The Business of Energy:
The Role of District Level Energy Networks

BOSTON UNIVERSITY **Boston University** Questrom School of Business

Framing Today's Discussion

- District Energy Systems have had a long and successful history of both private and public service and are projected to grow significantly through 2050.

- The Energy grid will evolve dramatically to address climate change, emissions regulation, energy security concerns and while adopting new emerging technologies.

- These two trends are on a collision course and present interesting opportunities for innovation at the district level.

District Energy Networks Will play a central Role in the Energy Landscape in the Future

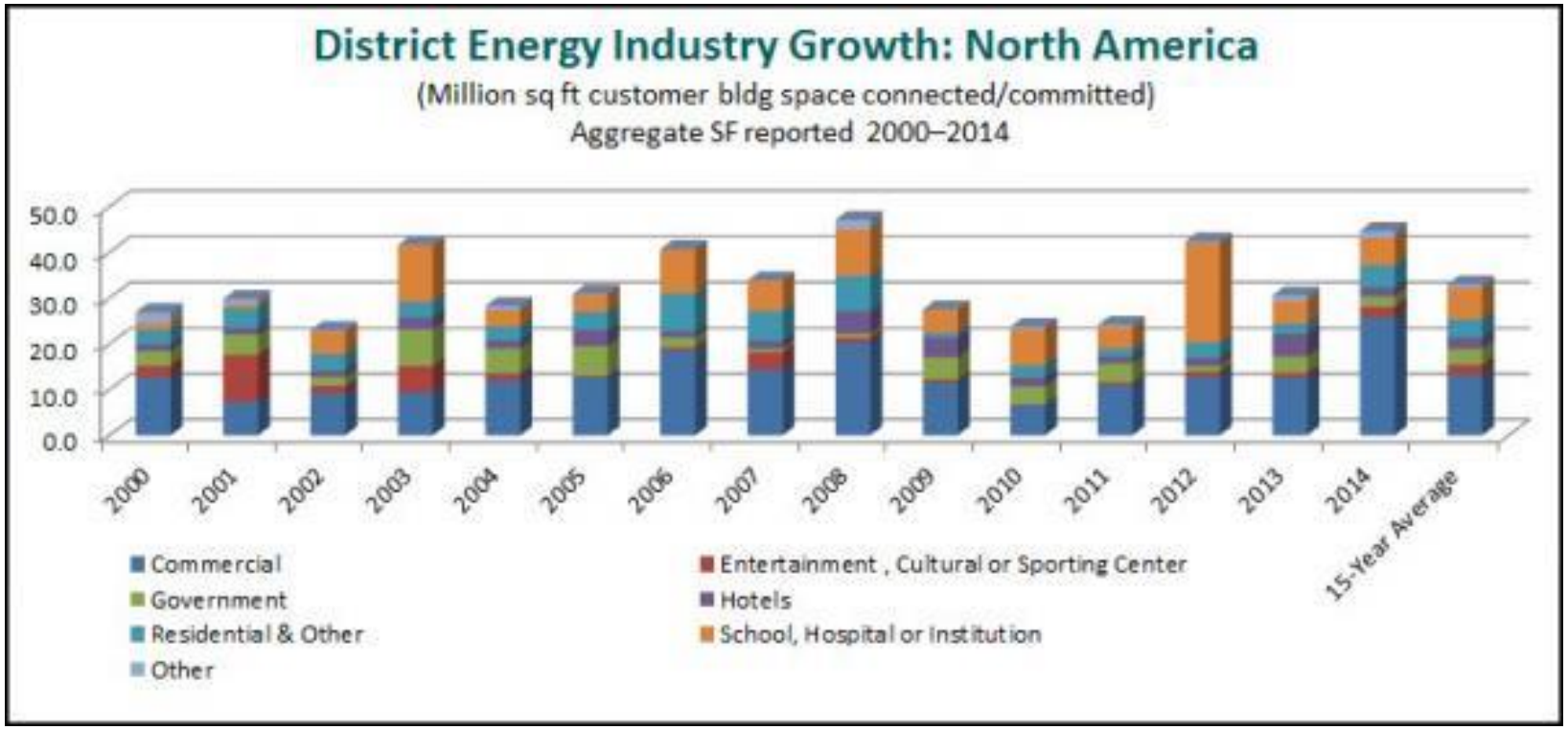
"A transition to modern district energy systems could contribute to 60 per cent of required energy sector emissions reductions by 2050, and reduce primary energy consumption by up to 50 per cent, according to a new report launched today by the UNEP in collaboration with the Copenhagen Centre on Energy Efficiency (C2E2), ICLEI – Local Governments for Sustainability, and UN-Habitat."

-- UNEP, 2014

Example

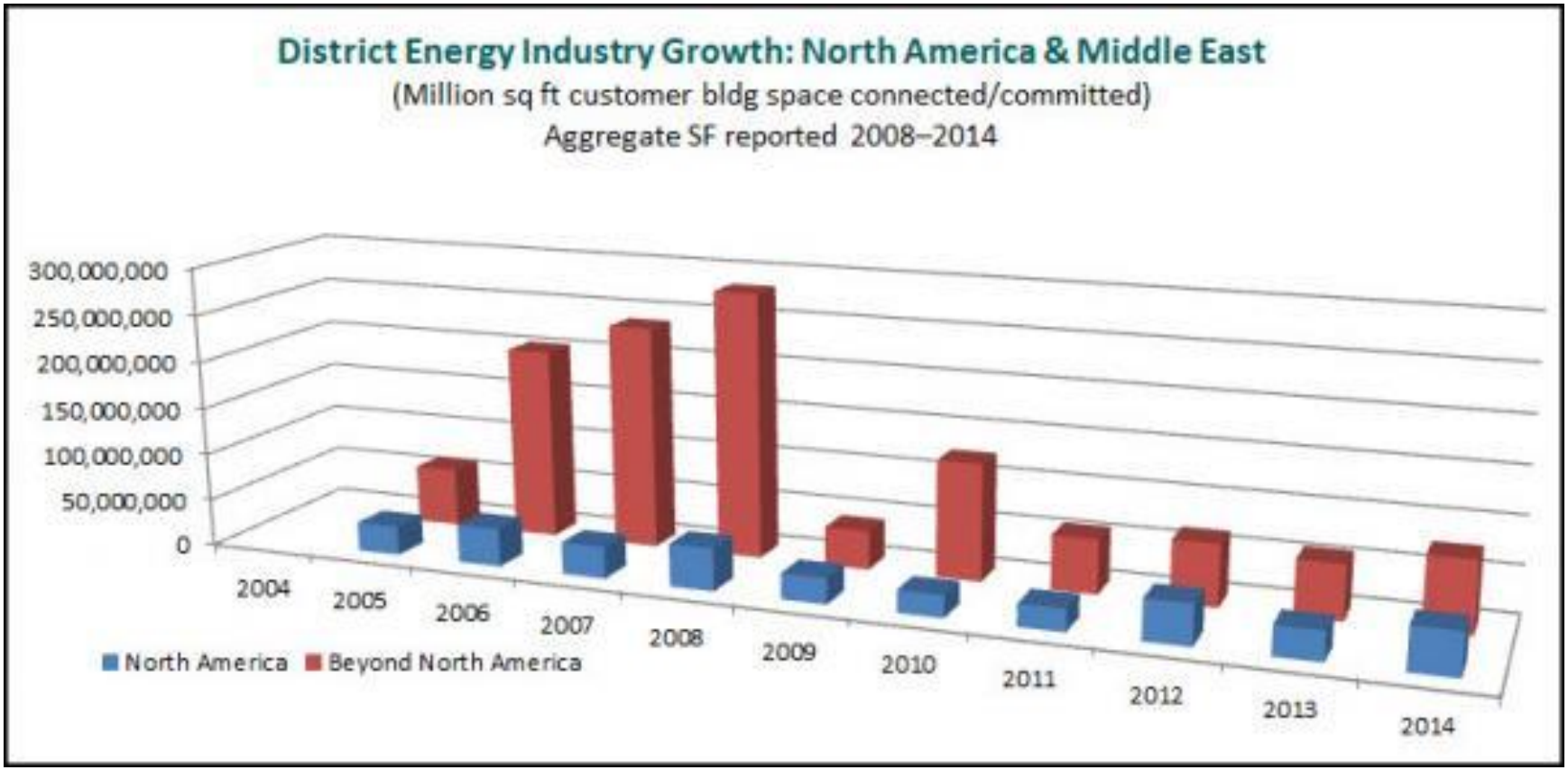
Source: Envida Community Energy

A Significant Market



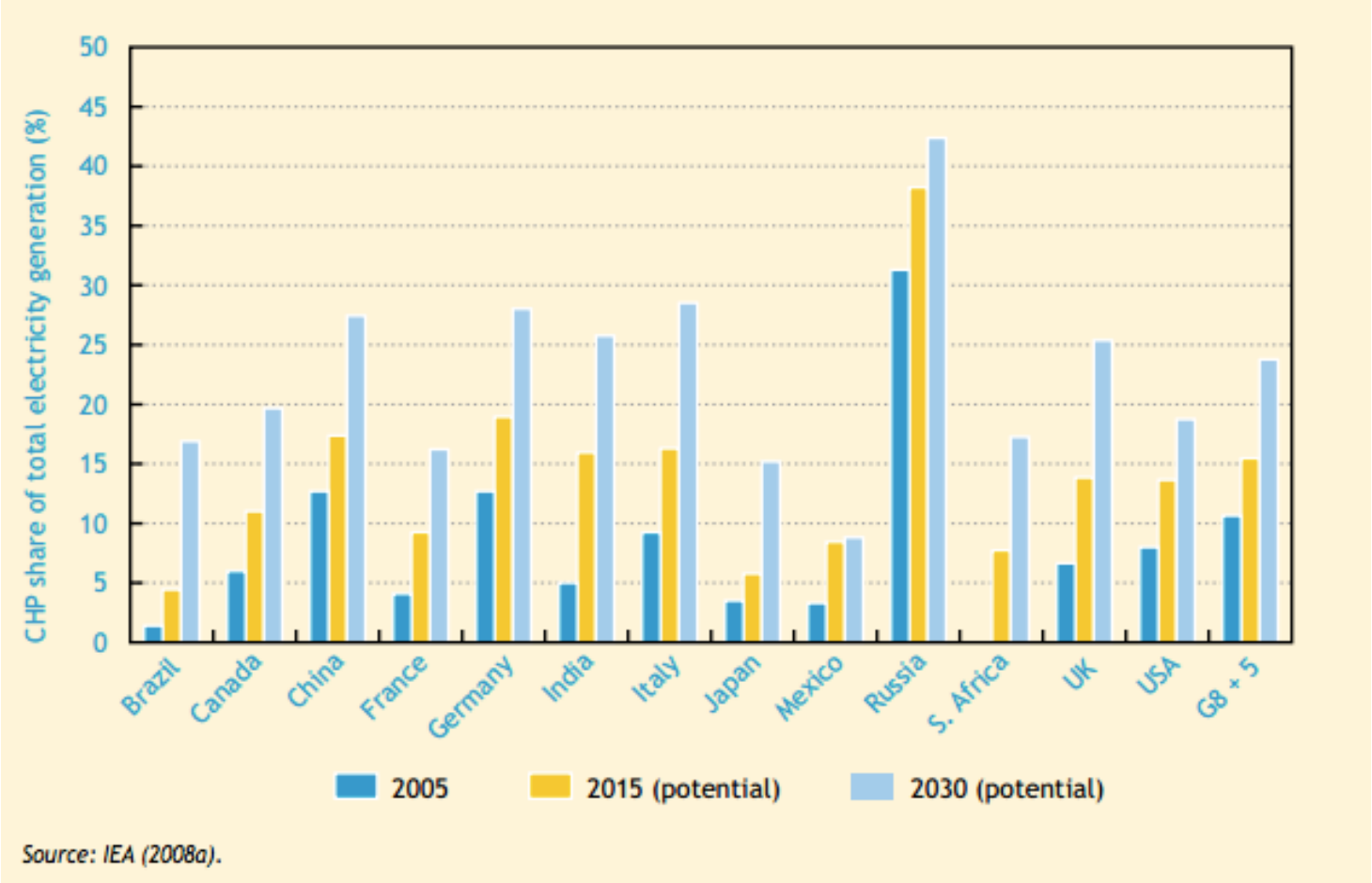
Source: International District Energy Association

And Bigger Opportunities Internationally



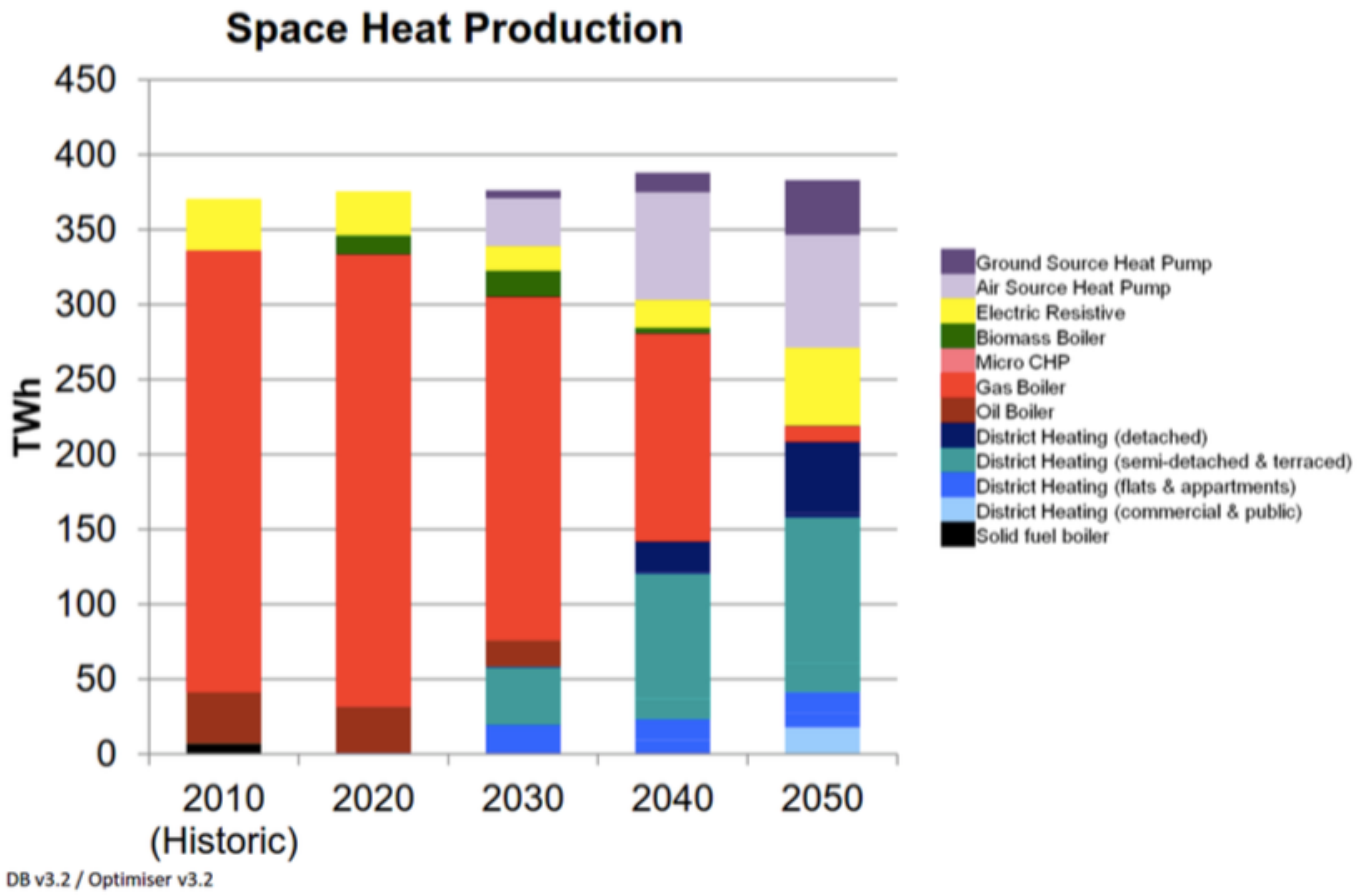
Source: International District Energy Association

District Energy Growth Potential



Source: IEA (2008a).

Perhaps More Significant than Growth is the Broadening of the Fuel Source Portfolio

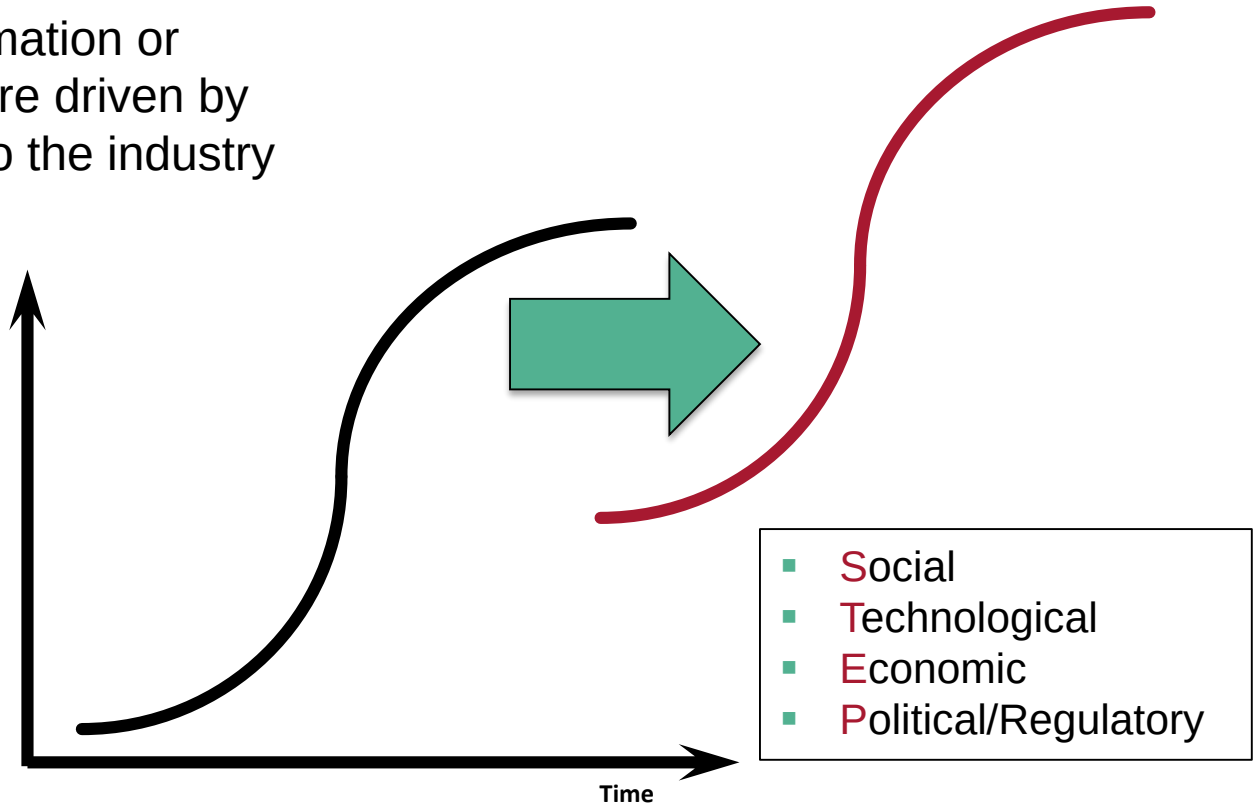


Source: Energy Technologies Institute

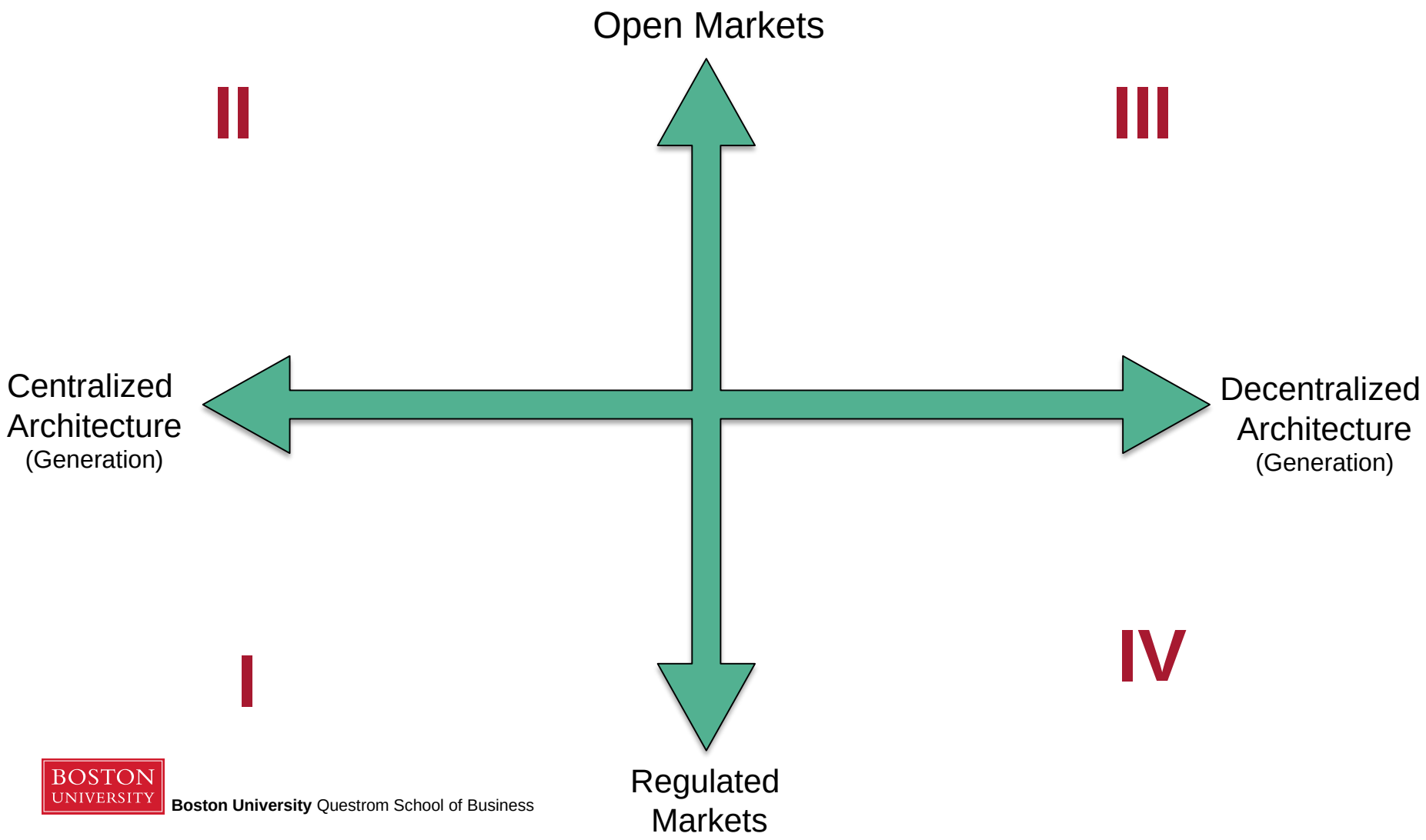
On the Grid Side…

Industry transformation is being driven by powerful external forces

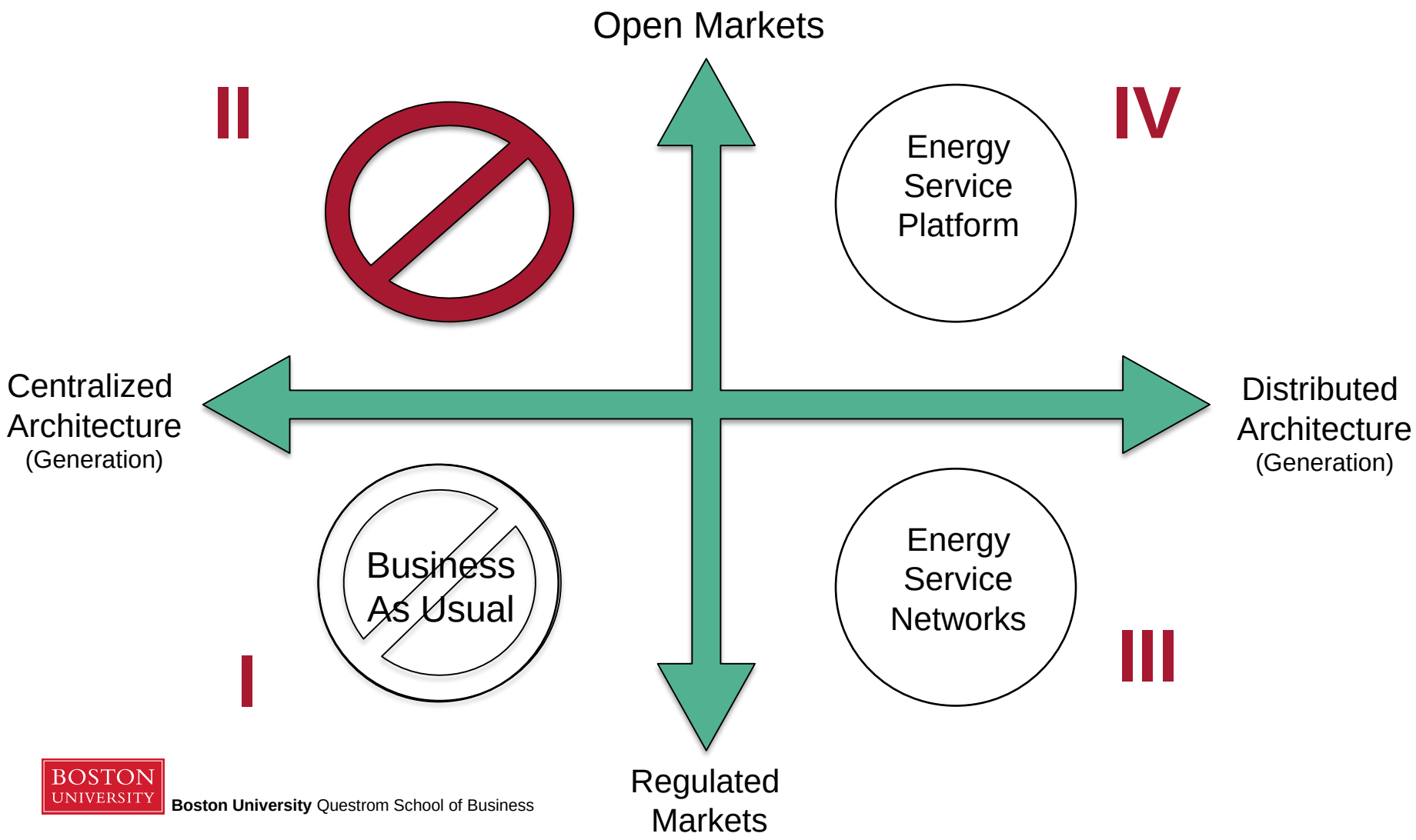
Industry transformation or paradigm shifts are driven by factors external to the industry itself.



Scenarios for the Grid's Evolution



The Possible Structures



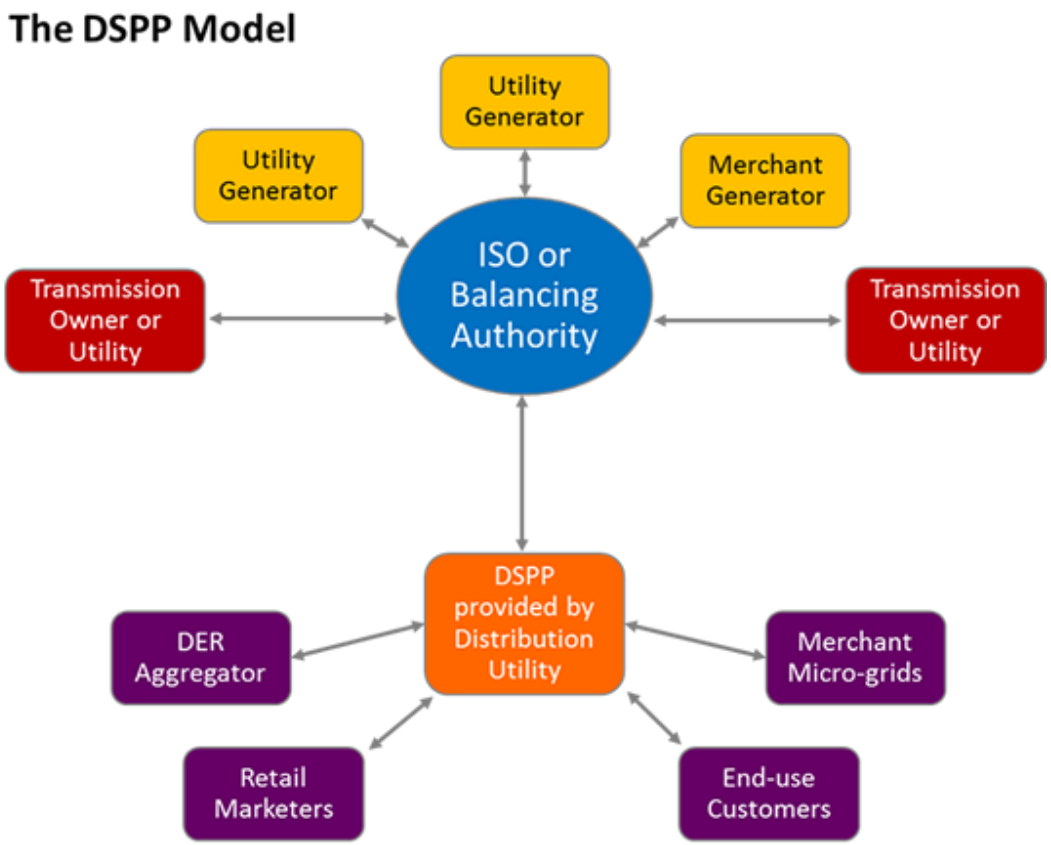
III - The Energy Service Network Model

- Extension of the current Generation, Transmission model to include DG assets and third party services.

- The Distribution Company would own, integrate and operate all distribution utility assets and would oversee the utility through outcome-based incentive regulation.

III – NY's Distribution System Platform Provider Model

Distributed Resource Dispatch, Distribution, Operations and Planning



- The DSPP is being developed in New York's Reforming the Energy Vision proceeding designed to radically restructure the role of the electric utility and the way that regulation is implemented[3]. Under New York's vision, the regulated electric distribution company would:
  - coordinate customer distributed resource activities to optimize use of energy efficiency, demand response, distributed generation, and microgrids
  - provide a platform for third-party providers to offer services to customers
  - The DSPP would own and operate all distribution utility assets and the New York Public Service Commission would oversee the utility through outcome-based incentive regulation.

http://www3.dps.ny.gov/W/PSCWeb.nsf/All/CC4F2EFA3A23551585257DEA007DCFE2?OpenDocument

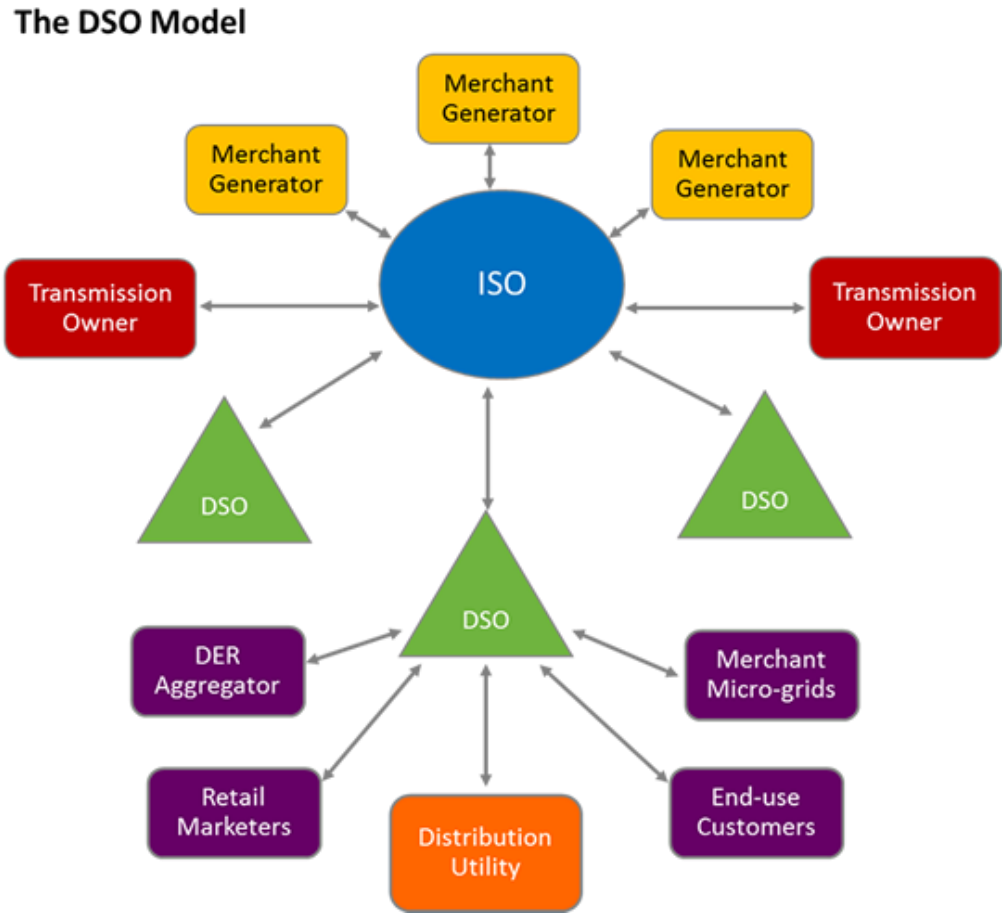
IV - The Energy Platform Service Model

- Extension of the current Generation, Transmission model to include DG assets and third party services.

- The Distribution Company would own, integrate and operate all distribution utility assets and would oversee the utility through outcome-based incentive regulation.

IV – NY's Distribution System Operator Model

Generation dispatch, transmission system operations and planning, and facilitation of wholesale markets

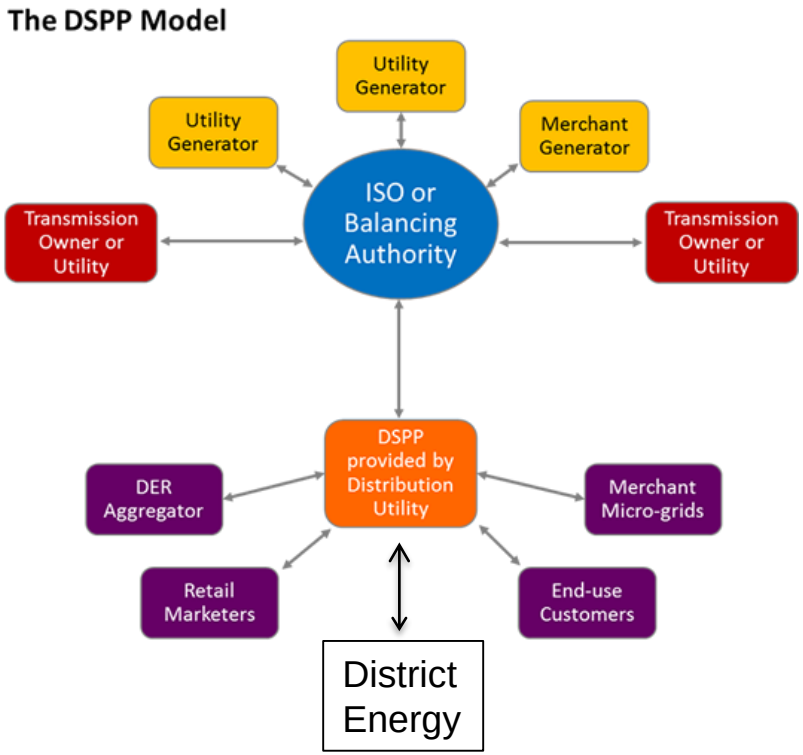


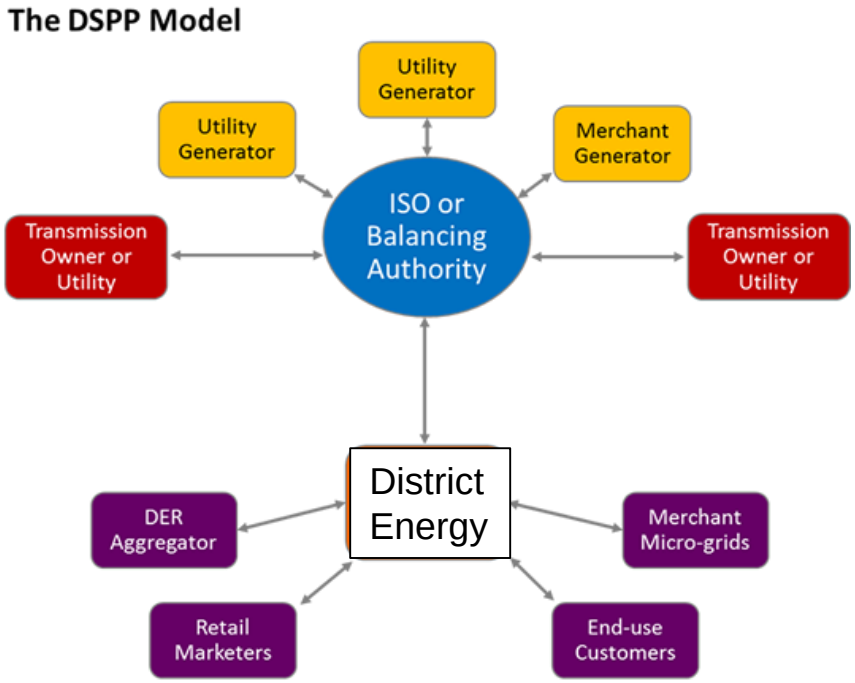
Like ISOs, the DSO would be an unbiased entity without ties to any market participant.

To facilitate active retail markets, the DSO would bid aggregated distributed resources into competitive ISO wholesale markets in competition with centralized generators.

http://www3.dps.ny.gov/W/PSCWeb.nsf/All/CC4F2EFA3A23551585257DEA007DCFE2?OpenDocument

District Energy Can Play a Role in Either Scenario





Advantages, Disadvantages, Challenges and Opportunities

- Extends the advantages flexibility, cost, quality of district power across the full energy portfolio **within the district**, expanded revenue opportunities

- Potential to significantly increase the offset of peak (heating/cooling) demands, increase reliability and resilience **for the grid** and improve levels of service and lower GHG emissions

- Requires changes in regulatory and pricing models, introduces a number of new stakeholders into the mix, needs large scale

- Provides opportunities to accelerate rollout of localized value-added services from 3rd parties

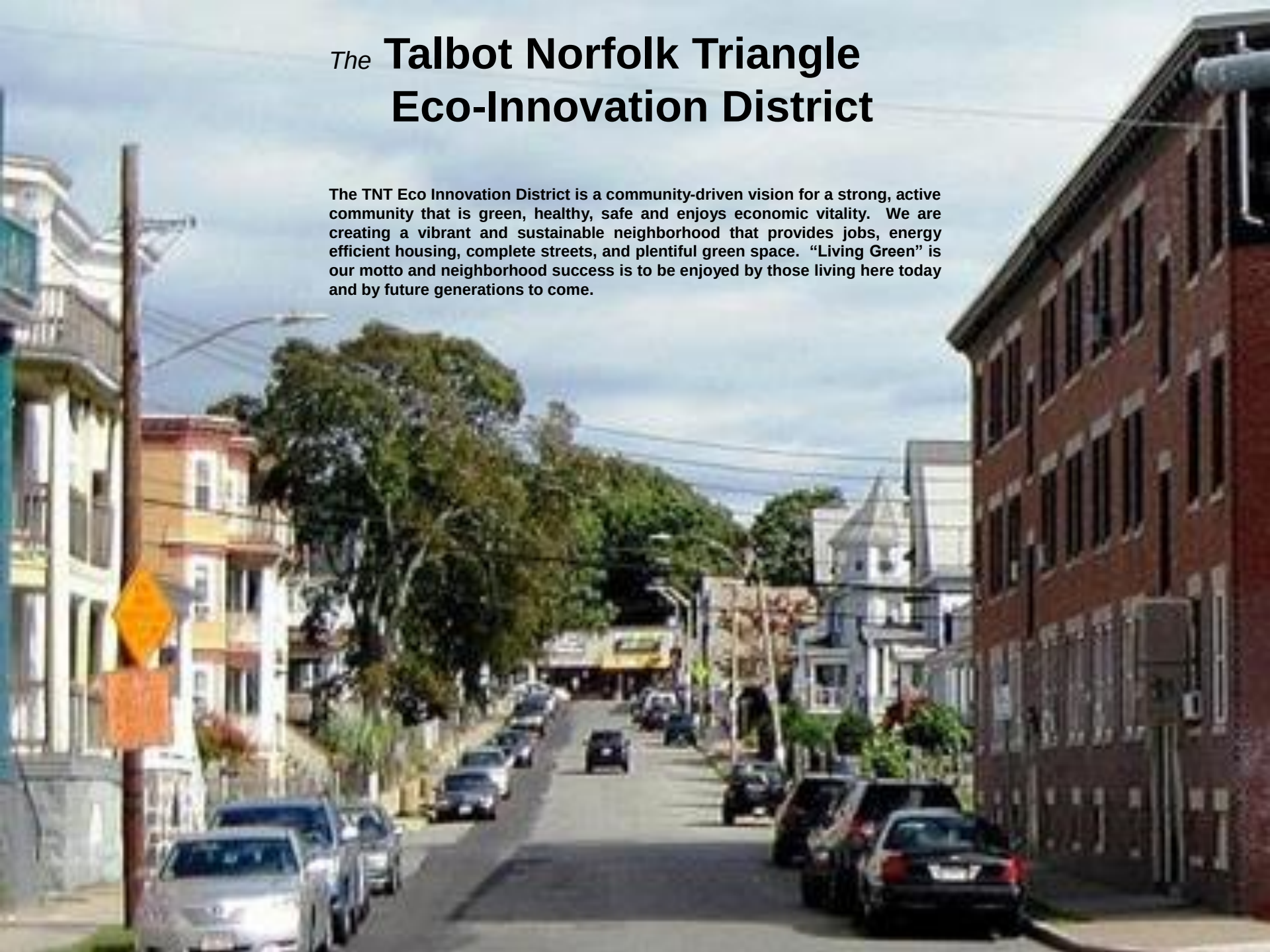
In Summary

- District Energy systems are proven solutions well positioned to to respond to growing demand and GHG issues
- The grid is evolving toward a more granular and distributed architecture
- As the business architecture will mirror the technical architecture, District Energy networks are well positioned to step into new and significant roles in landscape of the emerging smart gird

SMALL SCALE COMMUNITY BASED PROGRAM IN BOSTON

The Talbot Norfolk Triangle Eco-Innovation District

The TNT Eco Innovation District is a community-driven vision for a strong, active community that is green, healthy, safe and enjoys economic vitality. We are creating a vibrant and sustainable neighborhood that provides jobs, energy efficient housing, complete streets, and plentiful green space. "Living Green" is our motto and neighborhood success is to be enjoyed by those living here today and by future generations to come.



Background

- The Talbot Norfolk Triangle Eco-Innovation District is a comprehensive effort at neighborhood scale sustainability that marries green, transit-oriented development (TOD), renewable energy, water conservation, alternative energy, sustainable food systems, waste reduction, and climate preparedness through resilience.

- This first-of-its-kind project in the City of Boston is working in a 13 block section of Codman Square with 1300 residents—the Talbot Norfolk Triangle—using the LEED-ND rating system as an organizing principle.

FOCUS AREA: DISTRICT ENERGY

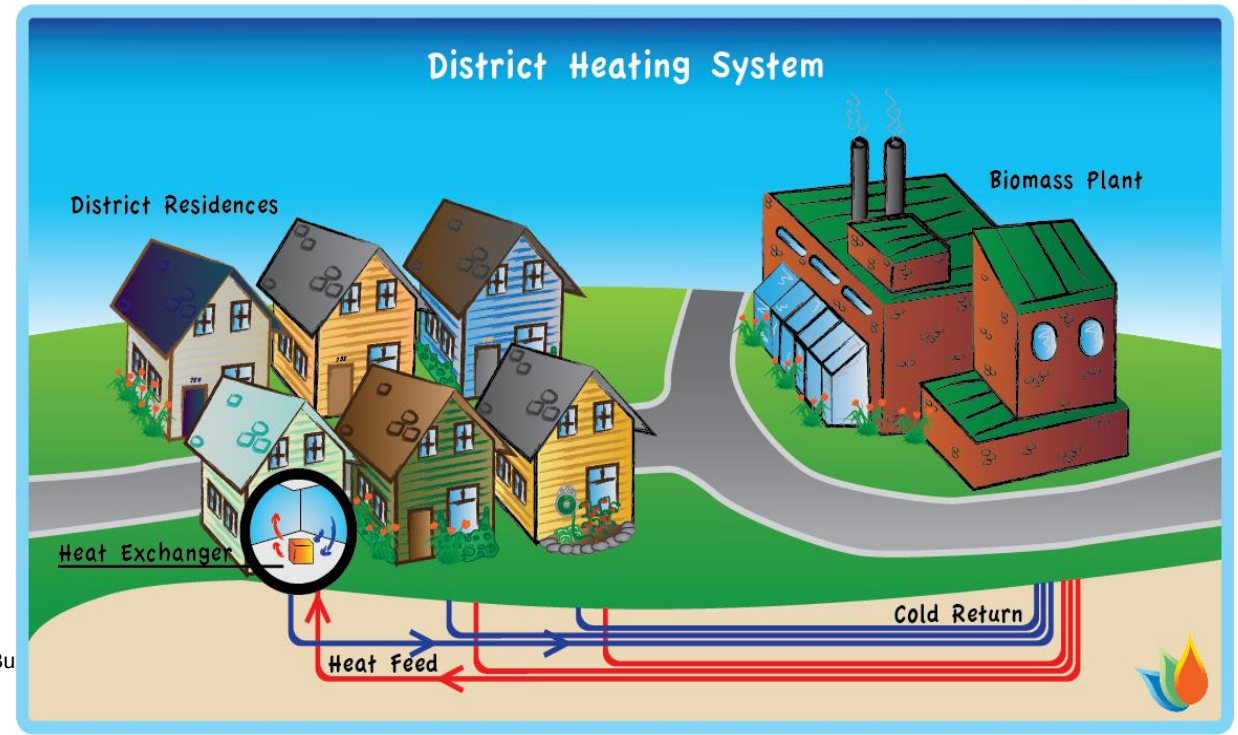
District heating and cooling (DHC) is the idea of connecting multiple energy consumers within a community to a central heating and cooling source through a piping system. This could allow a neighborhood like TNT to select a cost-effective, environmentally-friendly heating technology that can considerably reduce building energy loads, helping reduce greenhouse gas emissions in the neighborhood and lowering residents' utility bills. District energy is generally more efficient than individual heating systems, by better optimizing the energy supply-and-demand mix of a district to share surplus energy and use heat energy that might otherwise be wasted. Additionally, DHC systems can increase local resilience to extreme events by operating as a microgrid if the main utility experiences

Bu

Combined heat and power (CHP), or the simultaneous generation of heat and electricity through a single fuel source, is one of the most popular sources of district heating and cooling. Combined heat and power systems can operate on any of a number of fuel sources, including natural gas, oil, or renewable sources like solar, geothermal, or biomass energy. Other common DHC energy systems include high-efficiency boilers, natural gas chillers, geothermal- and solar-sourced heat pumps, and biomass-fueled systems.

Characteristics of a Typical DHC Project

DHC projects work best in areas of high occupancy density, high energy use intensity, and anticipated development or occupancy growth. Over 50% of the capital costs of district heating projects come from building the transmission and distribution network, and generally these projects are most economical when applied to large, urban areas with high population densities to achieve economies of scale. District energy systems require considerably high upfront capital costs and financing, so they typically require a long-term investment by a party (generally a utility) with a long-term stake in the community's infrastructure. The process of having the utility interconnect a DHC system to the grid can also be non-transparent and result in back-up charges.



DHC FUEL SOURCE OPTIONS

Geothermal-Sourced Heat Pumps
Geothermal heat pumps are another excellent source of renewable power for CHP systems. Geothermal systems utilize deep wells to harness the earth's energy to heat and cool buildings. The most famous example of geothermal power in action is Iceland, which heats 97% of its homes through ground heat thanks to its unique geographical endowment. Geothermal heat pumps are an excellent green energy source, with negligible carbon emissions. While the costs of installing a geothermal can be 30-40% higher than conventional heating systems, they typically have payback periods of 7-15 years depending on the profile of the building. Powering a 50-unit apartment building with a geothermal system can reduce greenhouse gas emissions by over 100 metric tons per year! Prior to transmission and interconnection charges, a district-scale geothermal project would likely be a six-figure expenditure.

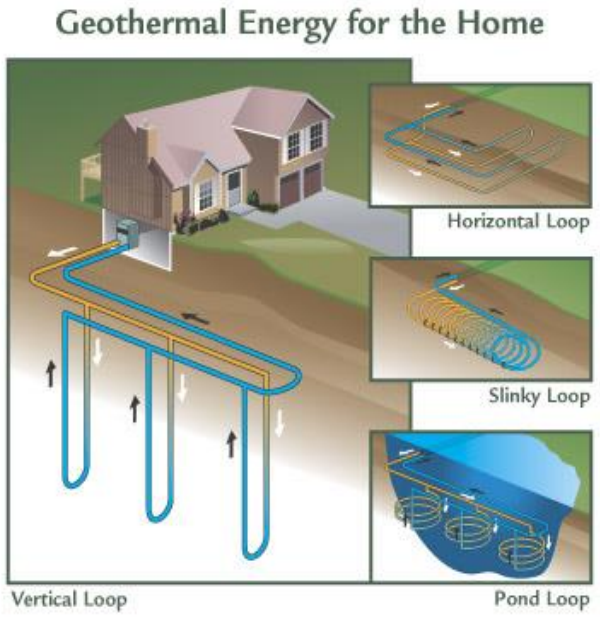
Solar-Sourced Heat Pumps
Solar heat pumps are a great option for CHP systems in regions where there is optimal roof or ground-space to meet the heating and cooling needs of the nearby neighborhood. It is unlikely that the CSNDC neighborhood would be able to power a CHP system through on-site solar generation. A 50-unit building in Dorchester consuming 50% less electricity than the US average would require over 200 kW (equivalent to roughly 28 residential rooftop installations) of solar capacity to meet its electricity demand. Based on the Next Step Living assessment, the CSNDC has capacity for roughly 58 kW of rooftop solar.

Biomass Systems
Biomass fuel sources, such as waste wood and combustible agricultural waste, can also be used in CHP systems. These are renewable sources that can take advantage of waste from local commercial uses. Sullivan County in New Hampshire recently installed a $3.4 million CHP system fuelled entirely off of locally-sourced wood chips to power a large nursing home and nearby prison complex. There is much debate about the greenhouse gas footprint of biomass fuel sources, with some reports claiming that the wood-burning can create more nitrous oxide emissions than oil and coal over its life cycle.

High-Efficiency Boilers and Natural Gas Chillers
Natural gas-fired boilers and chillers are also solid option for DHC systems. These high-efficiency systems utilize natural gas, a lower-emission intensive fossil fuel, to meet the heating and cooling needs of a neighborhood. Depending on the existing heating system, they can achieve energy efficiency improvements of 30-50% and systems can be easily sized to meet the energy demands of the nearby neighborhood.

Steven's Croft biomass plant in Lockerbie, Scotland provides renewable power to 70,000 homes

Geothermal heat pump diagram



DHC PROGRESS & RECOMMENDATIONS

Examples of DHC Systems in the United States

ConEdison's New York City steam system is the largest commercial district heating system in the US and has operated it since 1882. NRG Energy operates district systems in San Francisco, San Diego, and Minneapolis, and Veolia has a 26-mile long district system in Boston and Cambridge.

Veolia's Boston system operates on CHP processed steam plant located in Cambridge that pipes energy across the Charles River to heat Boston's financial district. The project is expected to reduce 475,000 tons of GHGs per year, the equivalent of removing 80,000 cars from the road. The project, which transmits energy via an extensive city-wide pipeline, required a $112 million investment from Veolia. Major customers of the Cambridge generation plant include hospitals, biotech R&D facilities, data centers, office towers, and universities.

Kendall Cogeneration Station – Cambridge, MA

Current Progress

CSNDC has approached a DHC firm, American DG Energy, to explore the feasibility of building DHC systems in the EID. They have suggested the potential for designing a high-efficiency centralized boiler system to service the forthcoming Whittier Place development (13 units across 3 buildings) and a localized DHC node to serve the forthcoming Talbot Commons I and II developments (85 units total). American DG is also investigating the feasibility of using DHC at the Washington Columbia I and II developments.

Recommendations

We recommend that the CSNDC conduct assessments for geothermal heating and explore options for a district-scale high-efficiency natural gas cogeneration plant.

While there is opportunity for small-scale on-site solar generation, the district's energy demand is too large to merit solar power district heating. The district's urban location does not make it an ideal candidate for biomass heating, as there would likely be high costs associated with sourcing biofuel. The wood required to power this neighborhood would far exceed available local wastewood.

With its anticipated high population density and prime location for future growth, the Talbot Commons developments are the best options for development of a small-scale DHC cogeneration system. Such a system could be interconnected to provide power and heating to local homes and businesses. This system could greatly improve the energy efficiency of the immediate neighborhood by better serving the variable energy demands of different buildings within the neighborhood. For example, commercial buildings consume more energy during the day and much less at night, while residential buildings generally reach peak energy usage in the evening.

Estimated Current Annual Energy Consumption in the TNT District

4.36 GWh of electricity
440 Ktherms of gas
58,891 mmBTU total energy

The Talbot Commons development is a prime candidate for CHP

THANK YOU & QUESTIONS

ADDITIONAL SLIDES

About Platforms

- What are they? Specifically, Multisided Platforms (MSPs):
  - Identify, develop and deliver innovative technologies, products or services that create value primarily by enabling direct interactions between two or more participant groups.

- What are they good at?
  - Problems/Opportunities that are by their nature:
    - large scale or broad in scope
    - Multi-sided
    - Emergent, and
    - Dynamic

  - In particular that by their nature:
    - Require simultaneous innovation across traditional Industry, sector, domain and functional boundaries
    - Benefit from collaboration to create economies of scope
    - Benefit from “network effects” to create scale economies
    - Depend on cross-subsidization to function

Why Platforms May Be A Market-Based Solution for Energy Challenges

- Energy Challenges:
  - Are immense in scope by nature
  - Are Multi-sided by nature
  - Are both emergent and dynamic by nature
  - Require simultaneous innovation across traditional Public, Private, Industry, Civil Society boundaries:
    - Policy/Regulatory,
    - Technology,
    - Economic,
    - Social/Cultural,
  - Benefit from:
    - Network effects
    - Collaboration to to create economies of scope
    - Depend on cross-subsidization to function

Collision Course

- District Energy Systems will be in an advantageous position to assume the role in both the Network Services and Energy Platform Scenarios
  - Combining traditional assets, combined with increasing renewable portfolios and storage.
  - Utilizing a broad portfolio of fuels, active management and waste recovery maximize efficiencies and lower GHG emissions.
  - Leveraging relationships with key stakeholders: large subscribers, local authority, utility company, community representatives