Insights into District Energy
October 21, 2014

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Implementing Community Energy Systems
Our Background

Ever-Green Energy leverages industry-leading expertise to plan, develop, operate, and manage advanced community energy systems that integrate sustainable and effective technologies.
U.S. ENERGY FLOW – 1981
(NET PRIMARY RESOURCE CONSUMPTION 73 QUADS)

Net hydroelectric 0.89
Net geothermal & other 0.02
Nuclear 2.9

6.9
Utility electricity generation
21.6
Export 0.05

14.7
Conversion
7.4
Field use 0.6

15.3
Distribution losses
4.4
Resid. Comm'l.

17.6
Industrial

19.8% of rejected energy

Natural gas 19.9
Imports 0.9
Coal 19.0
From stocks 0.4
Petroleum and NGL 20.4
Imports 12.7

11.3
Useful energy
30.2

38.7%
41.5%
55%

31.9%
68.1%
45%

Source: https://flowcharts.llnl.gov/
Net Primary Resource Consumption 82 Quads

Net imports 0.2
Geothermal + other 0.2
Hydro 2.9
Nuclear 6.5
Natural gas 16.4
Imports 1.7
Storage 0.1
Coil 21.6
Petroleum and NGL 17.9
Unaccd crude 0.5
Imports 16.3

67.8%
32.2%
45.4%
59.1%
37.3%
40.9%

Facilities: 16.3% of rejected energy

Source: https://flowcharts.llnl.gov/
Net Primary Resource Consumption ~97 Quads

Source: https://flowcharts.llnl.gov/
Facilities account for 15.2% of rejected energy.

Source: DOE Quadrennial Technology Review,
Integrated Energy Systems

![Diagram of an integrated energy system](diagram.png)
Combined Heat & Power (CHP)

The simultaneous generation of electricity and useful thermal energy from the combustion of a single fuel source.
District Heating & Cooling

- Underground network of pipes aggregate heating and cooling needs
- Customers can be served by one or several energy sources located on the system
- Potential for off-peak energy storage to reduce energy costs
Benefits of an Integrated Energy Approach

• Increases energy efficiency, reduces primary energy consumption and associated GHG emissions
• Enables beneficial use of surplus thermal energy from dispersed sources, including renewable energy
• Enables energy storage and smoothing of energy peaks
• Achieves significant energy conservation and GHG emissions reductions using currently emerging technologies
• Stable, competitive energy rates
• Flexible infrastructure and market resilience
Key Considerations

• Local champions are critically important
• Optimize local resources
• Focus on the needs of the local building owners and local stakeholder groups, both private and public
• Involve stakeholders early and often
District Energy St. Paul
Heating and Cooling the Capital City
St. Paul Cogeneration

- 33 MW of electricity production capacity
- Up to 300,000 tons per year of clean, renewable wood residuals
- Greenhouse gas CO$_2$ reduced up to 280,000 tons per year
Thermal Storage

- 6.7 million gallons of storage capacity
- Chilled water storage reduces peak-electric demand
- Firm capacity for weather events
Solar Thermal Integration
Stakeholders

- City of Saint Paul
- State of Minnesota
- U.S. Department of Energy
- U.S. Environmental Protection Agency
- U.S. Housing and Urban Development
- Building Owners and Managers Association
- Saint Paul Area Chamber of Commerce
- Local electric and gas utility
- University of Minnesota
Customer Benefits: Rate Stability

District Energy St. Paul, Inc.
Combined Rate Summary, 1984-2015

$ Per kWh

Fiscal Year

*1700 utilization hours

Inflation
District Energy - Stable Rates

Energy Charges: District Energy vs. On-Site

- Firm Natural Gas
- DE Energy Rate
- District Energy’s End Use Energy Cost
- 12 Mo. Avg Natural Gas

Price ($/MMBtu)

Year

Ever-Green Energy
ever-greenenergy.com
Burlington, Vermont
Stakeholders

• BURDES Committee (local energy coalition)
• Fletcher Allen Health Clinic
• University of Vermont
• City of Vermont
• Burlington Electric
• Vermont Clean Energy Development Fund
Burlington Study Mission

- Develop a community energy plan that is implementable
- Provide customers with stable, competitive energy rates
- Utilize local, renewable energy sources
- Reduce the carbon footprint for the Burlington community
- Improve the energy efficiency of the Burlington community
- Establish an initial customer base that makes implementation of a community energy system that is technically and economically feasible
- Provide guidance for system financing and development
**Natural Gas Volatility**

- Biomass prices are relatively stable over long term
- Natural gas prices fluctuate significantly over time
Customer Loads - Study Buildings

Building Annual Load

- 0 (6 Bldgs)
- 1 - 600 MWH (15 Bldgs)
- 601 - 3400 MWH (15 Bldgs)
- 3401 - 7020 MWH (5 Bldgs)

BURDES DISTRICT ENERGY STUDY
Building Load Plan
Burlington, Vermont
Developing Burlington’s Community Energy System

- Reducing greenhouse gas emissions
- Economically competitive in today’s market
- Stable, cost-based energy rates
- Investment in the community
- Resilient, reliable energy system
- Improves the efficiency of Burlington’s energy program
- Fundable in the private markets
- Implementable plan
Conclusions

- Development of integrated energy systems requires local system champions
- Optimize integration with local energy sources and existing infrastructure
- Leverage connections to nearby energy sources
- Coordinate with infrastructure improvements
- Start small, but plan for the system vision
- Develop systems with a multi-faceted stakeholder groups, including public and private participants
- Customize the plans to each individual community and their customers
Thank You

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Montpelier, Vermont

DISTRICT HEAT MONTPELIER
AN ENERGY INDEPENDENT DOWNTOWN

Jessie Baker
Assistant City Manager
October 21, 2014
City of Montpelier

- Smallest State Capital
- Population
  - 7,800 night time
  - 20,000 day time
- Council/Manager form of government
- Municipal Staff – 105 FTEs
DHM History

• 2000: Capital District Master Plan
• 2010: Montpelier Energy Advisory Committee
• 2010: City was awarded $8M from the Dept. of Energy
• 2011: Engineering services RFP issued and contract awarded
• 2012: Customer recruitment, Design of distribution system and boiler plant, Construction RFPs released
• 2013: Distribution System and Plant construction started
• Dec. 2013: Deliver hot water to ‘mini-system’ customers
• Oct. 2014: Commercial Operation of system
Case for District Heat

The Wood Fuel Situation in Vermont

Vermont Wood and Oil Energy Price History

#2 Heating oil would need to be less than $1.00/gal to have the same $/million Btu value as wood chips at $49/ton.

Year

$0.00
$5.00
$10.00
$15.00
$20.00
$25.00
$30.00

Oil $/MMBTU
Wood $/MMBTU

Schools paid an average of:

- 2003-04: Wood $32/green ton. #2 oil $1.01/gal.
- 2005-06: Wood $40/green ton #2 oil $1.96/gal.
- 2006-07: Wood $44/green ton. #2 oil $2.31/gal.
- 2007-08: Wood $49/green ton. #2 oil $2.94/gal.

Vision

Better Environment, Stronger Community

• Efficient energy use
• Fuel flexibility
  • Incorporate local, sustainable resources
  • Allow for quicker response to future market changes and new technologies
• Stable energy rates
• Improved economic competitiveness
• Limit building owner liability – Remove individual oil tanks and boilers from the floodplain
• Effectively managed heat utility
District Heat Montpelier is the municipal utility that purchases energy produced by the State of Vermont’s heat plant and distributes it to customers in the City of Montpelier

- Agreements in place between City and State governing procurement and operations.
- Enterprise fund within the City of Montpelier.
- Leveraging industry expertise through consultants, engineers, and Ever-Green Energy.
Staffing

• Planning and Implementation
  – Required approximately 1.0 FTE
  – Required various skill sets
    • Analytic expertise
    • Political expertise
    • Planning expertise
    • Sales and communications expertise

• Operations
  – Existing Finance, Public Works, and Management Staff
  – Existing State Plant Operators
Operational Structure

Office of the City Manager

- Customer Service
- Overall system responsibility
- Policy development
- System planning and development

Department of Public Works

- Admin/Engineering Division
  - Customer Service
  - Technical support
  - Internal system coordination
  - Coordination w/BGS
  - City Hall boiler operations
  - Reports

- Water/Sewer & Streets Division
  - Customer Service
  - O&M distribution system
  - O&M City Room
  - SCADA

- Equipment Division
  - Customer Service
  - Thermal metering system
  - SCADA System

Finance Department

- District Heat Utility
  - Customer Service
  - Budget Development
  - Billing
  - Auditing
  - Reports

- IT Division
  - Customer Service
  - IT support
  - TMS software support
  - Network support
  - Data management
State’s Heat Plant
State’s Heat Plant

Inside the Central Heat Plant
State’s Heat Plant

Central Heat Plant – Boiler Train
Distribution Route

State Plant

City Hall
Distribution System

- 4,000 feet of trench
- 8,000 feet of pipe
- Approximately 1,000 welded joints

Figure 4: Typical trench/pipe arrangement
Customers

• State Campus – 19 office buildings
  • State House, Governor’s Office, Supreme Court

• City Distribution System – 20 Buildings (15 customers)
  • Public Customers – City Hall, Fire and Police, Elementary School
  • Non-profit Customers – Regional Library, Churches
  • Private Customers – Insurance, Office Buildings, Restaurants

• 20 year contracts with City customers
  • Attached to land records
Rates and Costs

- Cost-based Rates
  - Energy Charge
  - Capacity Charge
- Cost to Connect
  - Service Lateral
  - Meter
  - In-building Connection
- City leveraged grant opportunities to assist customers
Lessons Learned

• Need multiple champions
  • Policy makers, managers, planners, technical experts
  • May shift with time
• Capitalize on industry expertise
• Find or develop local experts
• Relentless Communication
  • On the system, the finances, the construction, the benefits
• Treat customers fairly and, if needed, negotiate individually with customers
Your Next Steps

• The business model
  • Does it financially make sense?
• Message the intent and proposal – Stay on message
  • What is the vision?
  • What is the plan?
• Identify Champions
  • Policy Champions
  • Implementation Champions
  • Customer Champions
  • Doing Champions
  • Construction Champions
• Answer all the questions and answer them again
Thank you!

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Green Streets Pilot Project
District Geothermal System
West Union, Iowa
Thank You

- **Funding and Political Support**
  - Iowa Department of Transportation (IDOT)
  - Iowa Department of Natural Resources (IDNR)
  - Iowa Economic Development Authority (IEDA)
  - Community Development Block Grant (CDBG)
  - Watershed Improvement Review Board (WIRB)
  - Department of Energy
  - Keep Iowa Beautiful
  - EPA Climate Showcase
  - Trees Forever – Alliant Energy
  - Iowa Great Places – 2009 and 2010
  - Iowa Jobs (IJOBS)
  - Main Street IJOBS and Challenge
  - Fayette County Administration

- **Community Support**
  - Hats off to ALL of the Residents and Businesses of West Union, Living Through the Project

- **Construction Teams**
  - Blazek Corporation – Streetscape and Distribution
  - K-2 Construction – Geothermal Field and Pump Systems

- **Design Team**
  - Conservation Design Forum
  - Fehr Graham Engineering & Environmental
  - IBC Engineering Services

- **Collaboration**
  - Shawver Well Company
  - KCL Engineering
  - Tri-County Refrigeration

Collaborative Team Effort – From Start to Finish –
West Union
Geothermal

West Union, Iowa
West Union Geothermal

Distribution
- Vine Street
- Elm Street
- Walnut Street

Fields
- Fayette County Courthouse
- Lions Park
- Zion Church Parking Lot
The geothermal system utilized by West Union, Iowa, as a district energy system is a ground source closed loop system with decoupled fields and End-User water-to-air heat pump systems.

Distribution is installed beneath the Streetscape with individual connections for Local Businesses and Fields.

Closed loop geothermal field installed at the Fayette County Courthouse with associated system pumps.

Infrastructure installed for future geothermal field at Lions Park, includes system pumps and manifold vault for future well connection.

Stub provided for future geothermal field at Zion Lutheran Church parking lot.
Expectations and Considerations

- Geothermal System Selection – Closed versus Open Loop
  - Closed Loop Geothermal Expectations
    - Is a means of energy storage.
    - Is a means of energy transportation.
    - Is a means of increased energy efficiency.
    - Is NOT energy production
      - i.e. PV and/or Wind Turbine electrical energy production
  - Envelope Considerations
  - Occupancy Considerations
    - Building Types – Dominant Heating/Cooling
    - Thermal Comfort
  - Climatic, Thermal Conductivity, and Geotechnical Considerations
  - Utility, Rates, and Payback
    - Assess Feasibility, Make Educated Decisions, Have Appropriate Expectations
    - Verify Performance – Are Expectations Being Met?
West Union Geothermal
By The Numbers

Fayette County Courthouse
Geothermal Field
- System Pumps in Lower Level
- Manifold Vault in West Greenspace
- 132 Vertical Wells
- 300 ft Deep
- Average 150 ft / ton (24,000btu / Well)
- Anticipated 264-tons of Energy Exchange

Lions Park
Geothermal Field
- System Pumps in Pump House
- Manifold Vault Southwest of Pump House
- 180 Vertical Wells Anticipated
- 300 ft Deep
- Average 150 ft / ton (24,000btu / Well)
- Anticipated 360-tons of Energy Exchange

Zion Lutheran Church
Geothermal Field
- Stub for Connection to Distribution

Schedule and Fiscal Reflection
West Union Start: 2004
Design Involvement: 2008
Street Ground Breaking: 2010
Geo Field Ground Breaking: 2012
Substantial Completion: 2013
Project Completion: May 2014

Project Cost: $9.3 Million
Geothermal - $2,250,000.00
Beyond the Geothermal

- Streetscape
  - Pervious Pavement and Rain Gardens
  - Amphitheater
  - LED Lighting
- Infrastructure
  - Storm Water Management
  - Water and Sanitary Service Replacement
- Revitalization of a Main Street Town
  - Business Façade Improvements
  - Housing/Rental Units Renovated
  - Overall Re-Investment in the Heart of the Town
- **Political and Fiscal Management**
  - Jeff Geerts, Iowa Economic Development Authority
    - Jeff.Geerts@iowa.gov
- **West Union City Administrator**
  - Teresa Ruroden
    - CityofWestUnionadmin@alpinecom.net
- **Landscape Architecture**
  - Jason Cooper, Conservation Design Forum
    - JCooper@cdfinc.com
- **Civil Engineering**
  - Jon Biederman, Fehr Graham
    - JBiederman@fehr-graham.com
- **Geothermal (MEP Engineering)**
  - Brian Kuhn, IBC Engineering
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Thank You for Your Attendance

Questions?
Understanding District Energy Feasibility in Arlington County, VA

October 21, 2014
Why is Arlington interested in District Energy?
Arlington’s Community Energy Plan (CEP)
Community Energy Plan - Benefits

Competitiveness
- Energy cost
- Employment
- Investment

Security
- Supply quality
- Fuel flexibility
- Community resilience

Environment
- Greenhouse Gas Reduction
- Air quality
Per Capita GHG Emissions

Arlington County Per Capita GHG Projections

- Buildings
- District Energy & CHP
- Transportation
- Renewables

Base Case

2050 Goal
District Energy

Goal 2: Increase local energy supply and distribution efficiency in Arlington using District Energy

- 104 MW combined heat and power (CHP)
- 450 MW of District Energy (DE)
- Infrastructure planning
How are we approaching District Energy?
DE is NOT a countywide goal – we’re targeting areas based on several key factors:

- High energy density
- Development in the pipeline
- County influence/benefit
- Interested building owners
Crystal City Integrated Energy Master Plan (IEMP)

• Partnership with local developer and utility

• Investigates opportunities for district energy compared to business as usual costs (also considered efficiency and renewables)

• District scale planning – good density, manageable scope

• “Feasibility grade” study – not investment grade
District Cooling Potential

Blue: Chilled Water Distribution Pipeline
Orange: Possible Location for CHP Plants
District Heating Potential

Red: Hot Water Distribution Pipeline
Orange: General Location for CHP Plants
### GHG Savings Potential

Net Estimated Opportunity for Savings vs. Business as Usual

<table>
<thead>
<tr>
<th>Energy Efficiency</th>
<th>7%</th>
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</thead>
<tbody>
<tr>
<td>DE System with CHP plants</td>
<td>21%</td>
</tr>
<tr>
<td>Distributed solar electric</td>
<td>2%</td>
</tr>
<tr>
<td><strong>Potential GHG Reduction</strong></td>
<td><strong>30%</strong></td>
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Takeaways
District Energy - Headwinds

• Low cost of electricity

• Development mentality - buildings with low initial costs

• Collective action/chicken-egg problem

• Legal restrictions
District Energy - Tailwinds

- Committed local government
- Private sector interest
- Long term energy price increases, desire for reliable/predictable power (and costs)
- High energy density, development in the pipeline
- May be best “bang for buck” GHG reduction strategy
- Opportunities for projects to serve government facilities
Thank you!

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Questions?

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