

A photograph of the Cornell University clock tower at sunset. The sky is a mix of orange, red, and purple. The tower is dark, but its clock face and the top section are illuminated from within. Bare trees are visible in the foreground and middle ground.

“Earth Source Heat” Deep Geothermal Energy

Dr. Lance R. Collins
Joseph Silbert Dean of Engineering
Cornell University
October 20, 2016

Agenda:

Carbon Neutral Commitment

- Carbon Footprint
- Senior Leaders Climate Action Group Plan 2015

Earth Source Heat (direct use geothermal energy)

- Regional Resource
- System Schematic

Why Cornell?

- Atkinson Center for a Sustainable Future
- Culture of Collaboration Across a Broad Campus
- Living Laboratory
- History of Successful Energy Projects

Cornell aspires to carbon neutrality by 2035

Senior Leaders Climate Action Group (formed Fall 2015 to identify options)

- Committee of the Provost, Vice Provosts, Deans, Faculty, Students and Staff
- Co-Chaired by Dean of Engineering (Lance Collins) and Vice President for Infrastructure Properties and Planning (KyuJung Whang)
- Report entitled, “Options for Achieving a Carbon Neutral Campus by 2035,” released yesterday
- Report analyzes the feasibility of several technologies

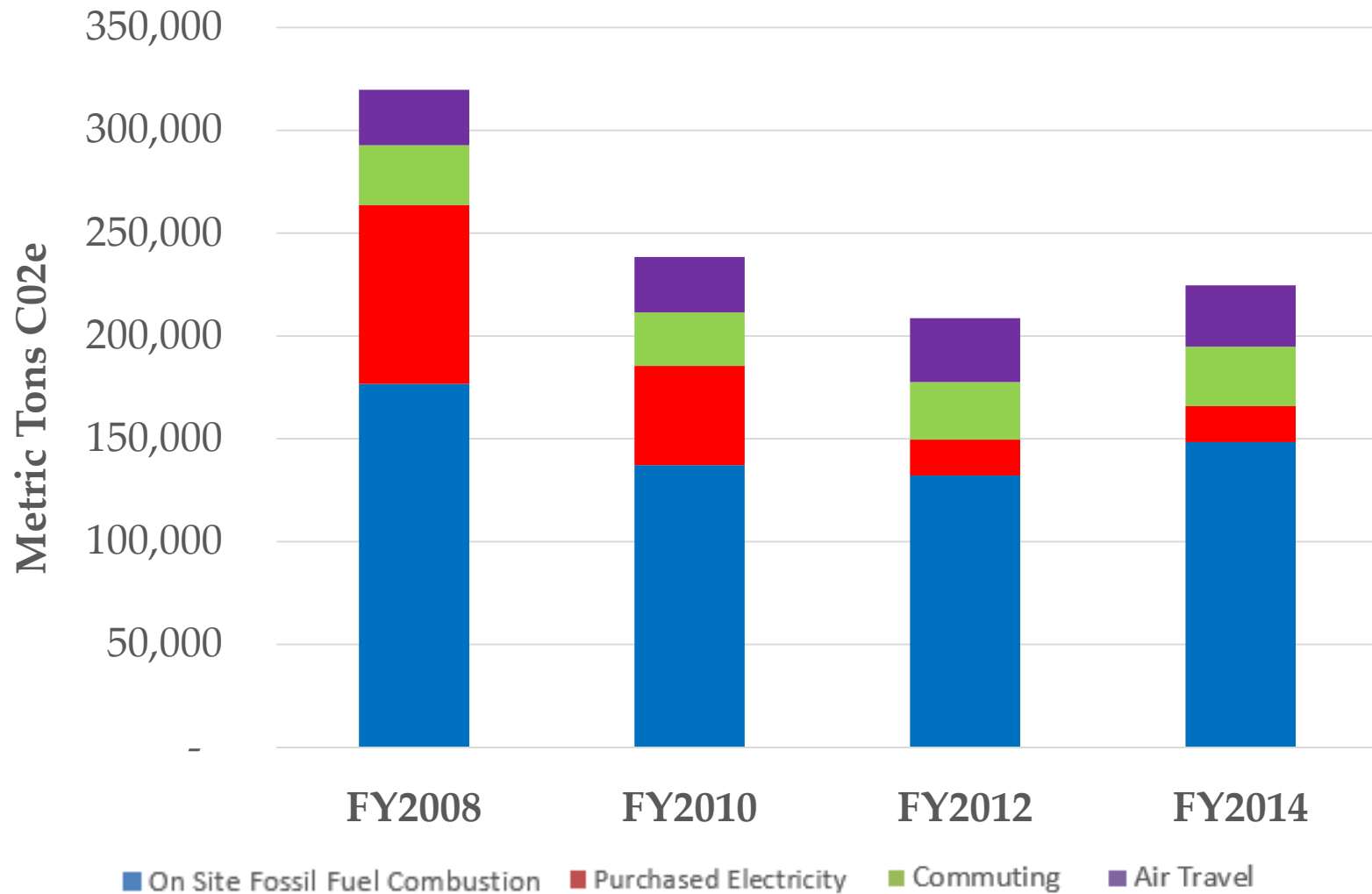
Cornell aspires to carbon neutrality by 2035

Size of the Problem

- 179,303 metric tons of CO₂e (energy produced + purchased from grid)
- 62,142 metric tons of CO₂e (transportation)
- **241,445 metric tons of CO₂e (total)**

- 580,000 metric tons of CO₂e from methane leakage

Cornell's Carbon Footprint



Options for Achieving a Carbon Neutral Campus by 2035

Reduce Demand

- New Construction and Renovations LEED Silver or above
- Increase Use of Electric Vehicles and Chargers on Campus
- Behavioral Changes (e.g., modifying temperature set-points)

Options for Renewable, Carbon-Free, Sources

- Air Source Heat Pumps
- Biomass Combustion or Gasification
- Earth Source Heat (direct geothermal energy)
- Ground Source Heat Pumps
- Nuclear
- Wind, Water, Solar

Options for Achieving a Carbon Neutral Campus by 2035

Reduce Demand

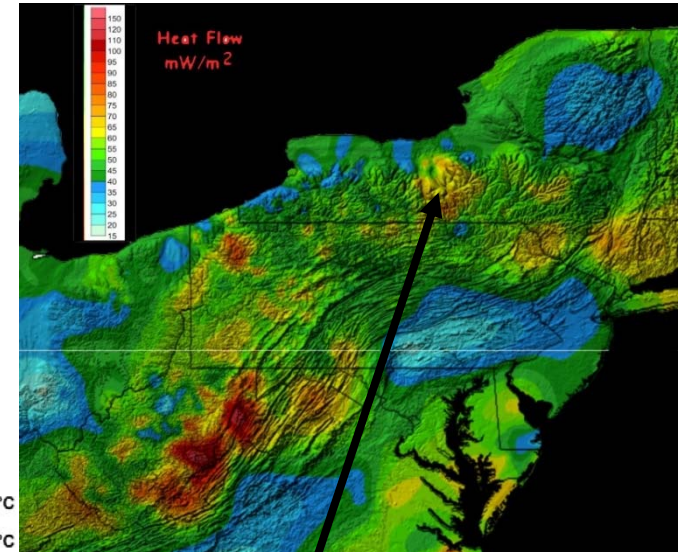
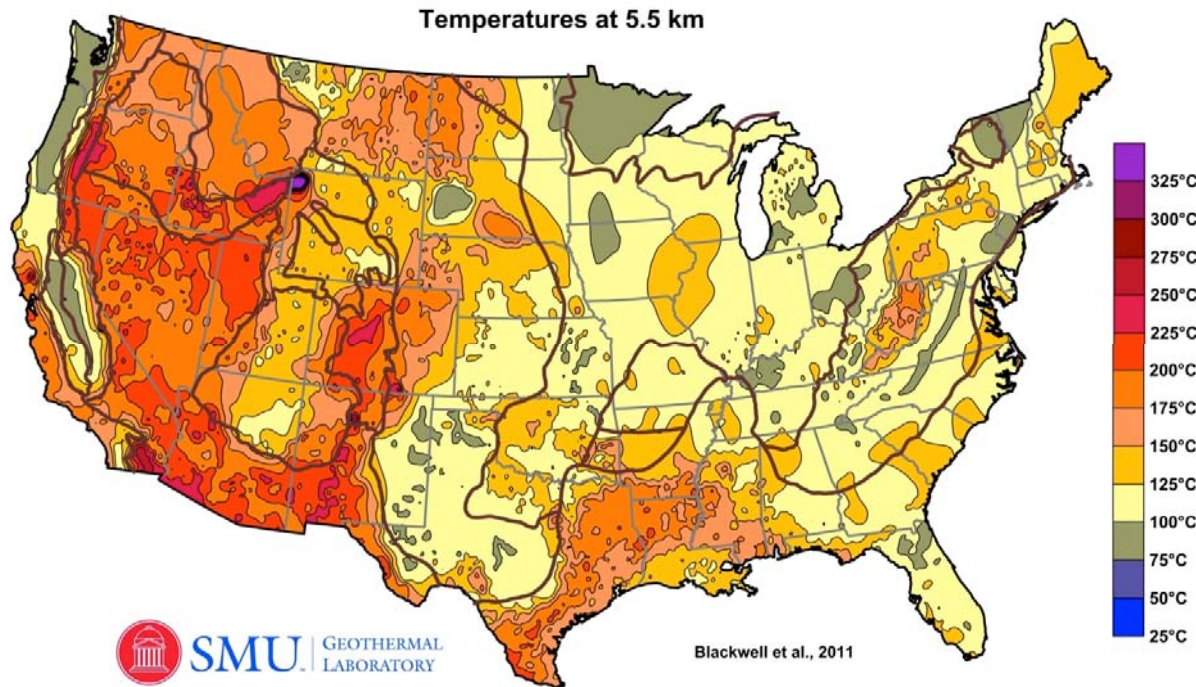
- New Construction and Renovations LEED Silver or above
- Increase Use of Electric Vehicles and Chargers on Campus
- Behavioral Changes (e.g., modifying temperature set-points)

Options for Renewable, Carbon-Free, Sources

- Air Source Heat Pumps
- Biomass Combustion or Gasification
- Earth Source Heat (direct geothermal energy)
- Ground Source Heat Pumps
- Nuclear
- Wind, Water, Solar

Geothermal Resource in New York

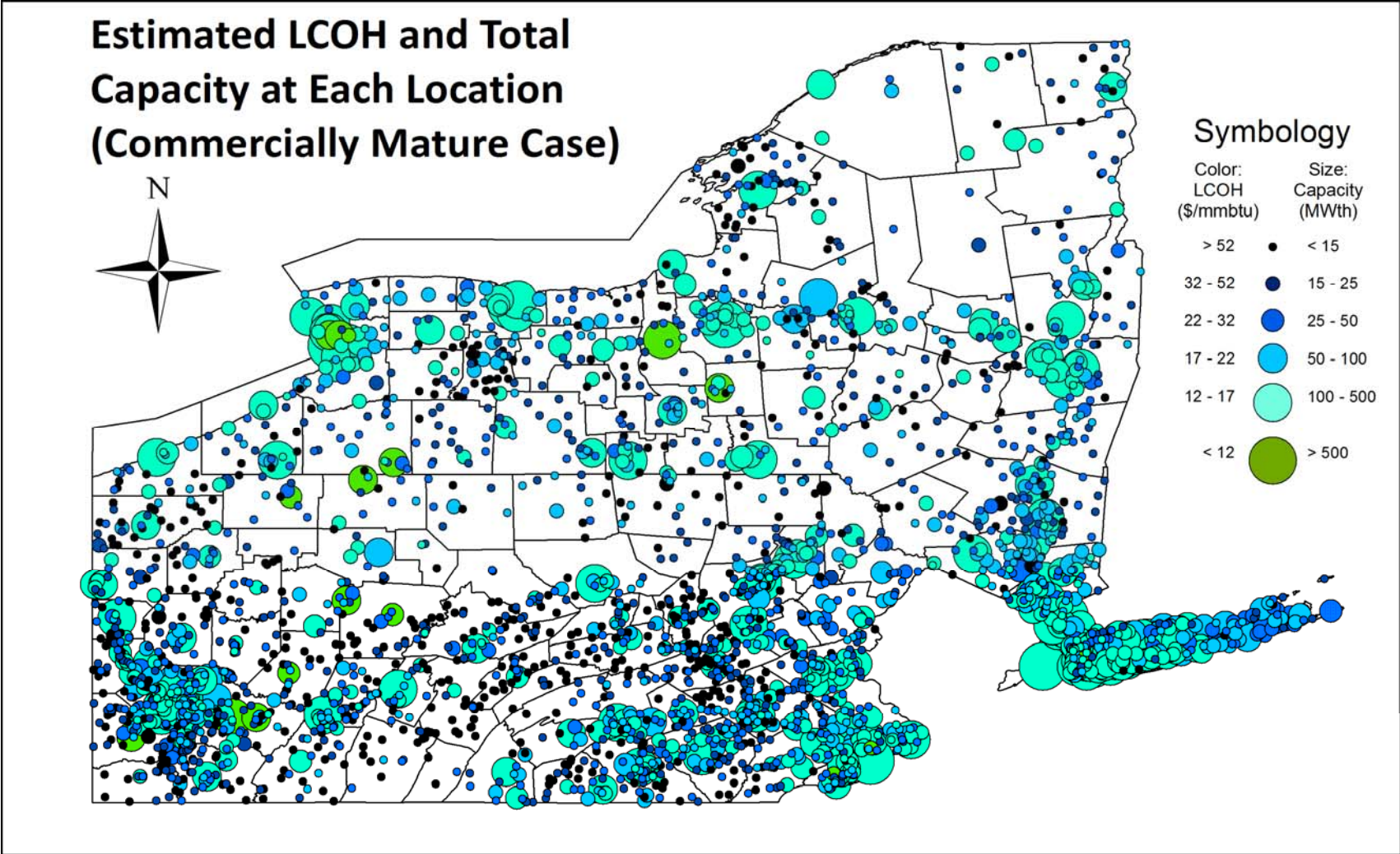
New York contains a large region of higher geothermal heat flow



Cornell

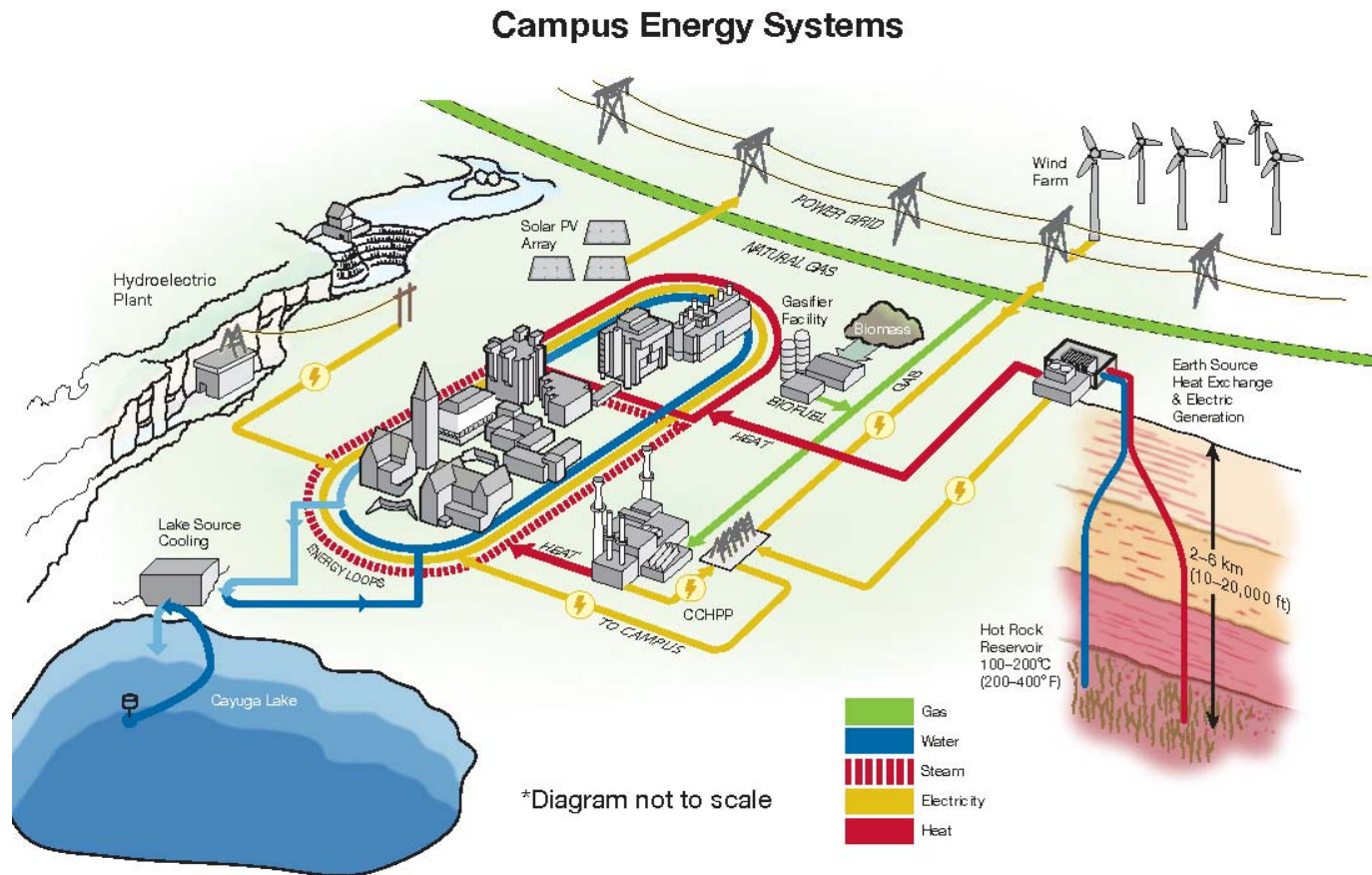
To reach rock at
100-140°C well depths
of 10,000 to 15,000 ft.
are needed

Potential of geothermal district heating in NY and PA



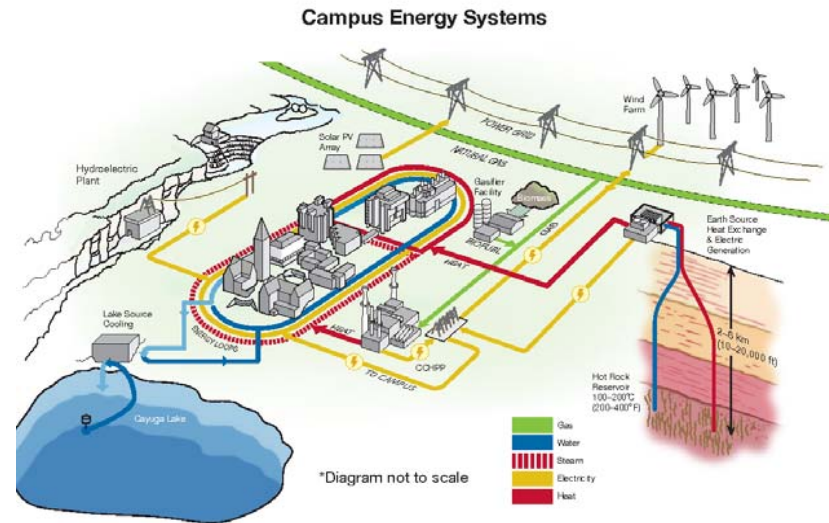
Reber et al., "The Transformative Potential of Geothermal Heating in the U.S. Energy Market: A Regional Study of New York and Pennsylvania", *Energy Policy*, 70, 30-44, (2014)

Renewable Energy Deployment



To meet its heating demand deep geothermal and biomass are feasible options and land exists for siting a demonstration

The Fair Comparison



Partnerships

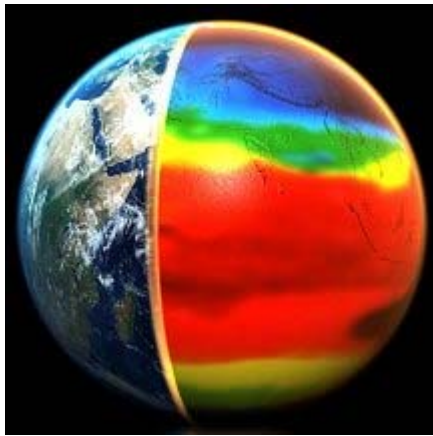
- **Memorandum of Agreement with Iceland**
Renewable Energy Education and Research and the creation of Renewable Energy Park
- **Verizon**
Geothermally cooled cell tower and data center energy management
- **U.S. DOE**
Direct use geothermal
- **NY State**
Systems approach to sustainable communities development in Utica NY
 - design a multi-block section the city that includes
 - Renewable district energy system
 - Retrofitted energy efficiency improvements
 - Utilizing geothermal heat pumps, solar PV and thermal, and anaerobic digestion of food wastes

WHY CORNELL?



Atkinson Center for a Sustainable Future

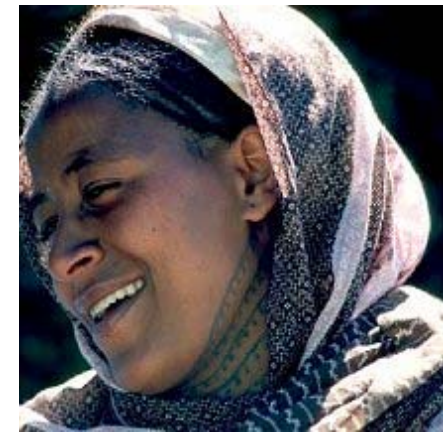
To create a world in which people can meet their needs and pursue their dreams without compromising the ability of future generations to do the same...



Energy



Environment



Economic Development

Energy Institute

Hydrocarbon Extraction
Sequestering Carbon
Renewable Energy Sources
Distribution/Management
Energy Storage

ACSF

Environment
Energy
Economic Development

Living Laboratory

CornellEngineering

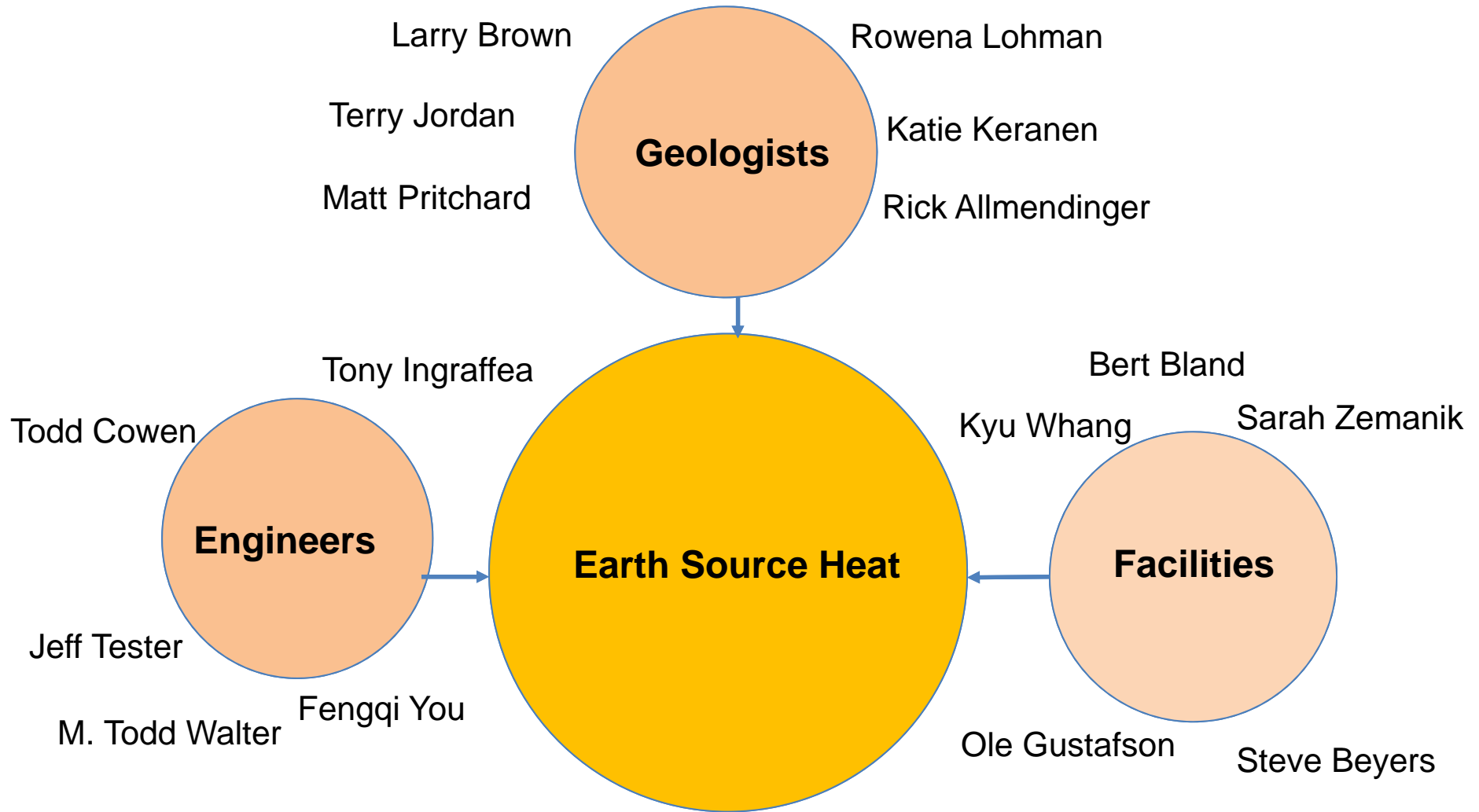


Collaborative Research: Creation of a new industry



- Cornell as a living laboratory to demonstrate the application of low temperature geothermal resources.
- Relevance of geothermal-ESH for district carbon-free heating applications at scale for the U.S.
- Developing partnerships to increase the impact of geothermal in N.Y. State and U.S. as a sustainable energy option.

Energy Research Requires a Multidisciplinary Team



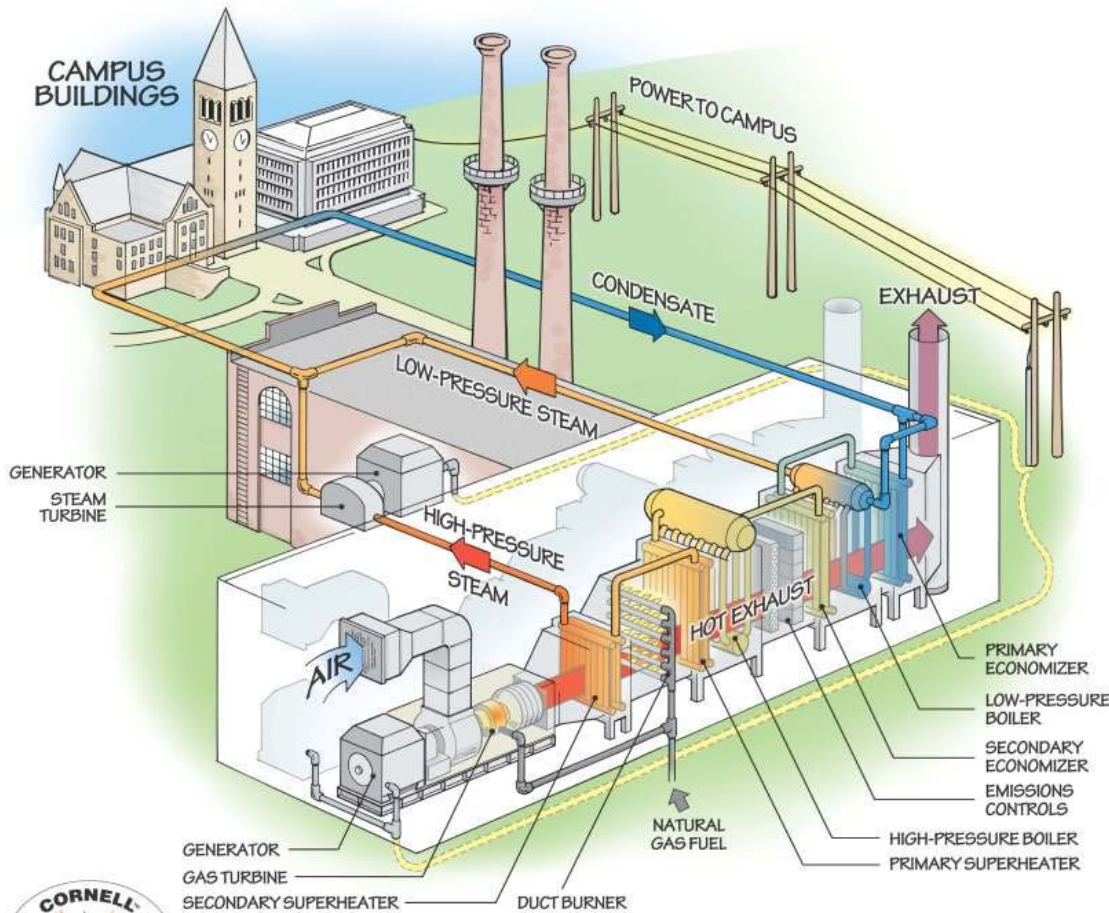
Transforming Cornell's Energy Systems: Historical Perspective

- Lake Source Cooling



Transforming Cornell's Energy Systems: Historical Perspective

- Lake Source Cooling
- Combined Heat and Power



Combustion Turbine with Heat Recovery Steam Generator



Transforming Cornell's Energy Systems: Historical Perspective

- Lake Source Cooling
- Combined Heat and Power
- Hydropower



Transforming Cornell's Energy Systems: Historical Perspective



- Lake Source Cooling
- Combined Heat and Power
- Hydropower
- Solar

Transforming Cornell's Energy Systems: Historical Perspective

- Lake Source Cooling
- Combined Heat and Power
- Hydropower
- Solar
- Black Oak Wind Farm

Phases of Work

1. **Preparatory Phase** (community engagement, design, permits) **Cost Estimate: \$3M**
2. **Test Well** (single well, no integration with campus) **Cost Estimate: \$12-15M**
3. **Demonstration** (one operating well-set, tie-in for use for limited portion of campus)
4. **Full deployment** (multiple well-sets, campus-wide)

Cornell has authorized the project, subject to the availability of funds

Consortium of Stakeholders and Investors

1. **Cornell (philanthropy)**
2. **Private Industry**
3. **Federal Government (e.g., DOE, NSF)**
4. **State Government**
5. **Foundations**

THANK YOU!