low-Income Trust for Electricity or VLITE (public benefit corporation)
- Governance—13 member board: GMP(4), BED, VEC, VPPSA, Public Power (2), VLITE (3) and VELCO CEO
- For profit corporation structured to deliver cooperative benefits to Vermont
- Flat budget-fifth year in a row

VELCO milestones

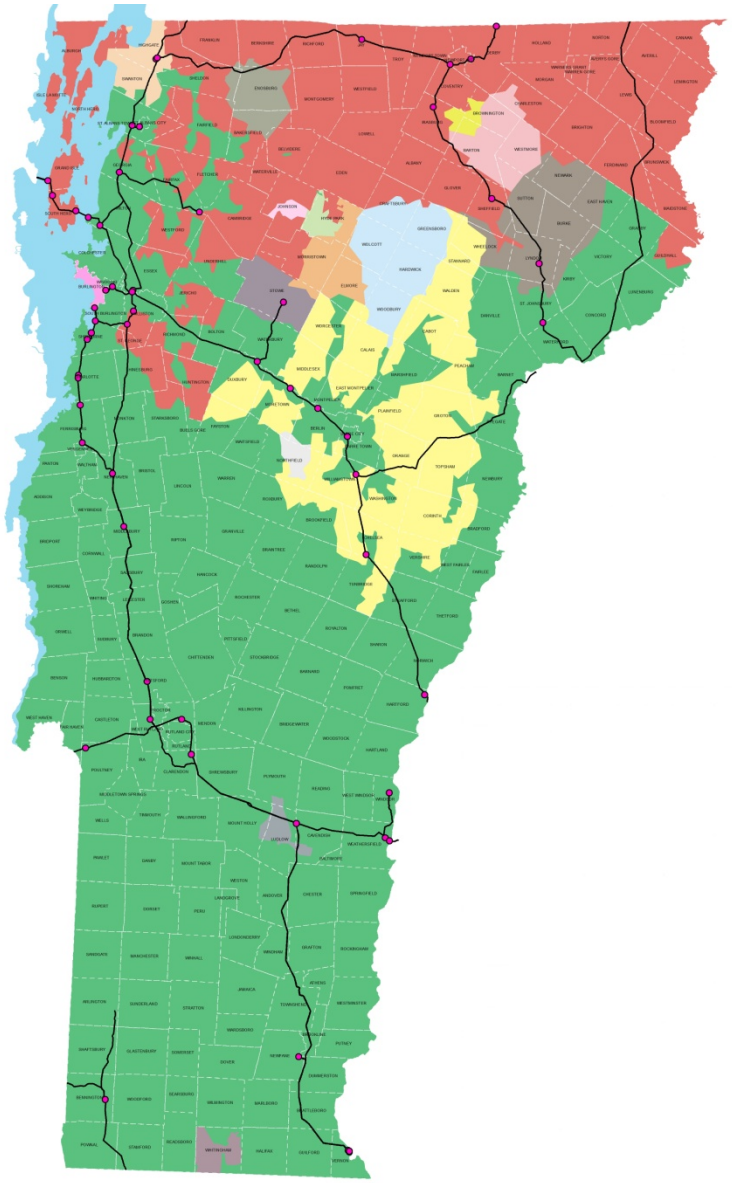


1956	VELCO formed-1st buildout (224 miles)
1968	NERC & NEPOOL established
1969	2nd buildout (215 miles)
1972	Vermont Yankee online (600MW)
1981	VELCO headquarters built
1982	VETCO formed/Phase 1 construction
1991	Fiber optic cable
1996	OATT issued
1997	ISO-NE created
2003	Northeast US blackout
2004	ISO-NE assumes system planning
2006	VT Transco formed; first Long-Range Plan
2006	NERC becomes US electric reliability organization adopts mandatory, enforceable standards
2007	3rd buildout starts (200 miles): NRP, LCP and SLP; VSPC created
2011	Sheffield Wind Project online
2012	GMP merger; VELCO governance changes
2013	1st transmission project deferral
2014	Vermont Yankee retires
2018	>300 MW of solar online; Coolidge Solar interconnects

VELCO asset growth 2000-2017



Vermont distribution utility owners



Stations

Transmission Lines

VT Distribution Utilities

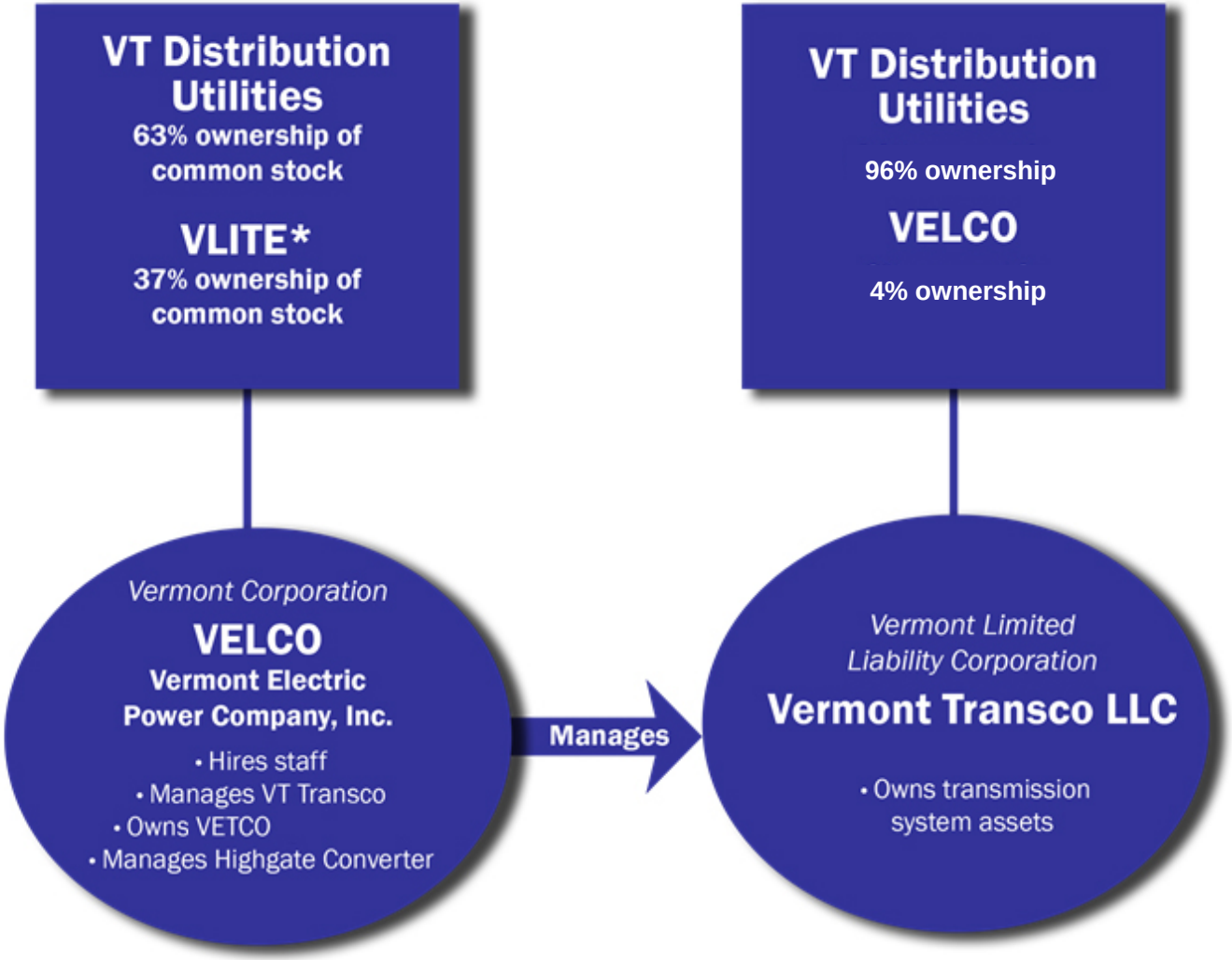
- Burlington Electric Dept.
- Green Mountain Power
- Ludlow Electric Light Dept.
- Swanton Village Electric Dept.
- Vermont Electric Co-op
- Village of Barton
- Village of Enosburg Falls
- Village of Hardwick
- Village of Hyde Park
- Village of Jacksonville Electric Dept.
- Village of Johnson
- Village of Lyndonville Electric Dept.
- Village of Morrisville Water & Light Dept.
- Village of Northfield
- Village of Orleans
- Village of Stowe Electric Dept.
- Washington Electric Co-op

VELCO substations connect to the sub-transmission systems of…

- **BED (20,000 customers)**
- **GMP (254,000 customers)**
- **Lyndonville (5,200 customers)**
- **Swanton (3,500 customers)**
- **Stowe (3,942 customers)**
- **VT Electric Co-op (34,000)**

13-member board of directors

Corporate structure



*VLITE: Vermont Low Income Trust for Electricity, Inc.
*VETCO single-purpose entity owning a 52-mile line in Northeast VT

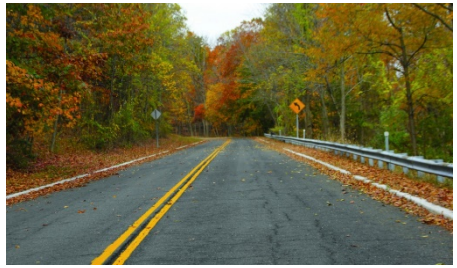
TRANSMISSION BASICS

Transmission—high-voltage, owned by VT Transco—450kV-115kV

Subtransmission—owned by VT distribution utilities—69kV-34.5kV

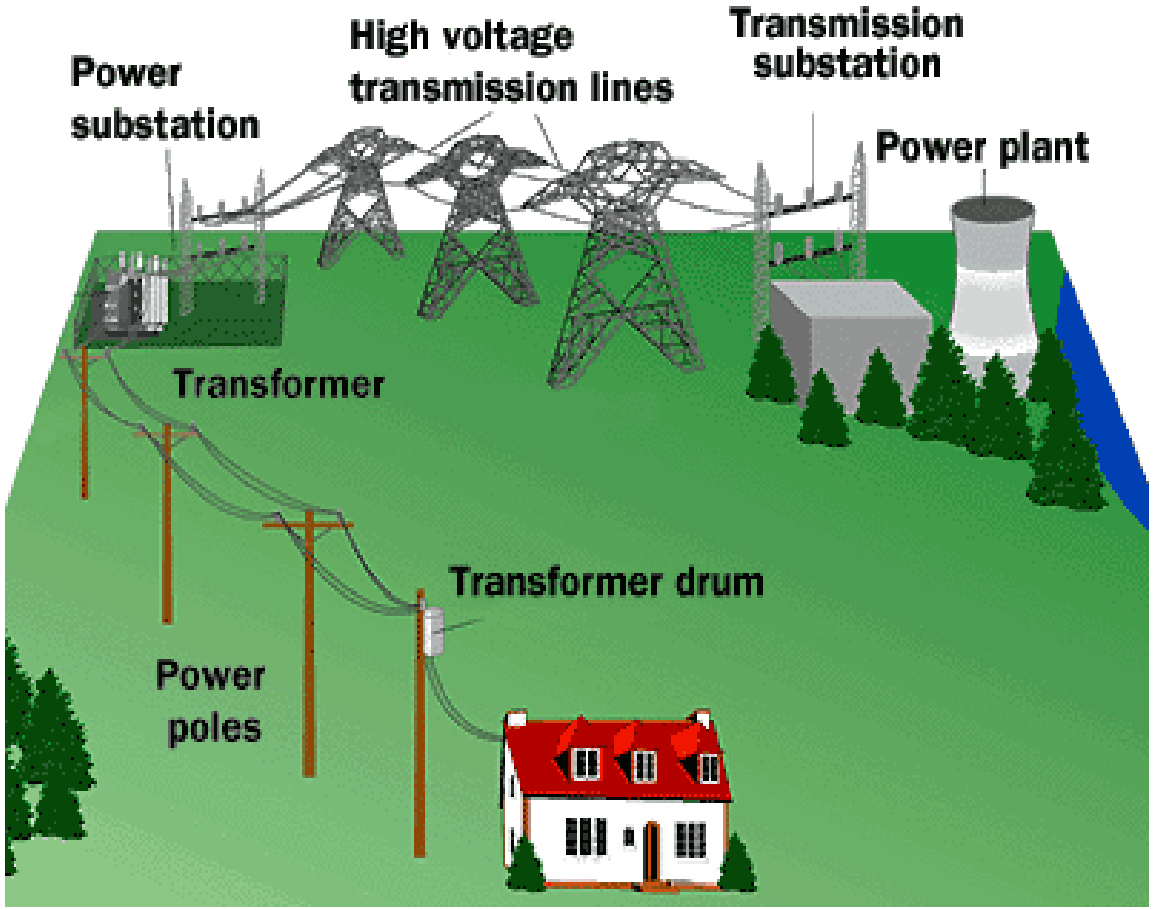
Distribution—owned by VT distribution utilities—13.8kV-2.4kV

Transmission: generally looped facilities at 115kV and above

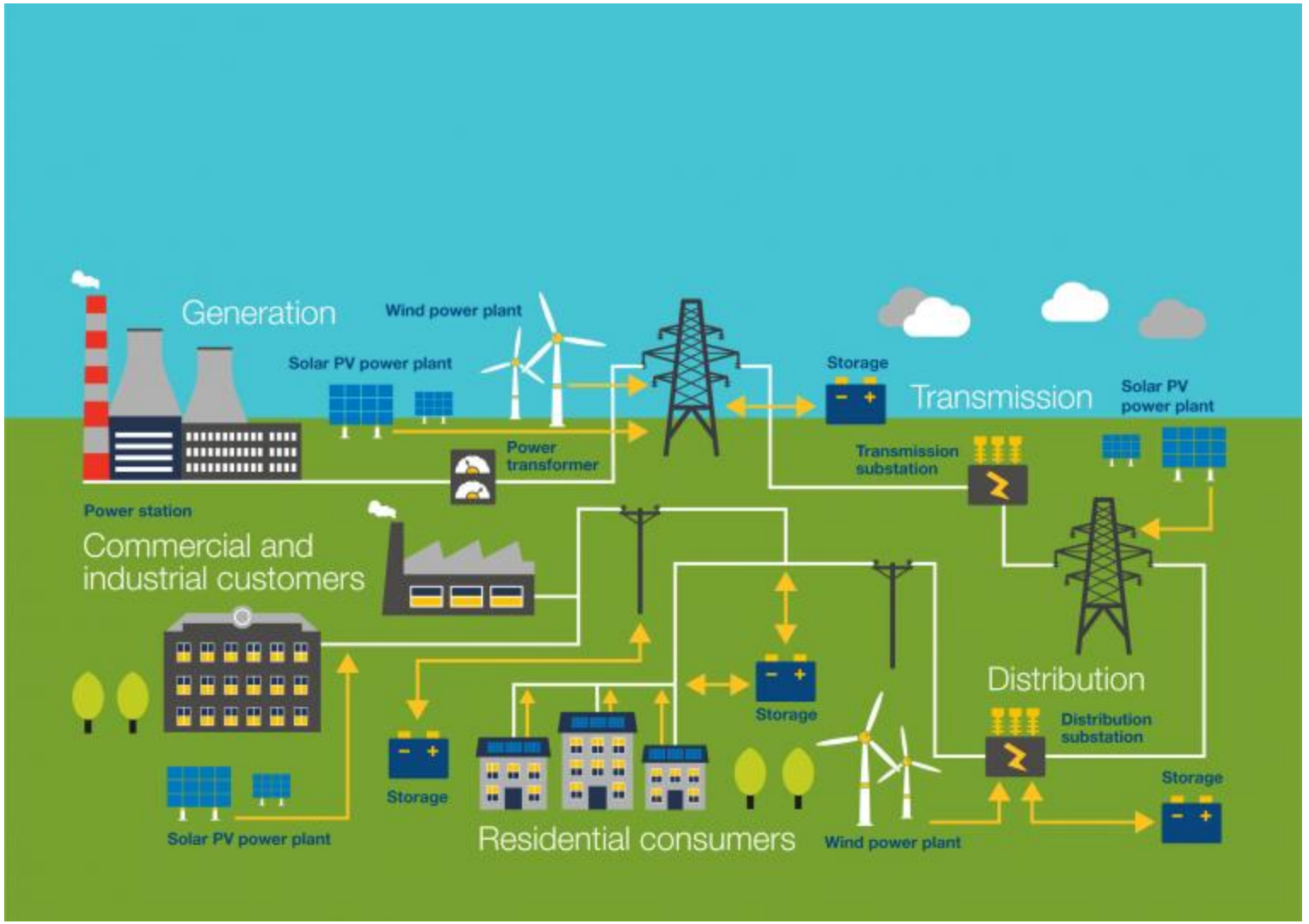


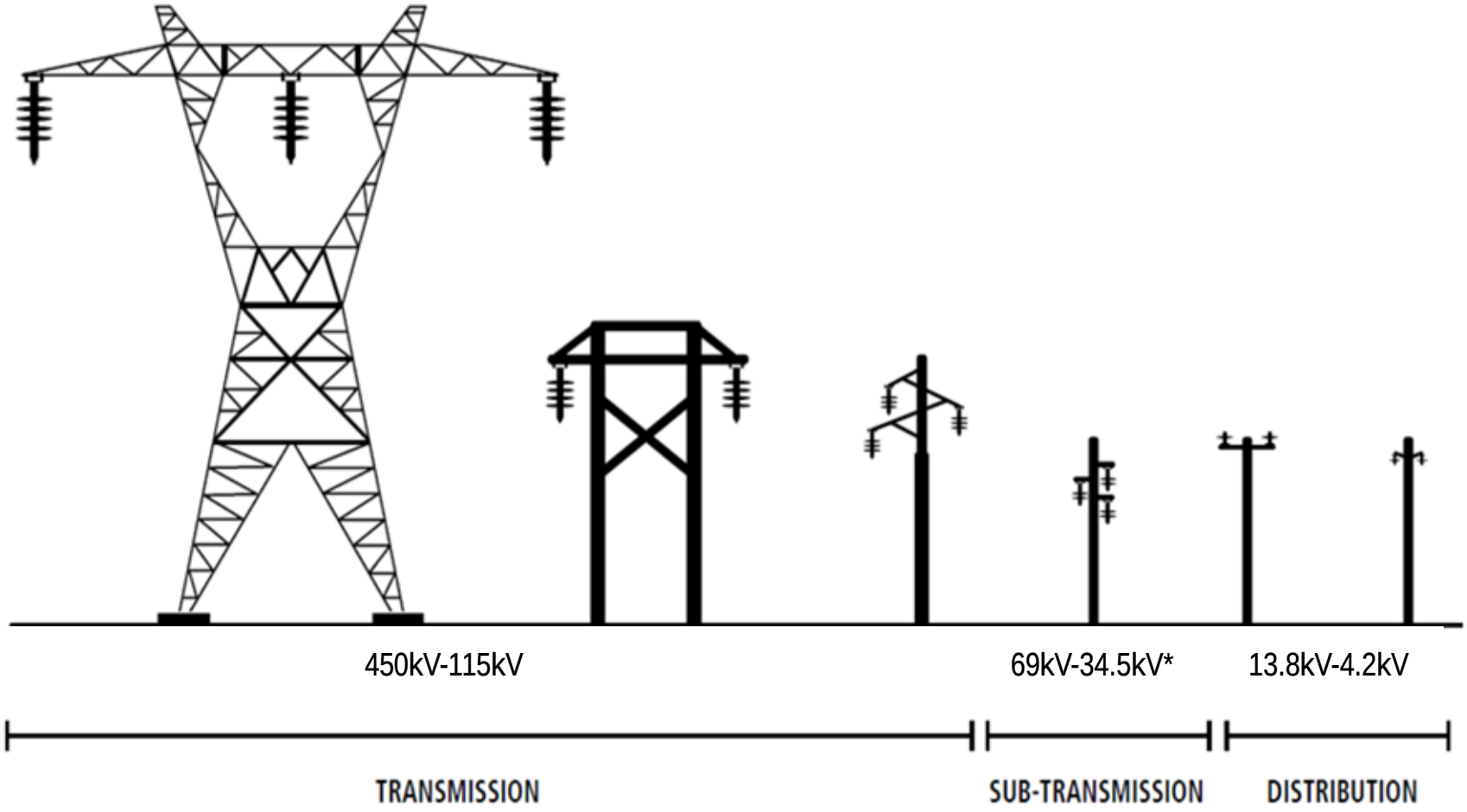
Analogy to road system: interstate, state roads, town roads

Traditional picture of transmission and distribution



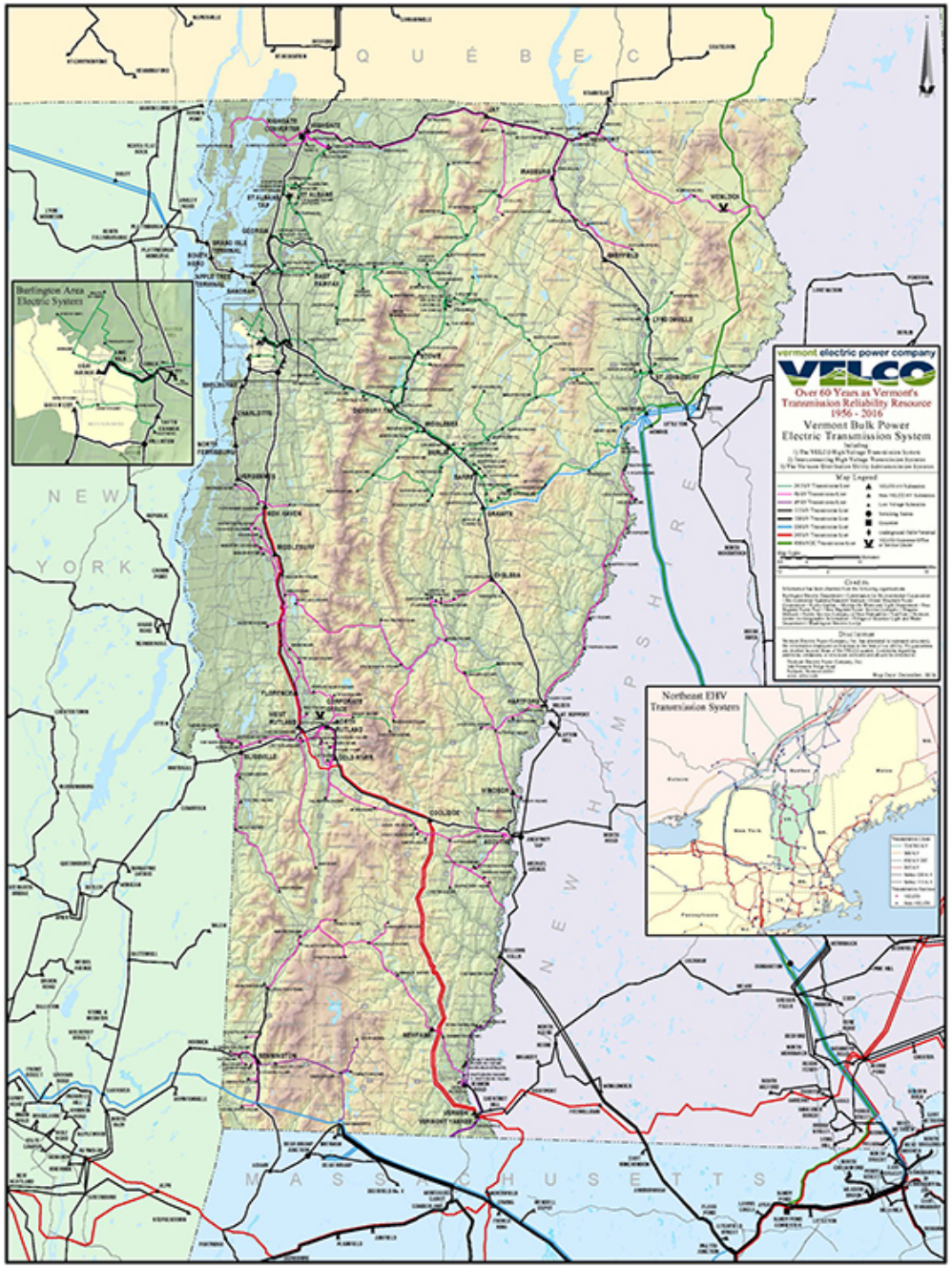
The evolving grid

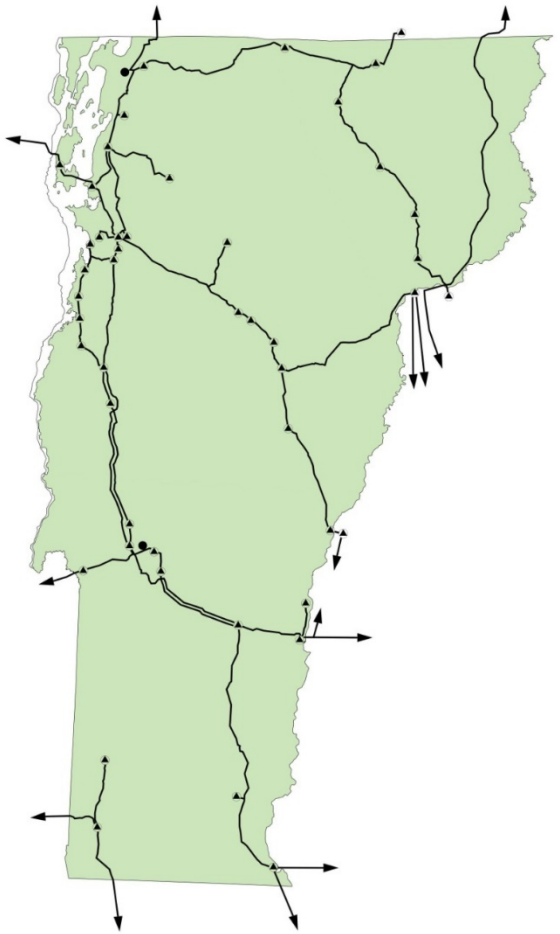




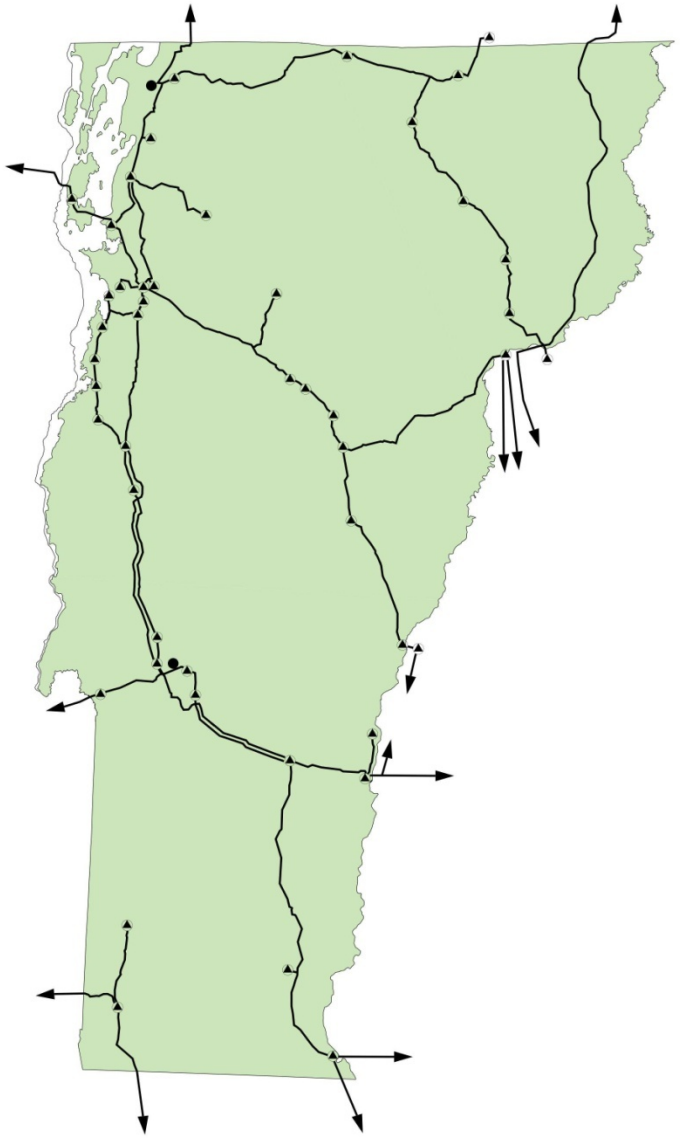
*34.5kV may also be a distribution voltage

VELCO system map





VELCO-managed assets



- 738 miles of transmission lines, 115 kV to 450 kv, predominantly wooden H-frame construction
  - (57) 115kV circuits = 514 miles
  - (10) 230 kV & 345 kV circuits = 200 miles
  - (1) 450 kV DC circuit = 54 miles
- 14,000 acres of rights-of-way
- 55 substations, switching stations and terminal facilities
- Equipment that enables interconnected operations with Hydro-Québec
- 52-mile high-voltage direct current line through the Northeast Kingdom owned by Vermont Electric Transmission Company (VETCO)
- 1500 miles fiber optic communication networks that monitor and control the electric system and provide the backbone for most Vermonters' high-speed data internet access

Vermont's dependence upon transmission

In 2014 VT *exported* power 73% of the time

12/31/14 Vermont Yankee (~ 600 MW) ceased operations

Since 2015, VT has *imported* power 100% of the time

REGULATORY AND STAKEHOLDER FRAMEWORKS

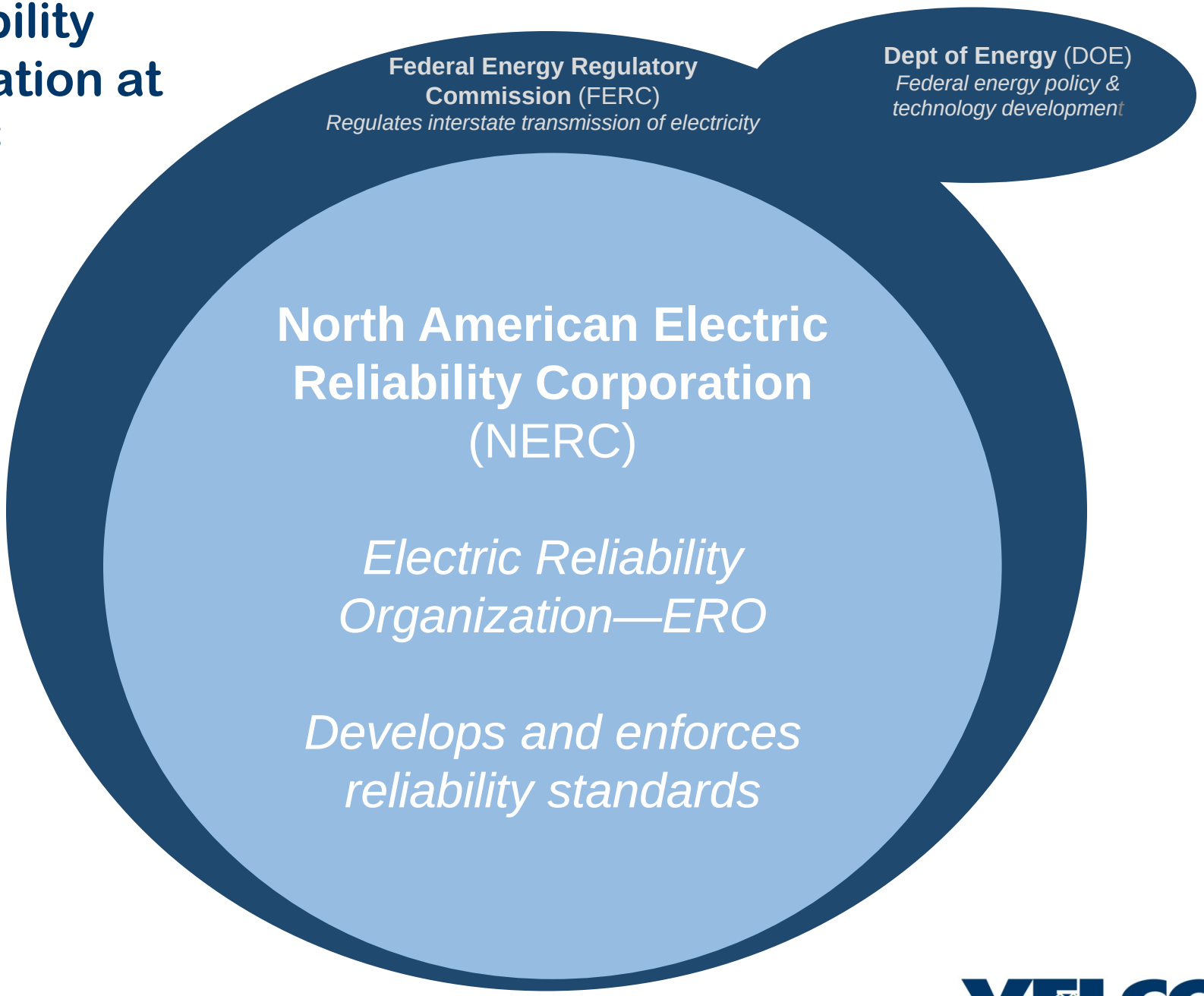
Transmission regulation at FERC

Dept of Energy (DOE)
Federal energy policy & technology development

Federal Energy Regulatory Commission (FERC)

- Reviews and approves rates, terms and conditions of transmission service
- Oversees development and enforcement of mandatory standards to ensure reliability, security and market integrity
- Establishes and enforces policy with respect to transmission planning and cost allocation
- Reviews certain mergers and acquisitions and other corporate transactions

Reliability regulation at NERC



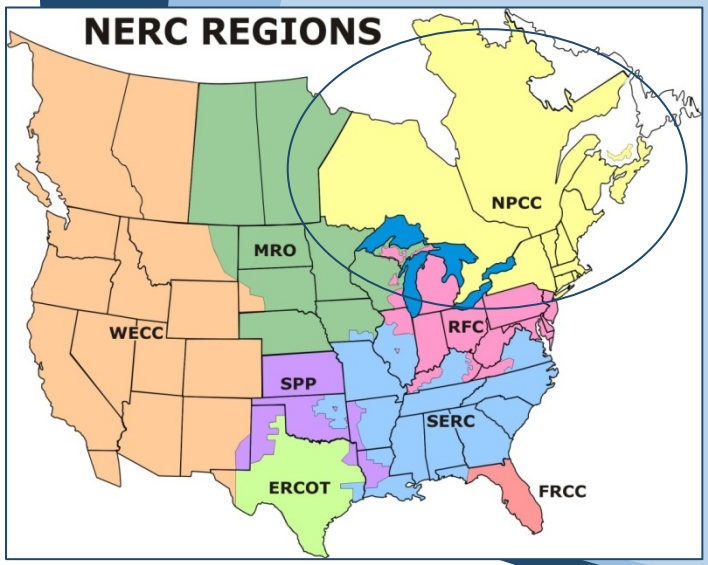
NPCC region of NERC

Federal Energy Regulatory Commission (FERC)
Regulates interstate transmission of electricity

Dept of Energy (DOE)
Federal energy policy & technology development

North American Electric Reliability Corporation (NERC)
Electric Reliability Organization—ERO
Develops and enforces reliability standards

Northeast Power Coordinating Council (NPCC)
Regional Reliability Organization—RRO
Establishes, monitors & enforces region-specific reliability requirements



NPCC's Five Control Areas

- **New England (ISO-NE)**
- New York (NYISO)
- Hydro Quebec (HQ/TE)
- Ontario (IESO)
- Maritimes (NBSO and NS)

ISO-NE

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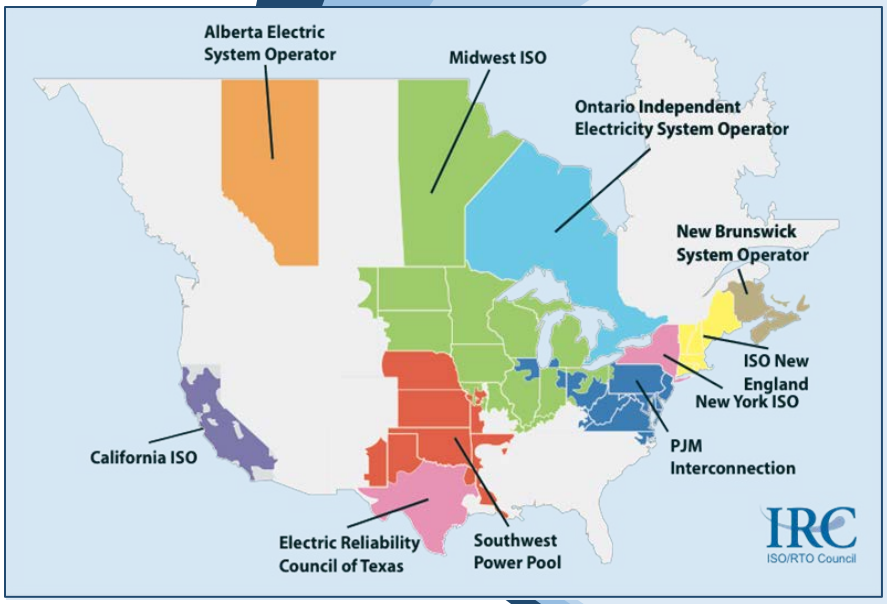
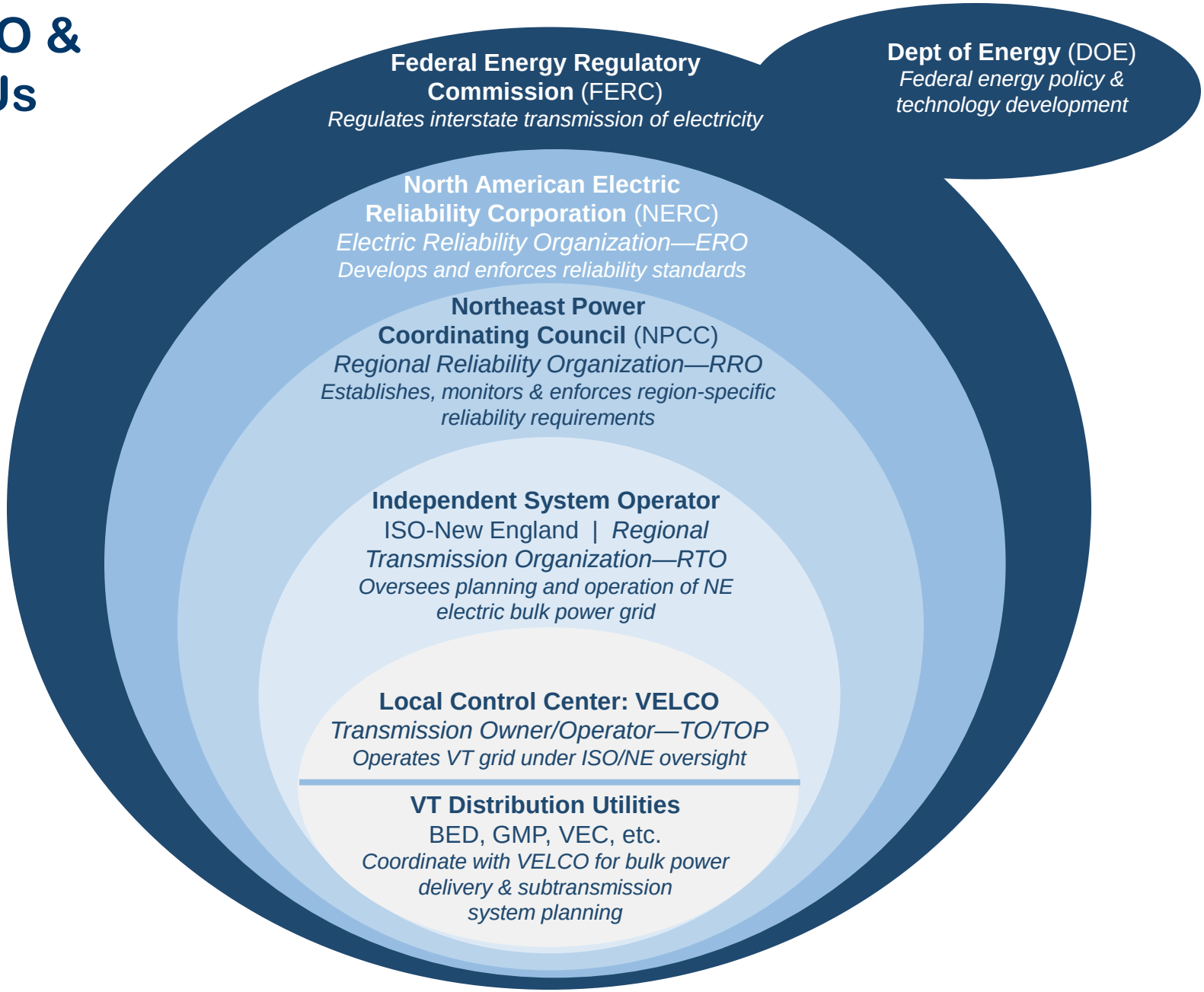


Independent System Operator
ISO-New England

Regional Transmission Organization—RTO

Oversees markets, planning and operation of NE electric bulk power grid

VELCO & VT DUs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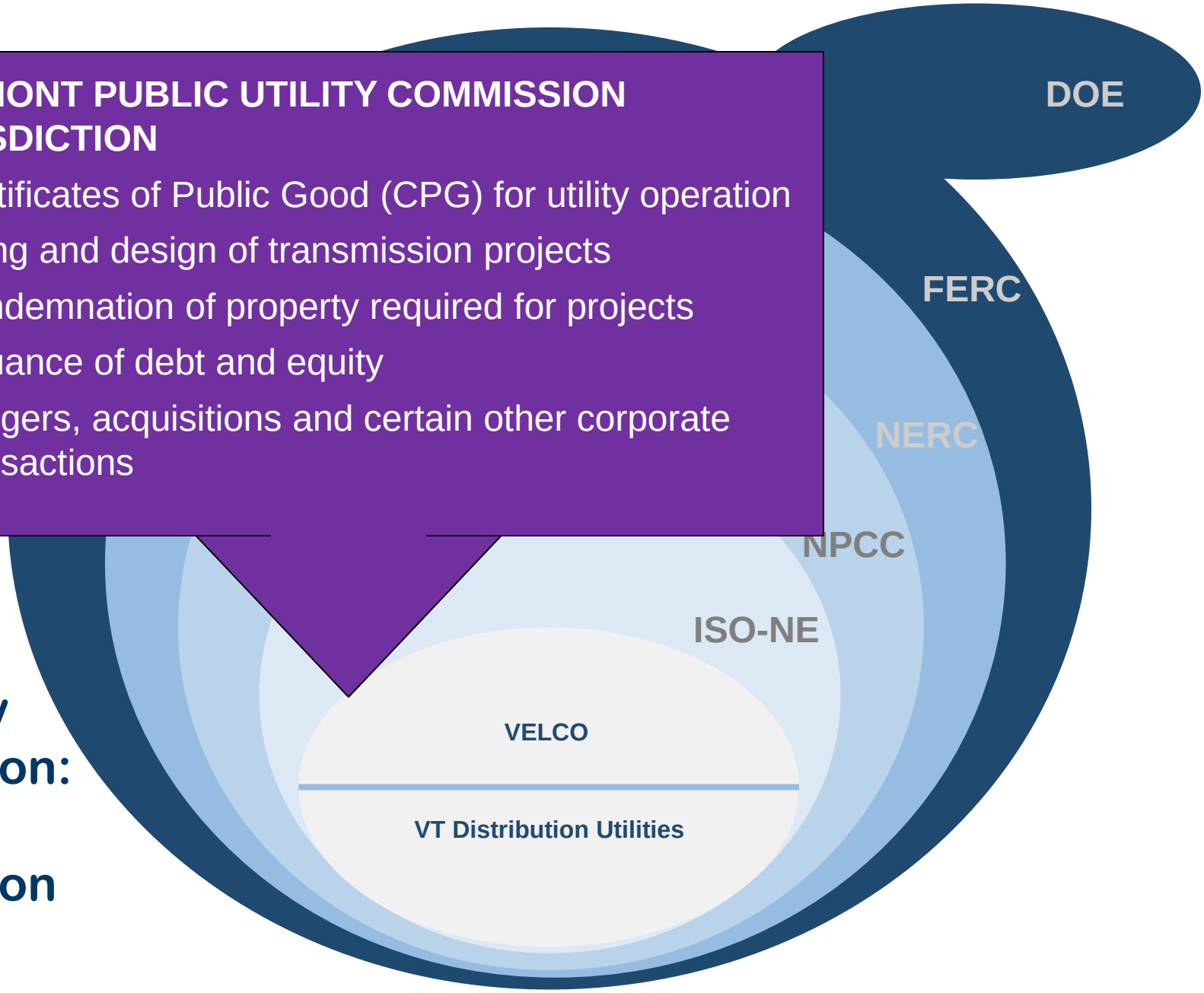
ISO-New England | Regional Transmission Organization—RTO
Oversees planning and operation of NE electric bulk power grid
Local Control Center: VELCO
Transmission Owner/Operator—TO/TOP
Operates VT grid under ISO/NE oversight
VT Distribution Utilities
BED, GMP, VEC, etc.
Coordinate with VELCO for bulk power delivery & subtransmission system planning

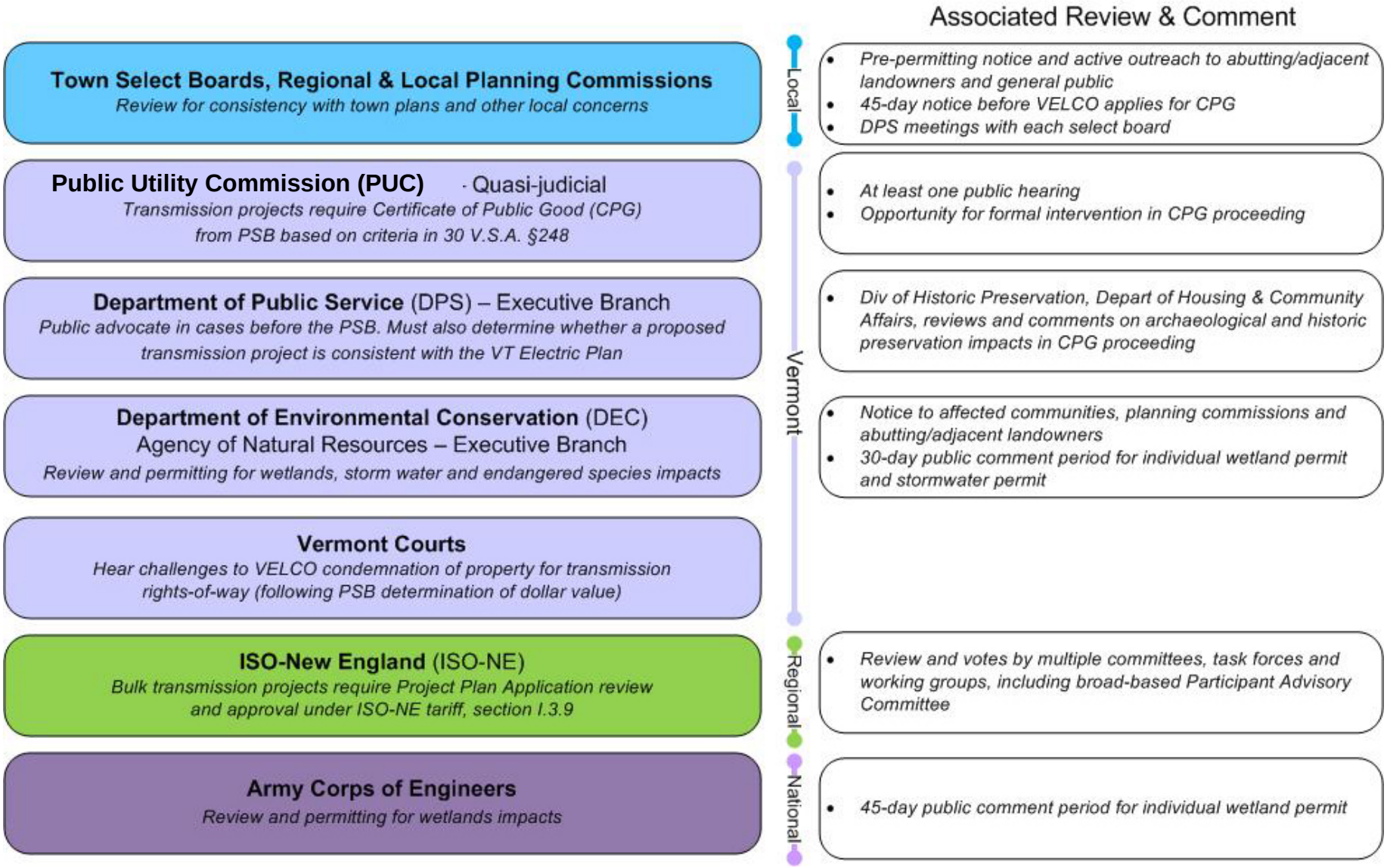
Electric industry regulation: state regulation

VERMONT PUBLIC UTILITY COMMISSION JURISDICTION

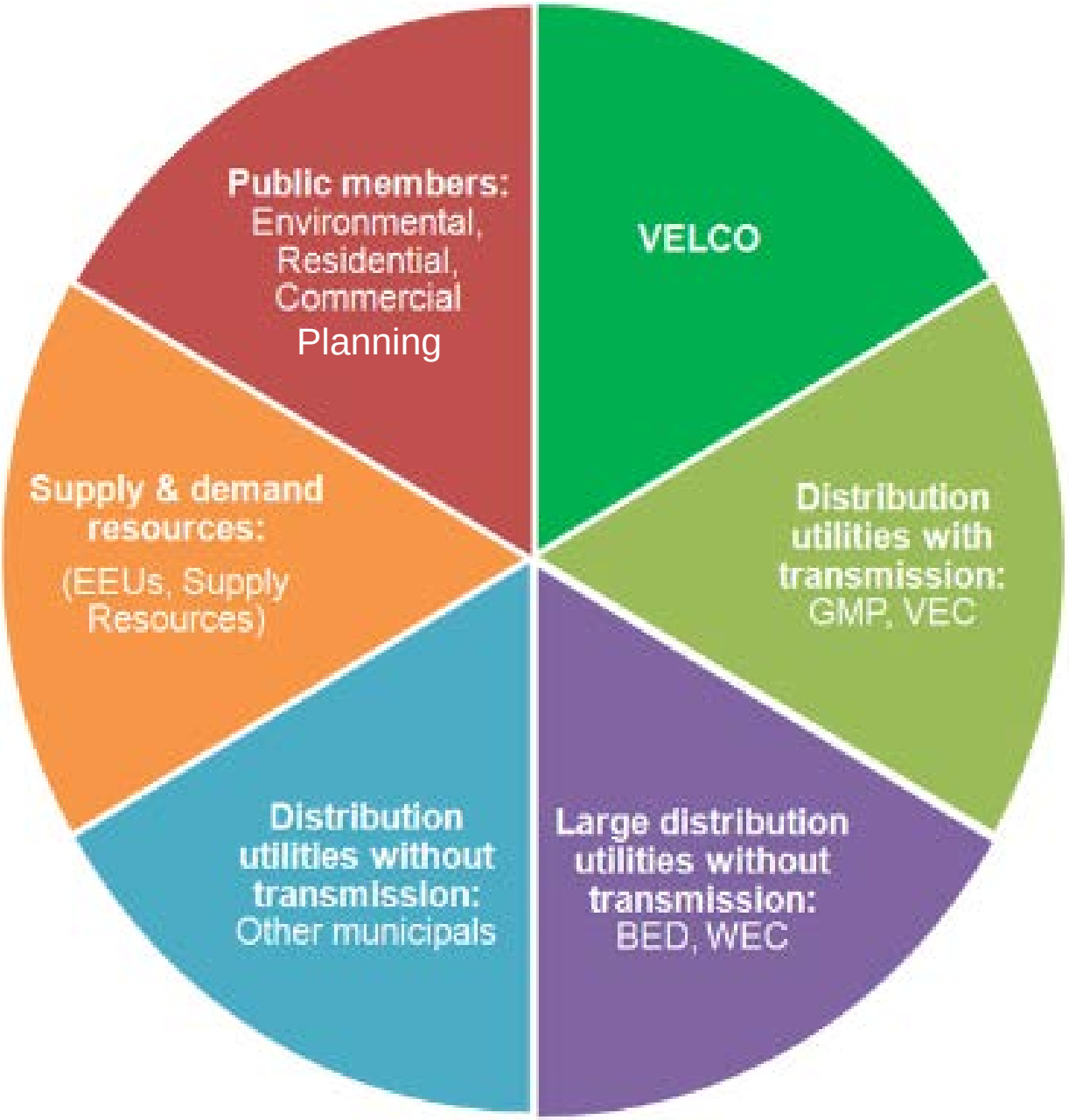
- Certificates of Public Good (CPG) for utility operation
- Siting and design of transmission projects
- Condemnation of property required for projects
- Issuance of debt and equity
- Mergers, acquisitions and certain other corporate transactions



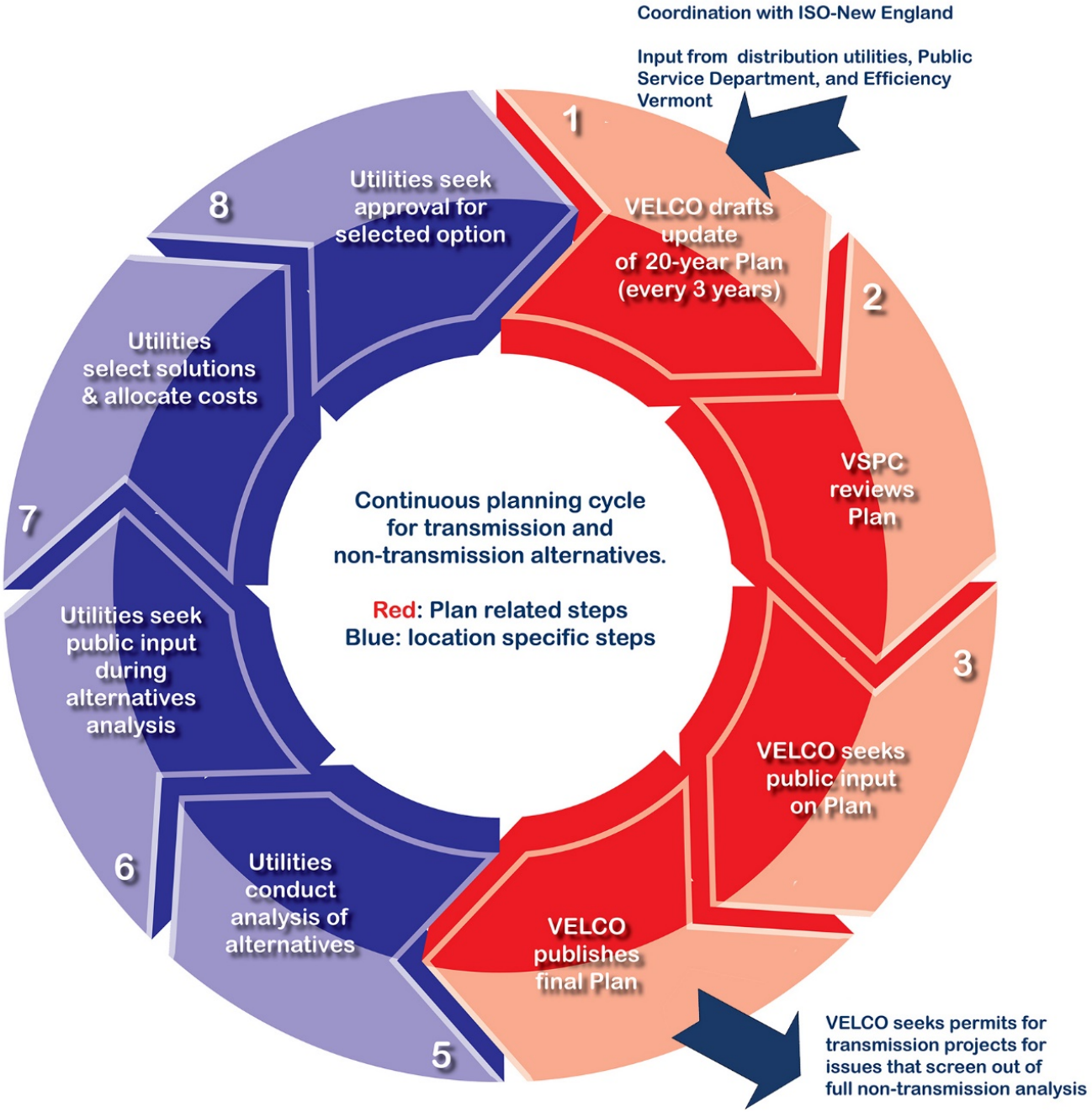
Permitting of Vermont transmission



Vermont System Planning Committee



Vermont planning cycle



Accomplishments of Vermont System Planning Committee process

- Contributed to deferral of >$400 million transmission upgrades
- Implemented and integrated geotargeting mandates for EE and DG (standard offer above the cap); PSB and legislature assignments for developing collaborative solutions
- Greatly increased collaboration and consensus on planning and load forecasting (previously contentious)
- Regularly convened diverse stakeholders (planners, advocates, VEIC, PSD) who were sometimes out of the loop and not necessarily talking
- Published plain-language, accessible 3-yr plans that paint the big picture and comply with mandates
- 2016 VSPC reviewed mission and processes and created a charter to refresh and simplify its work
- Initiated broad stakeholder conversation regarding curtailments associated with Sheffield-Highgate Export Interface

STRATEGIC INITIATIVES & CULTURAL TRANSFORMATION

Mission, vision & values

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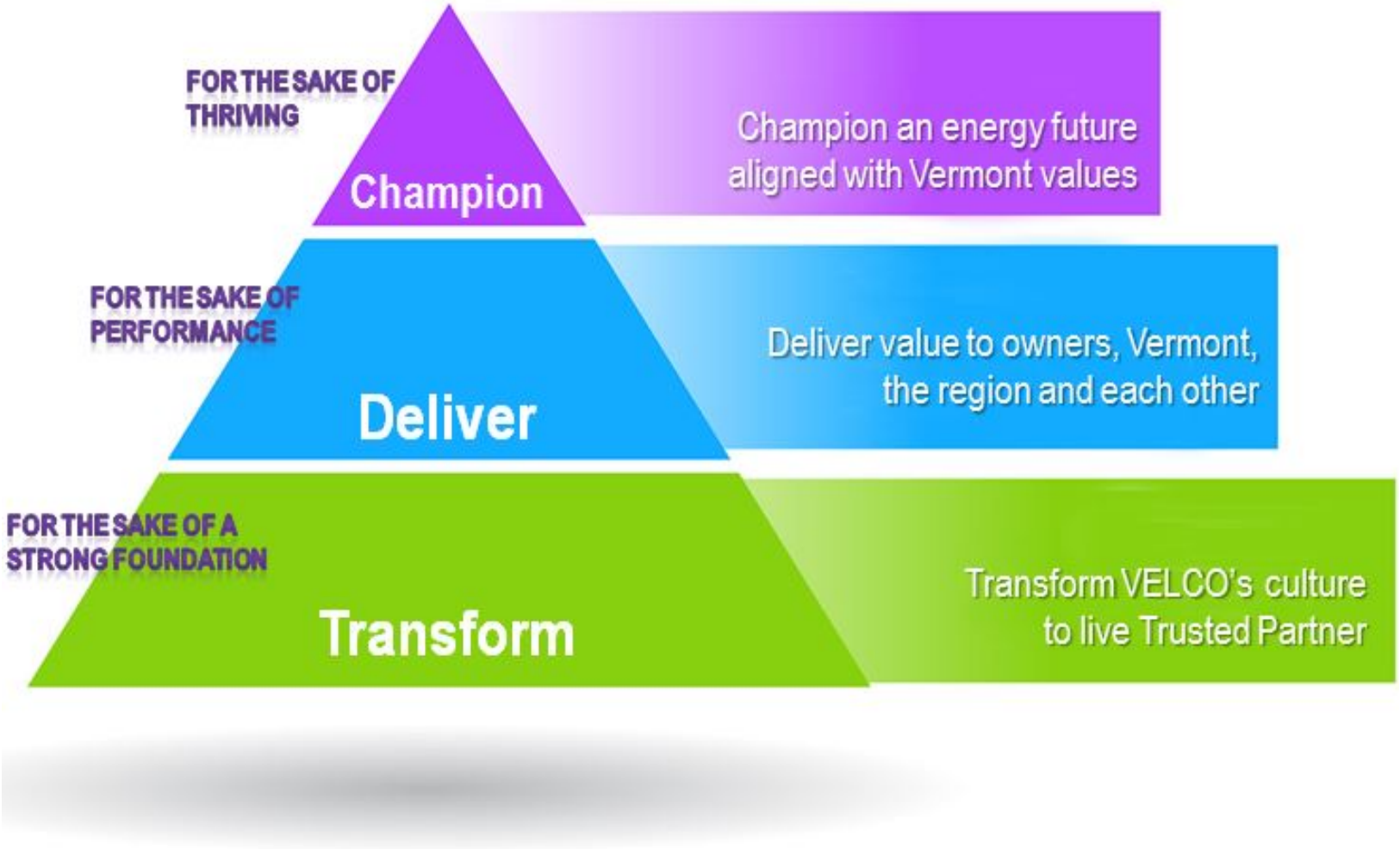
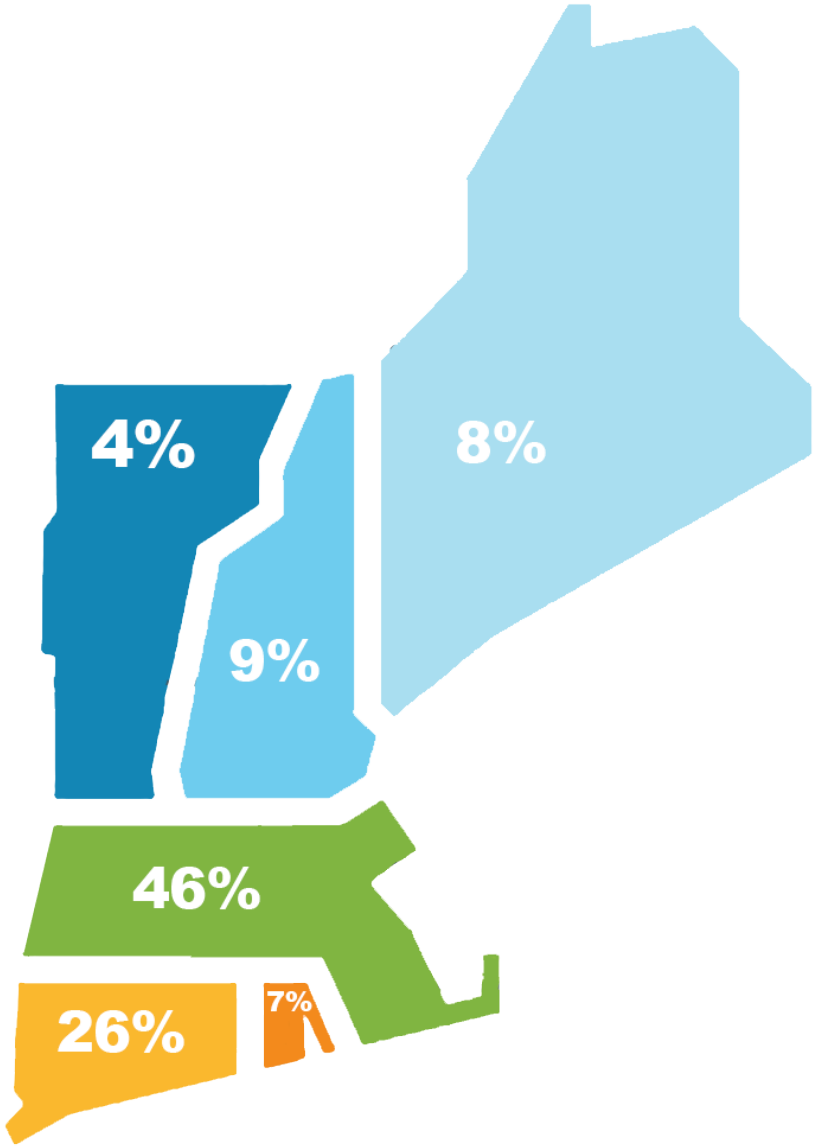
VELCO evolution

VELCO strategic initiatives

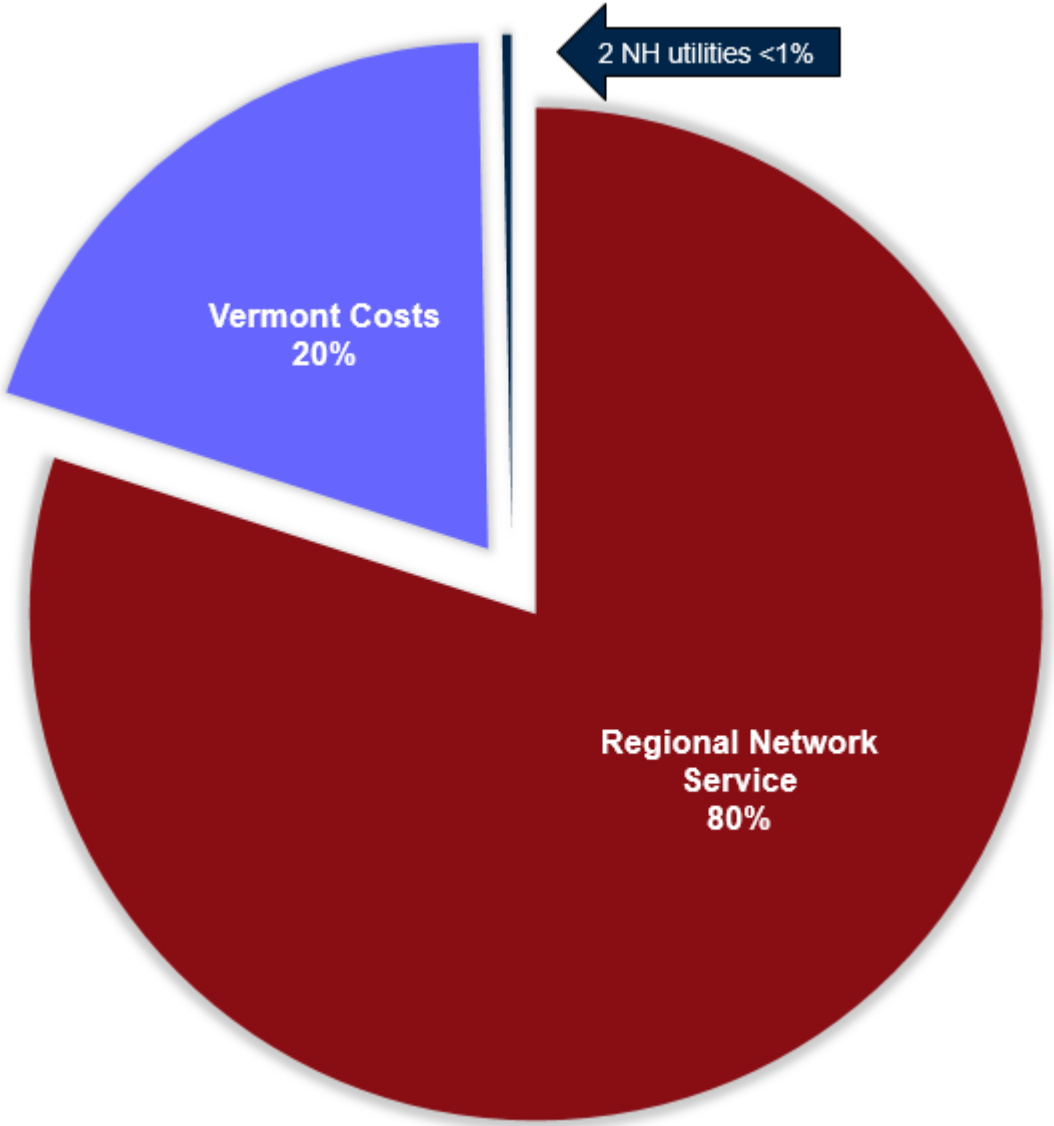


VELCO FINANCE

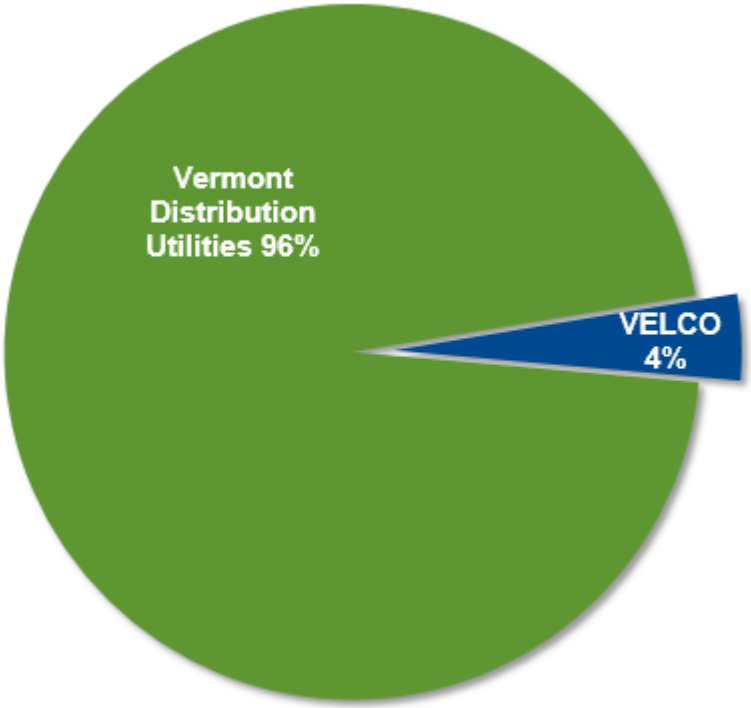
New England states load ratio share

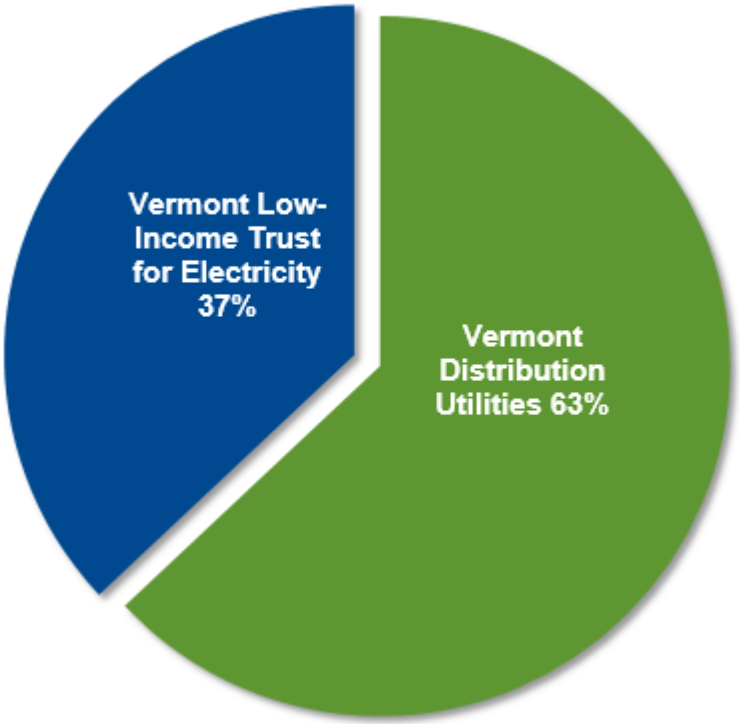


VT Transco revenue requirement: regional vs. local



VELCO & VT Transco shareholders





VERMONT TRANSCO LLC

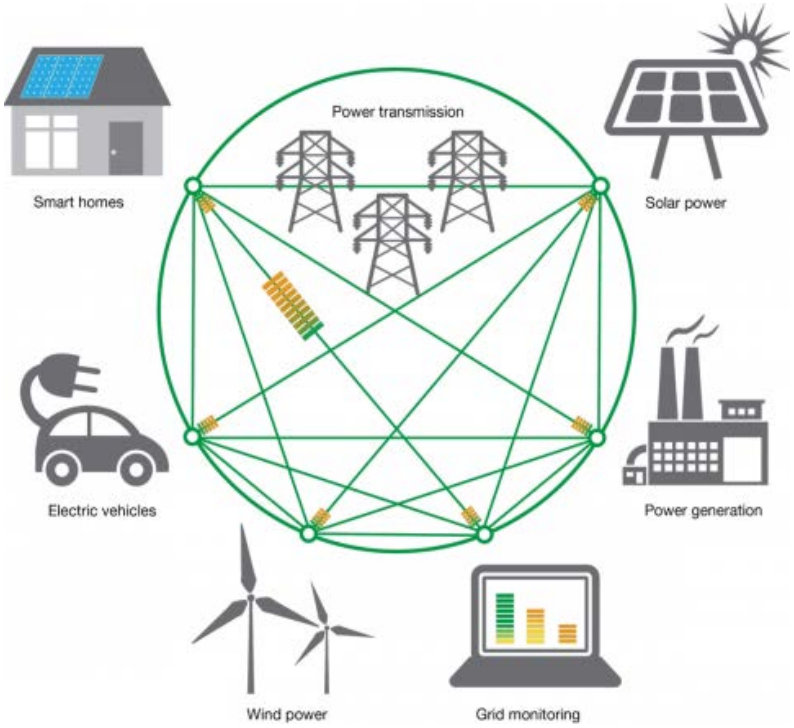
VELCO

VELCO

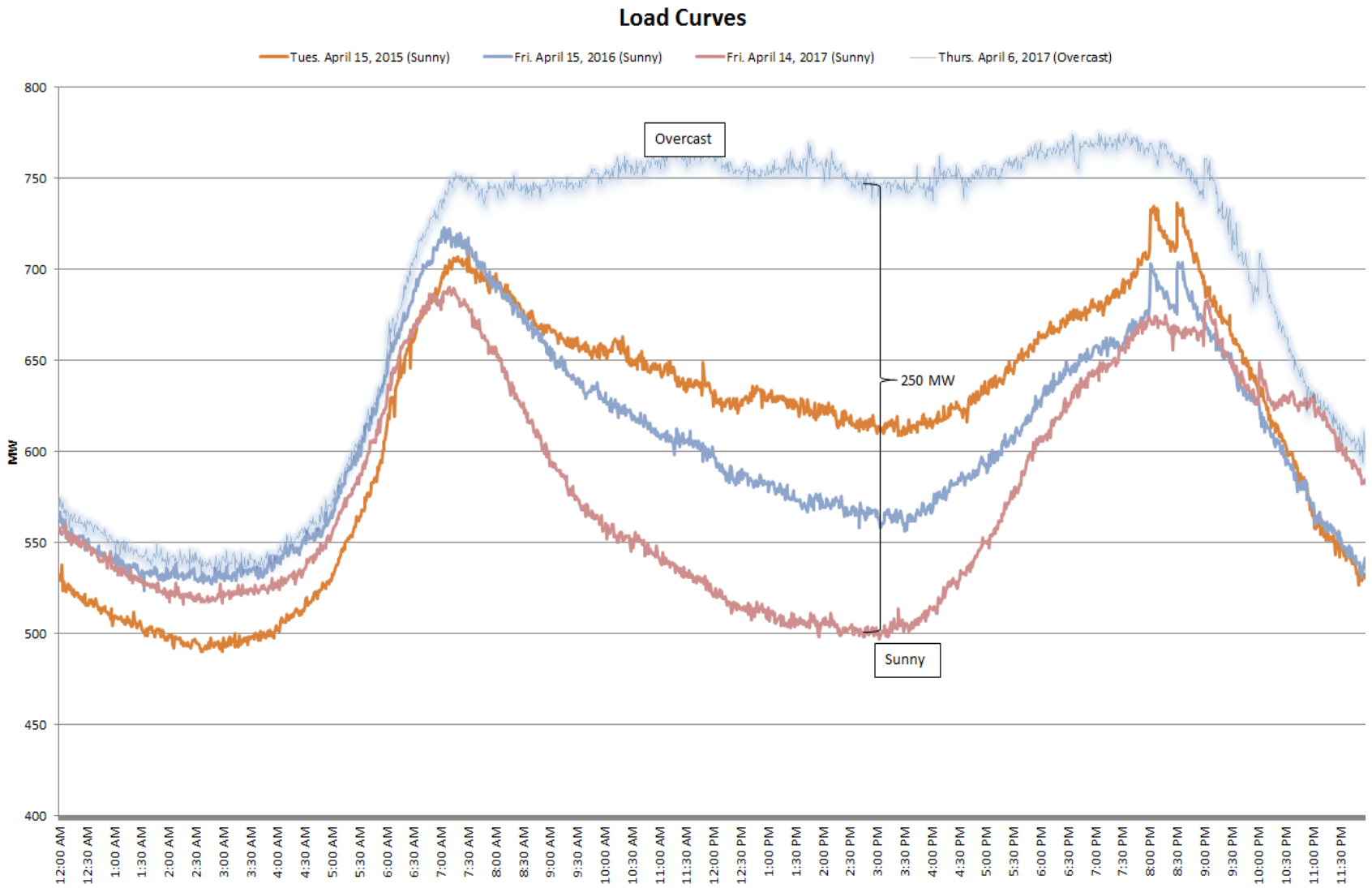
VT Transco earnings before tax

	Budget 2019
New England Open Access Transmission Tariff	88,500
1991 Vermont Transmission Agreement	41,100
Earnings before tax	(93,900)
Net Cost of Transmission	*35,700*

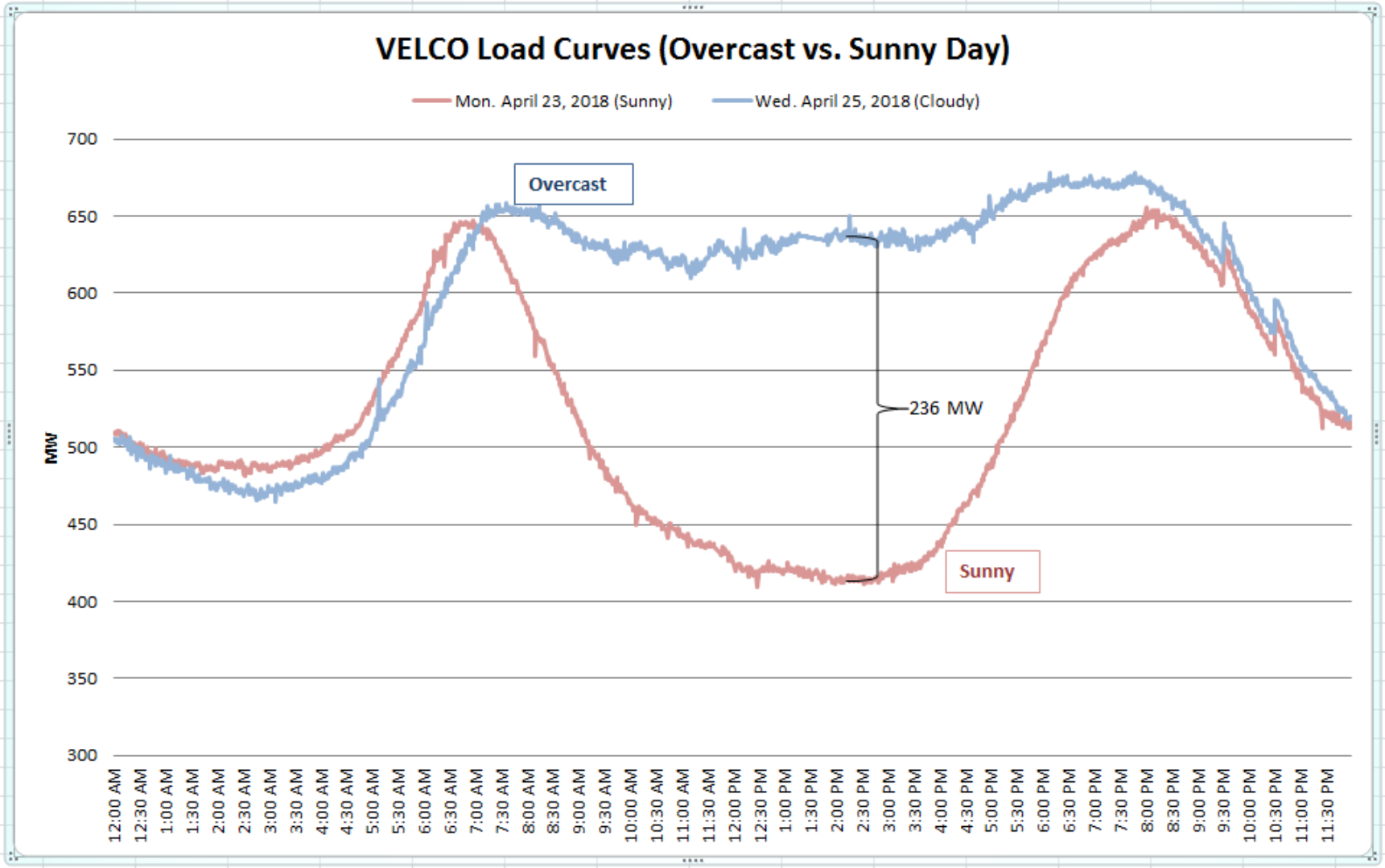
CURRENT ISSUES: EVOLUTION OF THE GRID



April load comparison

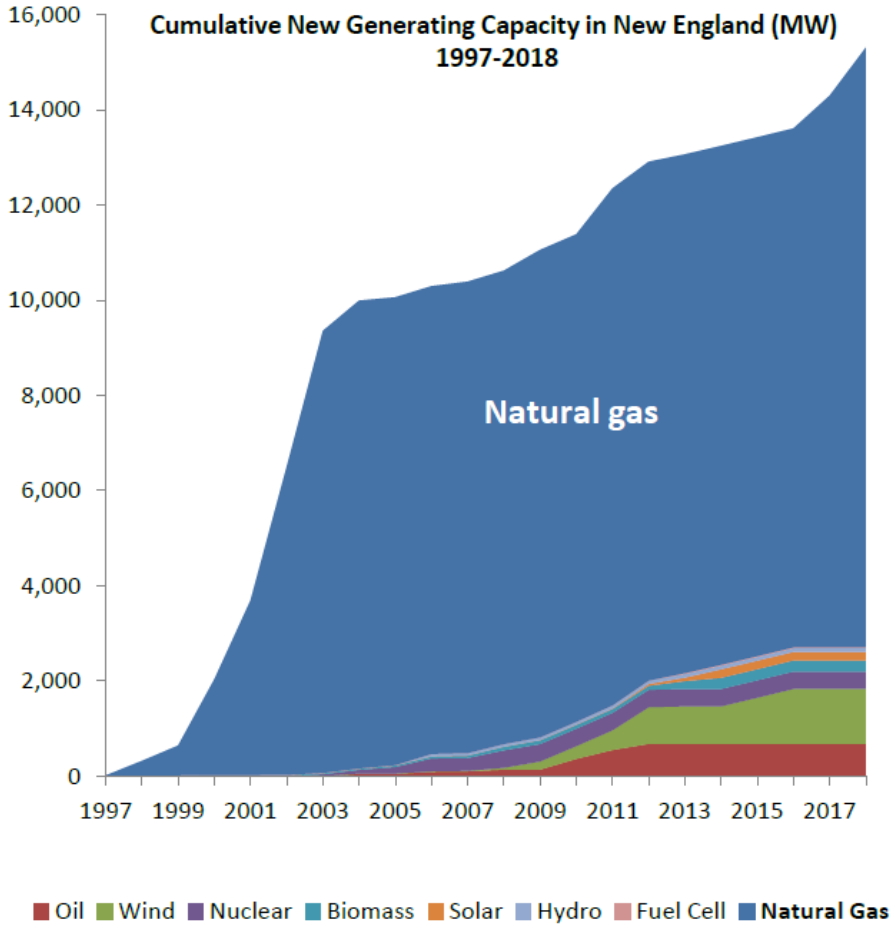


April 2018 load comparison



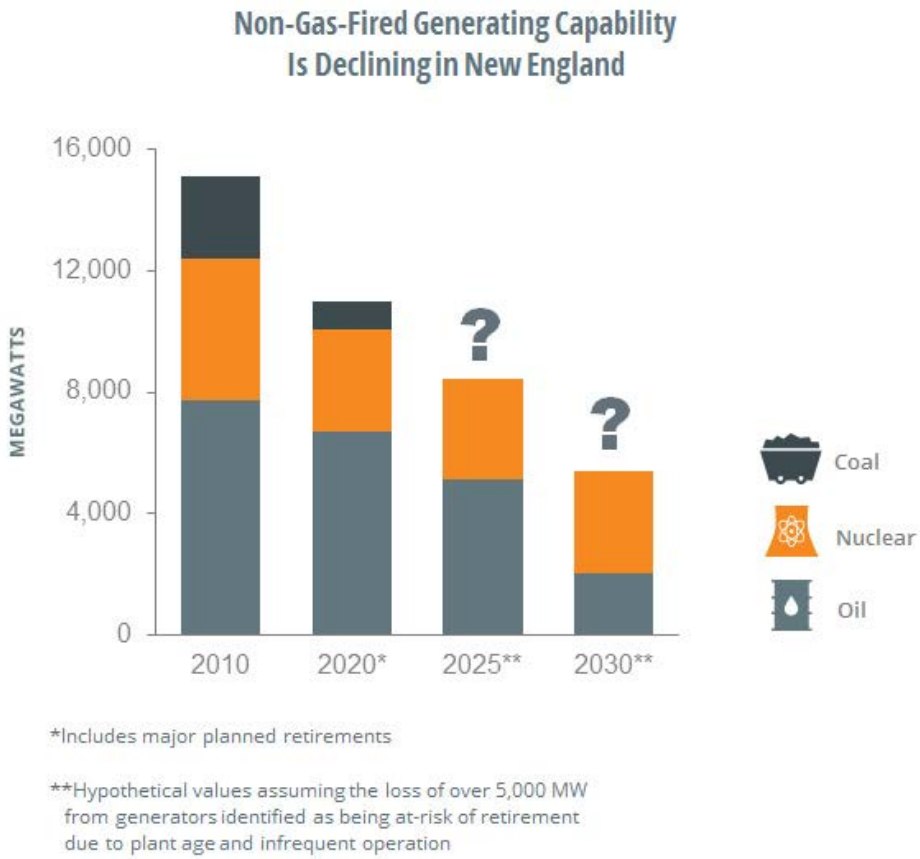
Region's resource mix transformation continues

- **Low natural gas prices**
  - Gas is the most economic fuel for new, conventional resources
    - 80% of new capacity since 1997 runs on natural gas
    - Nearly 65% of all proposed new generation would use natural gas
  - Demand for natural gas is rising
  - Gas pipelines are constrained during high demand periods, particularly winter
    - Creates grid reliability concerns and price volatility
- **Low prices are putting financial pressure** on coal, oil and nuclear baseload generators; some are retiring



Source: ISO New England "State of the Grid 2016"

Fuel security a major ISO-NE focus

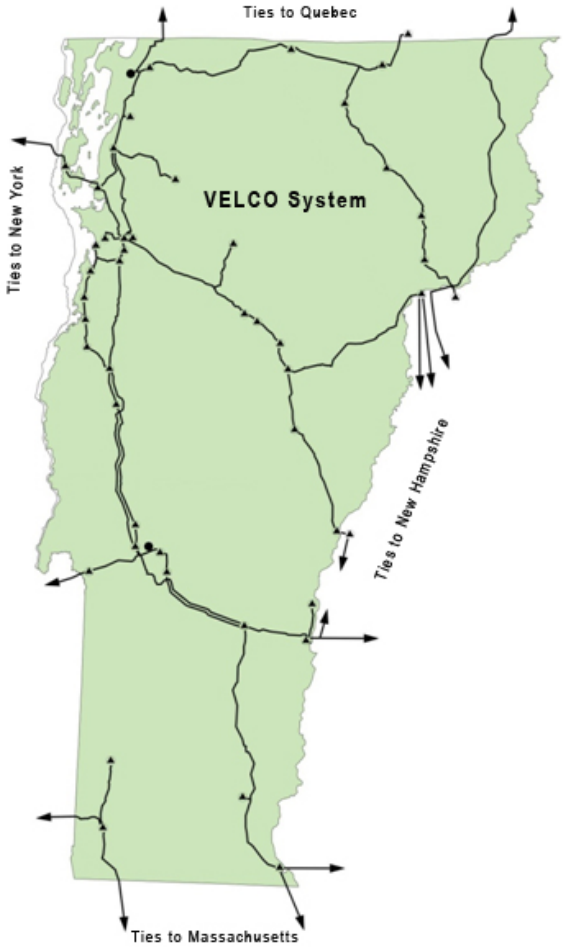


Shift to cleaner power continues

- **State policies drive renewable resource development**
  - Mostly large-scale wind and behind-the-meter solar
  - Other, fast & flexible resources will be needed to balance intermittent resources' variable output
  - New transmission needed to bring wind farms' energy from their remote locations to population centers
- **Distributed generation and the "hybrid" grid**
  - A significant portion of New England's future grid could be "behind-the-meter" (solar facilities on distribution system)
  - That will change how much and when power is used by consumers

Source: ISO New England "State of the Grid 2016"

Vermont now imports most of its power



Type		MW 2014	MW 2018
Fossil (fast start units)	Winter	188	188
	Summer	138	138
Hydro		152	152
Wind		123	151
Landfill gas		9	9
Biomass (wood)		72	72
Solar and other, e.g. farm methane		~100 and growing	~325 and growing
Nuclear		625	0
TOTAL IN-STATE NAMEPLATE GENERATION		**1265**	**845**

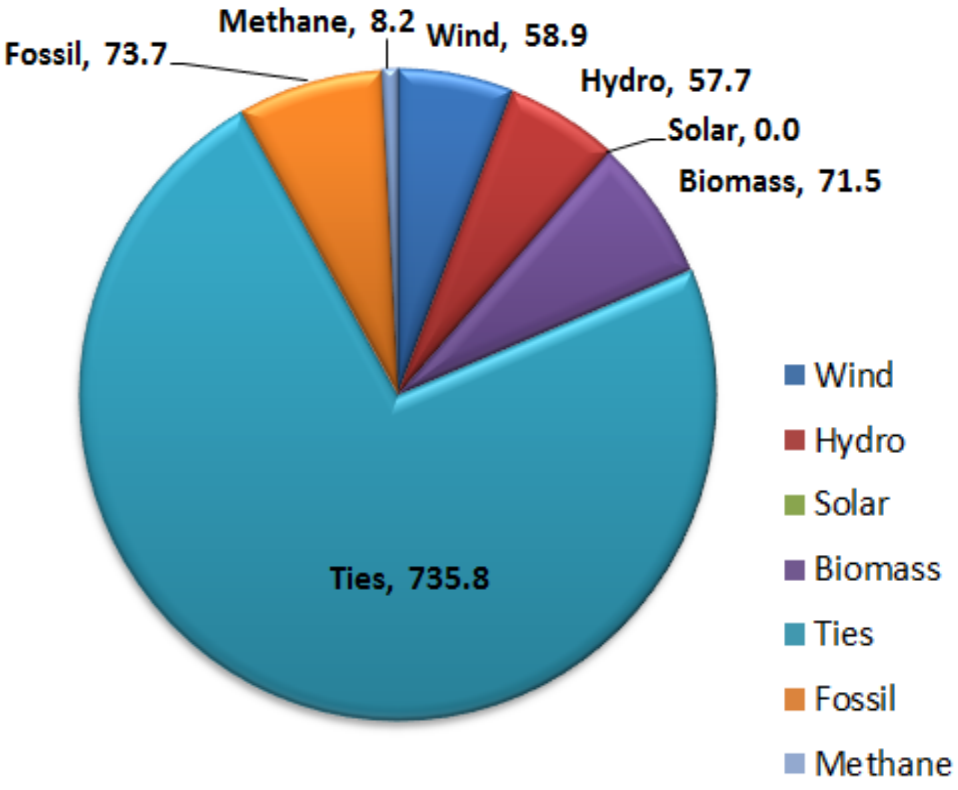
VT exported power 73% of 2014 hours

VT imported power 100% of 2017 hours

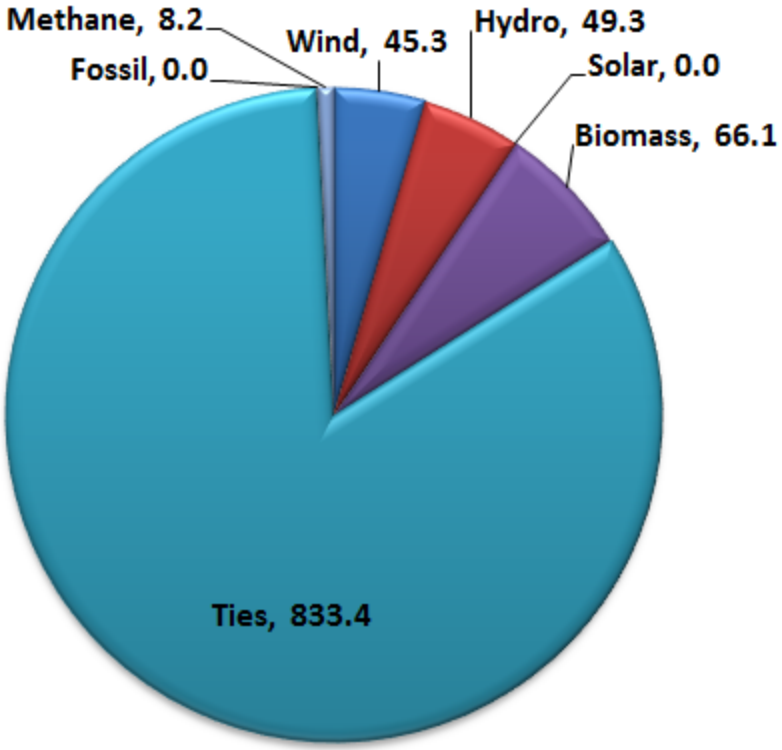
(80% >400 MWs)

2018 Vermont peak days

- 2017/2018 **winter** peak hour (12/29/17, 6 p.m.)
- Load was 1005.7 MW



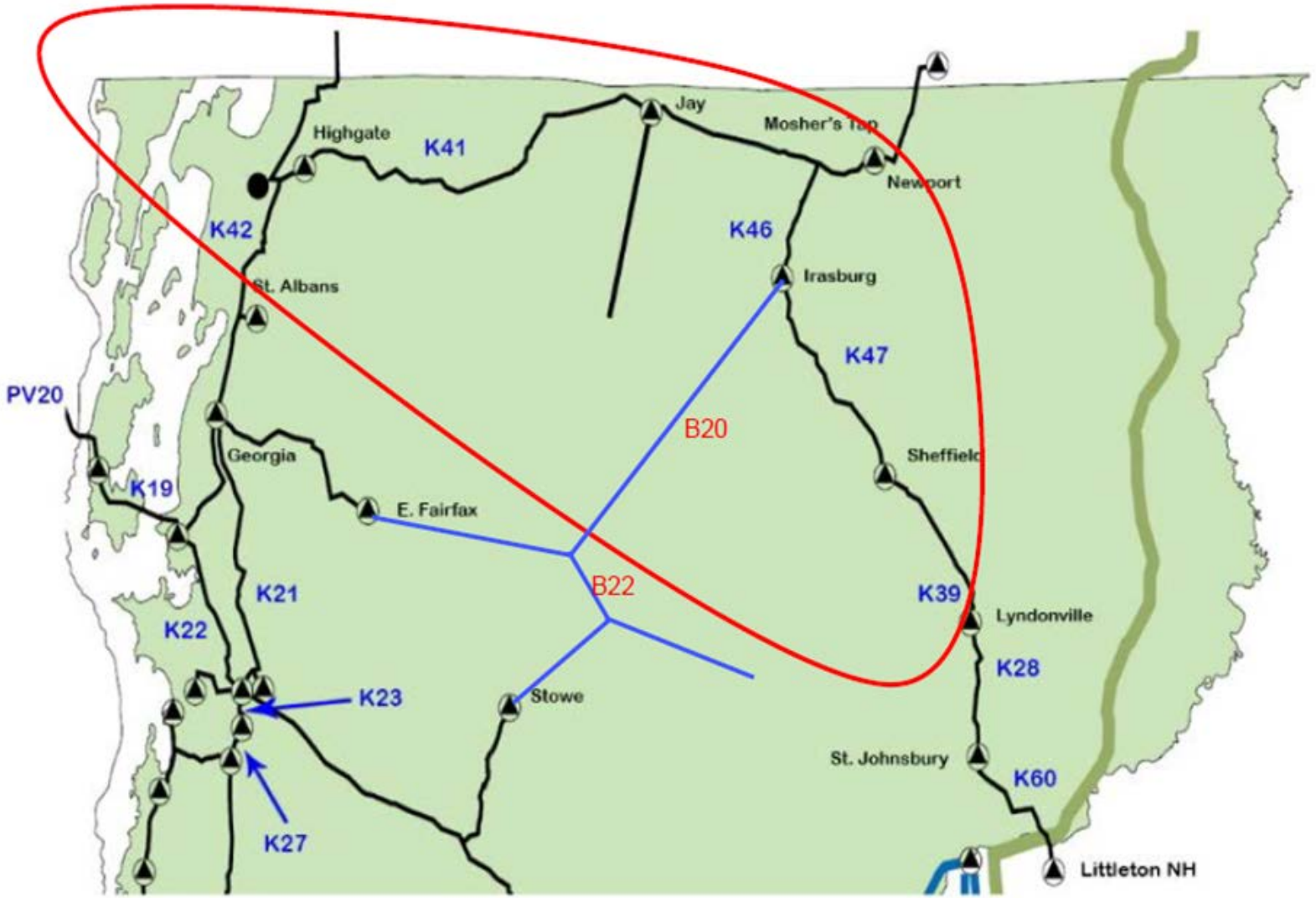
- 2018 **summer** peak hour (7/2/18, 8 p.m.)
- Load was 1002.3 MW



Grid operations are becoming more complex

1. Renewables (PV, wind) are intermittent
2. At sunset all VT PV essentially shuts down at once
3. Inverter-based generation—unlike rotating generation— does not contribute to fault current or add system inertia
   - Both must be generated from other sources
   - Until now smart inverters were not required—IEEE standard 1547 when fully implemented will mandate smart inverters
4. Much distributed generation not visible on transmission
   - Challenges situational analysis and model precision
5. No cyber standards currently apply to inverter-based generators
6. Weather key to intermittent resources
   - Little PV generation after snowstorms
   - Generally reduced output in winter
7. Role of storage not yet clear
   - Will it be scheduled?
   - Who will control it?

Sheffield-Highgate Export Interface (SHEI)

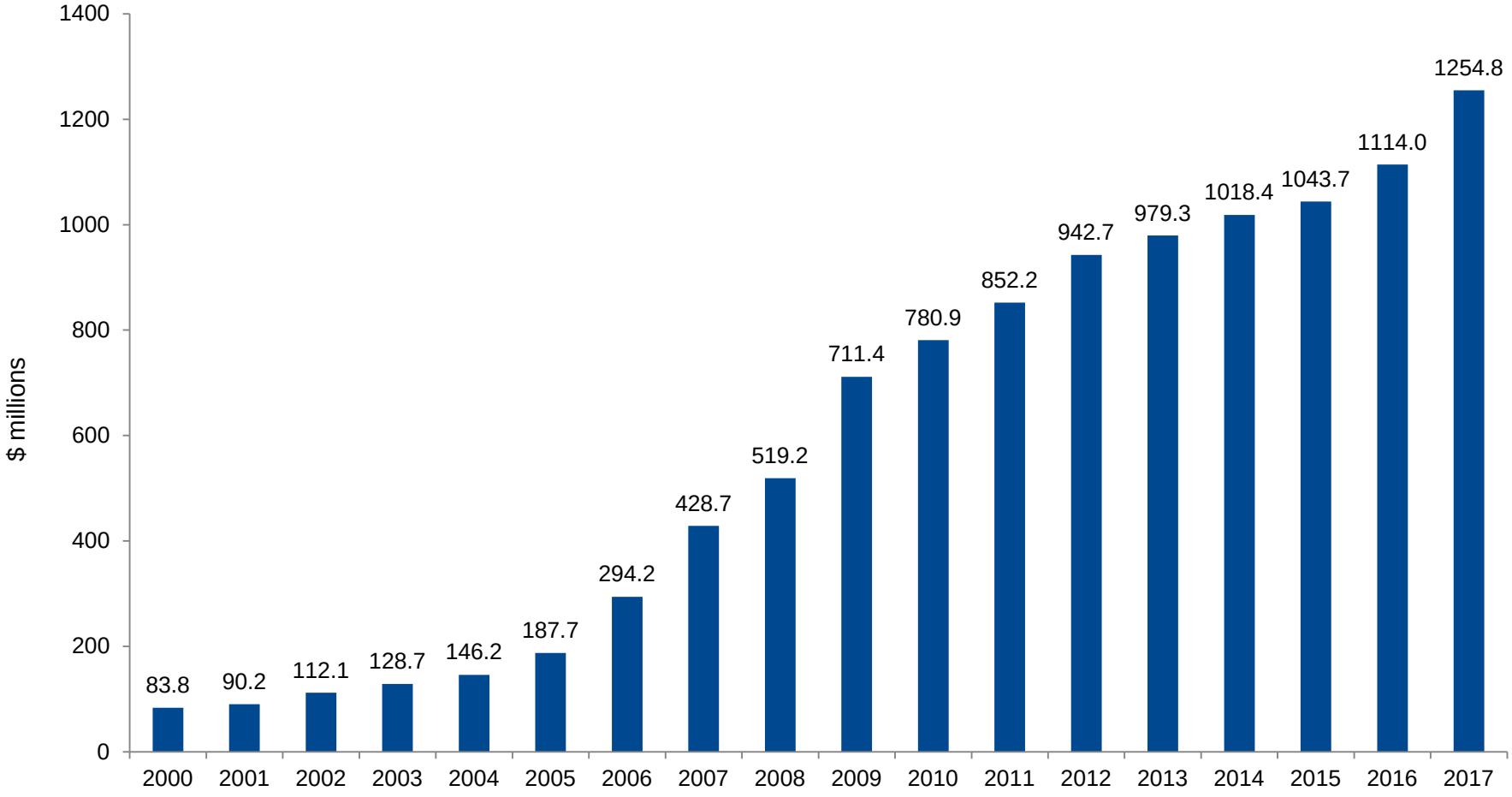


Vermont's evolving grid—summary

- Continued rapid PV growth on transmission and subtransmission, and behind the meter
  - At least six 20MW PV plants proposed—one under construction
- Location matters to grid impacts of intermittent resources
- VT peaks are now after dark when solar is unavailable, i.e., additional solar without storage won't affect peak
- Significant reliance on natural gas generation regionally
- Behind-the-meter PV looks like lower load to transmission operators
- Impacts of storage and strategic electrification are difficult to forecast at early stage of growth

GRID RESILIENCE & CAPITAL PLANNING

VELCO asset growth 2000-2017



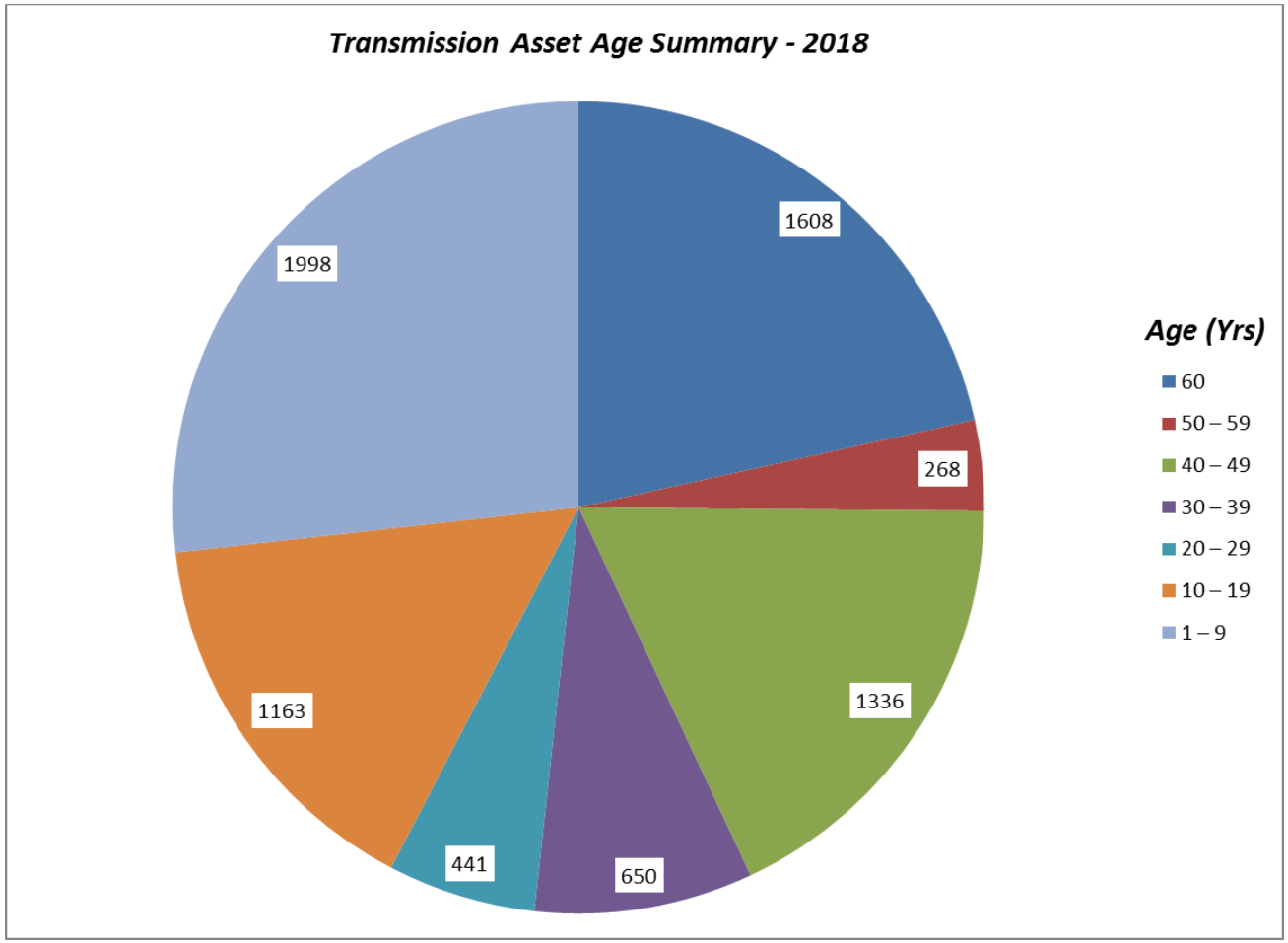
Vermont's 2018 electric reliability

- Vermont transmission system is highly reliable
  - Mature vegetation management program
  - Capital infrastructure improvements
  - Established capital maintenance programs
- VELCO continuously tracks via metrics, compares to past performance and industry
- One outage affected distribution customers 2018 YTD
  - May 5 tree contact on K24 115kV line (Duxbury to Stowe) causing permanent fault (~2,000 Stowe customers out for ~120 minutes)

Aging infrastructure projects—lines

Significant number of transmission assets are reaching end of life

- Transmission line pole replacements will be performed on 8-year cycle
- Scope based on engineering surveys as well as inspections performed with condition ranking tool



Aging infrastructure projects—stations

Refurbishing older substations as needed

- Replacing inadequate equipment
- Installing oil containment systems
- Constructing new control buildings
- Improving protection and control systems
- Addressing configuration issues
- Enhancing physical security

Other projects

Reliability standards and need for a more resilient system are driving other types of capital projects

- Data centers
- Back-up control center
- Control center upgrades
- Security improvements
  - Physical
  - Cyber
- River bank stabilization efforts
- Aging power electronic equipment

REGIONAL PLANNING, RELIABILITY STANDARDS & TRANSMISSION COSTS

North American Electric Reliability Company (NERC)

- Funded by all customers
- Reports to Federal Energy Regulatory Commission (FERC)
- Role
  - Recommends reliability standards to FERC for approval
  - Enforces compliance with reliability standards
  - Reports on reliability annually
  - Investigates major reliability issues
  - Enforcement through “Regional Coordinating Councils”
    - Northeast Power Coordination Council (NPCC)
    - Performs periodic audits for compliance
- Major standards on Bulk Electric System (BES)
    - Control rooms and operations
    - Cyber issues
    - Maintenance

Risks to grid reliability
NERC reliability issues steering committee

High risk profiles

- Cyber security vulnerabilities
- Changing resource mix
- Bulk power system planning
- Resource adequacy

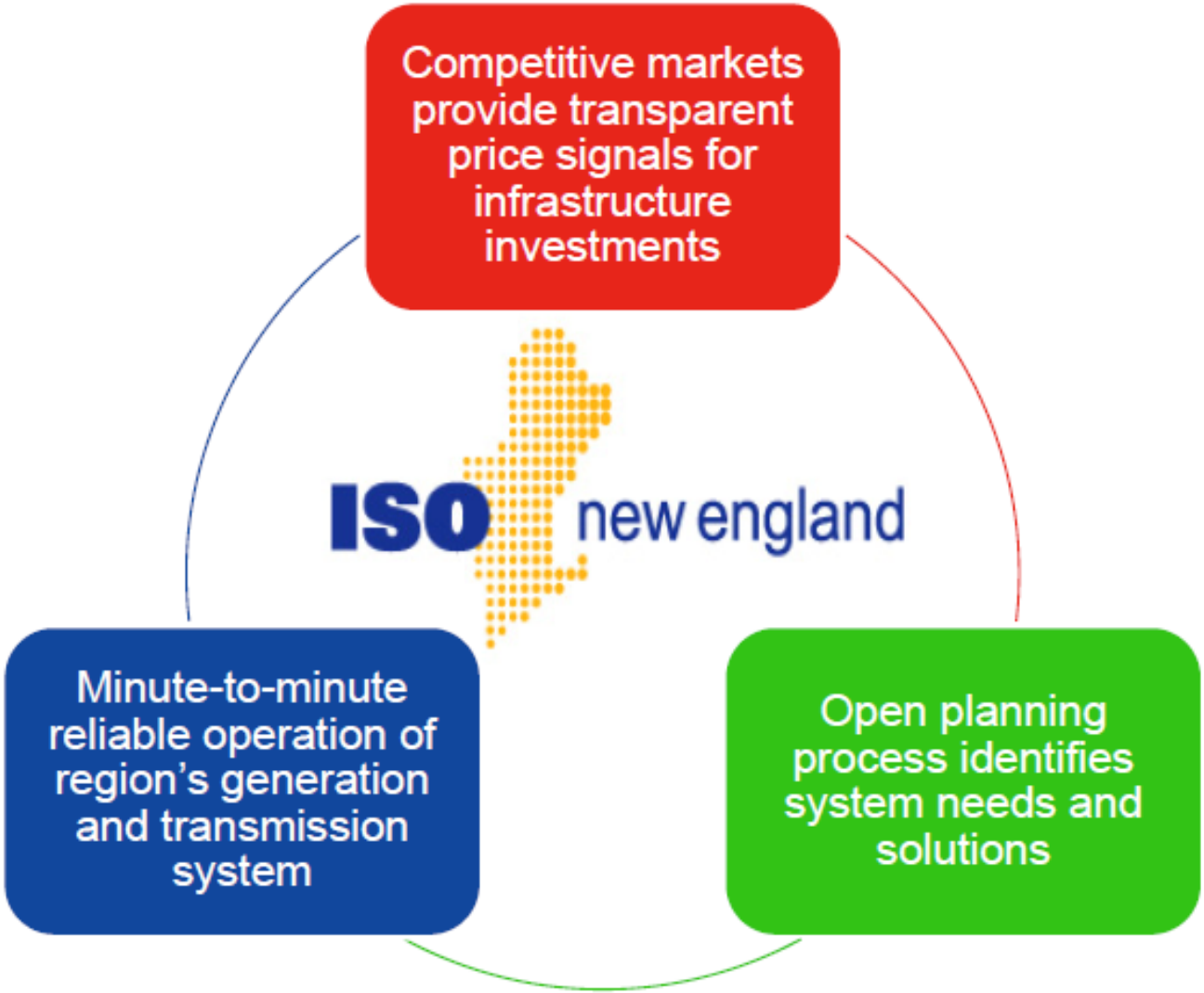
Moderate risk profiles

- Increasing complexity in protection and control systems and asset management
- Loss of physical awareness
- Physical security vulnerabilities
- Extreme natural events

Low risk profiles

- Human performance and skilled workforce

Foundation of New England's power system



Regional developments

- Declining loads, mainly due to solar development, reducing need for regional reliability projects
  - Load shedding criteria established by ISO-NE further reduces need
- Utilities addressing asset condition concerns, similar to VELCO
  - New England system built in “waves” with many lines over 60 years old
  - Reinforces overall New England grid and increases storm resiliency
  - Important to Vermont, especially with state’s dependency on regional tie lines
- ISO-NE recognized shift in capital project investments and associated costs
  - Changes to requirements regarding transmission cost allocation (TCA) applications
    - Requires cost recovery applications for maintenance projects
    - Sets lower thresholds on expenditures that would require TCA applications
    - Requires ISO committee review and approvals
    - Timing requires TCA submitted before start of major construction

Regional planning

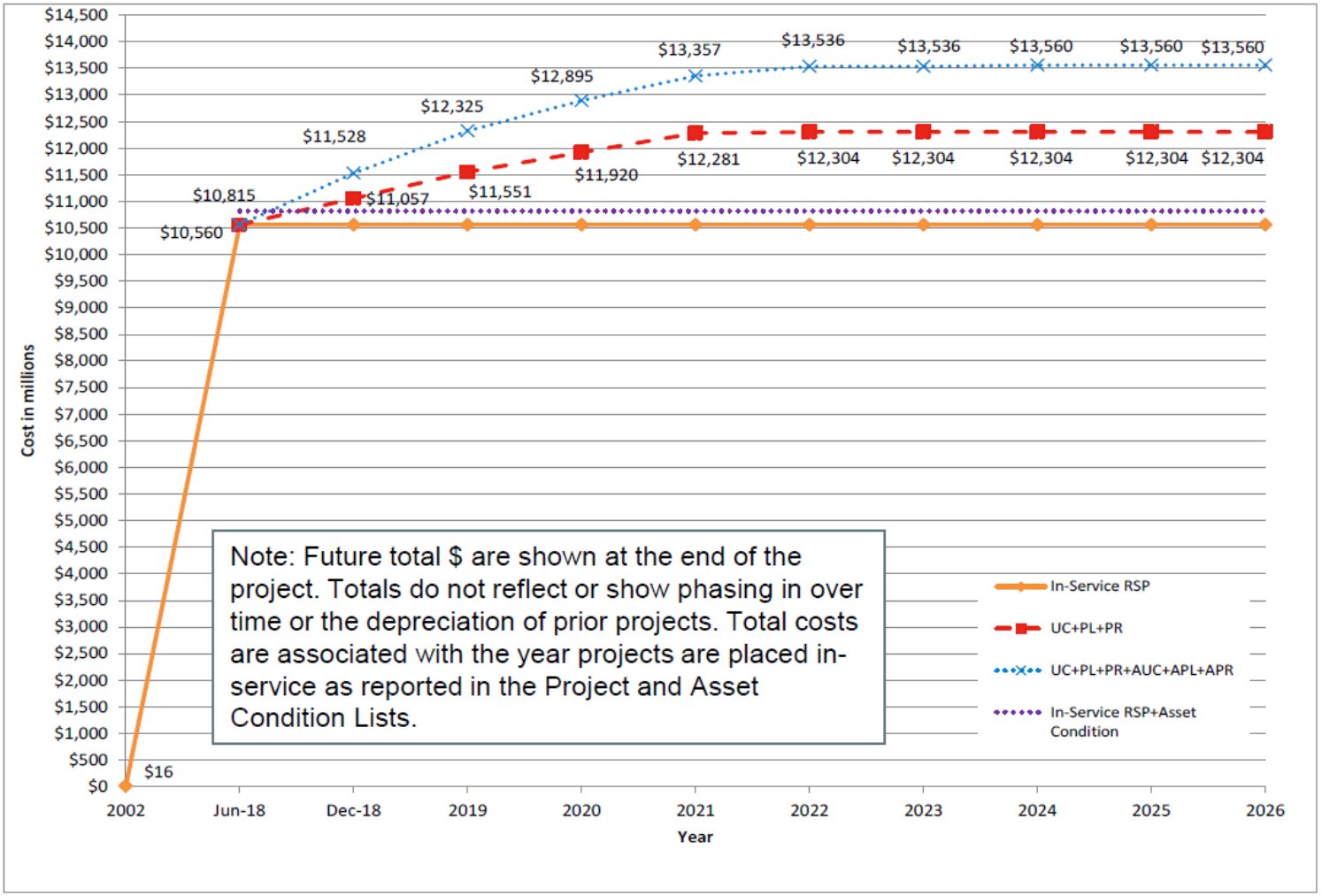
- All capital spending for regional reliability gets reviewed/approved by ISO-NE through its Committees
  - Planning Advisory Committee (PAC)
  - Reliability Committee (RC)
- Capital maintenance projects over $5M for a transmission line or substation over 5 years must be approved—VT led this change
- ISO-NE has taken over performing reliability studies for states/regions—previously performed by transmission owners

Project funding*

- Regional
  - Reliability projects as determined by ISO-NE needs and solution assessments
  - Maintenance of PTF assets
- Vermont customers
  - Local projects classified as Common, Specific or Exclusive**
  - Localized costs of regional projects as determined by ISO-NE
    - Unnecessary
    - Associated with local siting
    - Loss of load impact less than ISO-NE threshold, e.g., does not exceed 300MW (n-1, -1)
- Generation and merchant transmission developers
  - All grid reinforcements associated with interconnecting projects

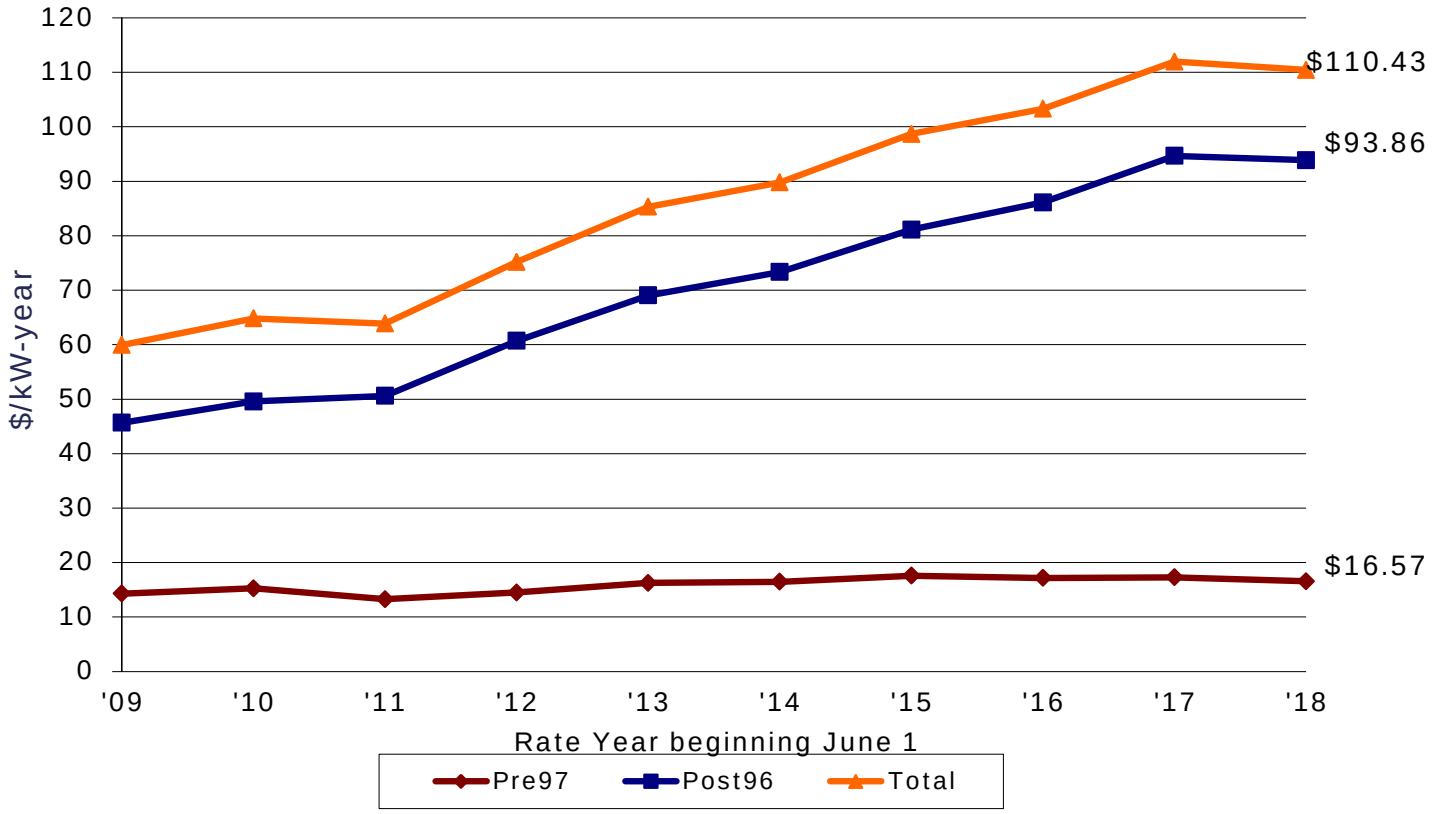
*ISO-NE Planning Procedure #4 (PP4) implements funding rules outlined in the ISO-NE Transmission Tariff
** As defined in the Vermont 1991 Tariff

Cumulative Investment of New England Transmission Reliability Projects and Asset Condition through 2026



Note: RSP - UC – Under Construction, PL – Planned, PR – Proposed,
Asset Condition - AUC – Under Construction, APL – Planned, APR - Proposed

Historic RNS Rates ($/kW-year)
June 1, 2009 – June 1, 2018



1. Note: The RNS rates above reflect the impact of transmission projects and do not reflect rate reductions associated with 1) Congestion Charges, 2) Daily Reliability Payments and 3) elimination of Reliability Must Run Agreements.

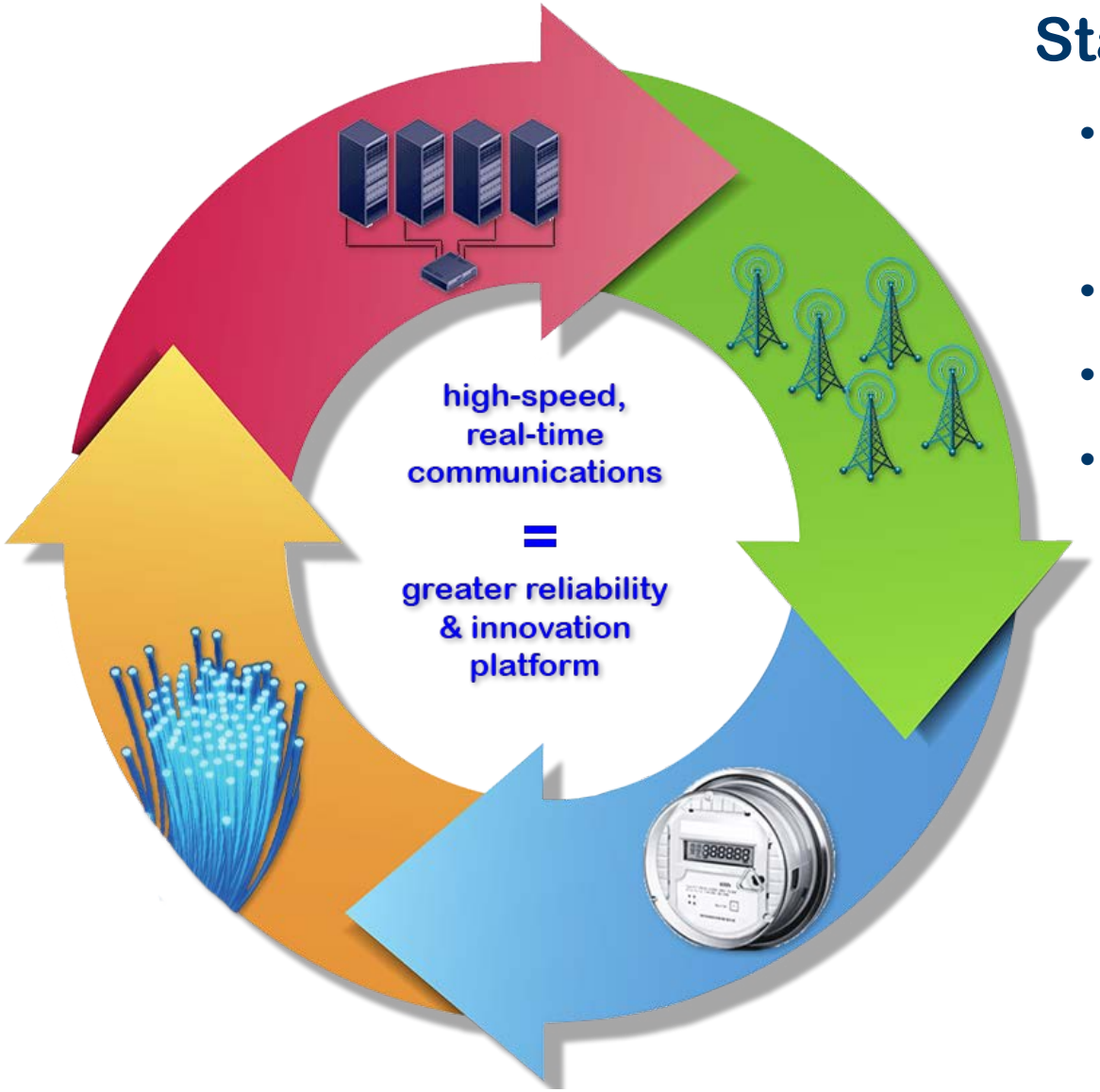
THE NEXT CHAPTER: STRATEGIC BUSINESS DEVELOPMENT

Vermont Weather Analytics Center

Pinnacle data center

- New 6,900-square-foot building to house and protect company IT, data storage, energy management systems (EMS) and communications equipment
- Separate building for two 800kW emergency back-up generators
- Buildings designed to protect electronic equipment and data from electro-magnetic pulse (EMP), severe weather and ballistic events
- Building system equipment startup, testing and commissioning to start in September 2018

Innovation workbench



Statewide infrastructure

- eEnergy VT smart grid
  - 92-94% smart meters
- Fiber optic network
- Radio system
- High-performance computing cluster—HPCC

Strategies to diversify revenue streams as capital needs and load decline

Examples of strategic opportunities

Construction mat rentals to distribution utilities, avoiding need for them to purchase their own

Use of radio and fiber systems to meet Vermont utilities' needs

- Actively marketing products and services to non-shareholder clients
- Recently signed contract to meet data connectivity needs of Northern Vermont University at market rate
- Revenue offsets a portion of our overhead and can contribute to our bottom line
- Uses an asset to do good for Vermont