Case Studies in West Coast Community Energy:
Stanford University, UCDSC and the University of Washington

IDEA JUNE 2014: MOVING COMMUNITY ENERGY FORWARD
ANNUAL CONFERENCE & TRADE SHOW
Agenda

• Drivers for Community Energy Review
• Case Studies
• Conclusions
Drivers for Review

- Aging Infrastructure
- Climate Change
- Policy Change
- Campus/Community Growth
- Resiliency
Drivers for Review

- Aging Infrastructure
- Climate Change
- Policy Change
- Campus/Community Growth
- Resiliency
Drivers for Review

- Aging Infrastructure
- Climate Change
- Policy Change
- Campus/Community Growth
- Resiliency
Drivers for Review

- Aging Infrastructure
- Climate Change
- Policy Change
- Campus/Community Growth
- Resiliency
Drivers for Review

- Aging Infrastructure
- Climate Change
- Policy Change
- Campus/Community Growth
- Resiliency
Case Studies

- University of Washington, Seattle, WA
  - South of Pacific Master Infrastructure Review
- UC Davis Sacramento Campus, Sacramento, CA
  - Utilities Master Plan
- Stanford University, Palo Alto, CA
  - Stanford Energy Systems Innovations (SESI)
Climate

- Seattle
  - 85/65 F Cooling
  - 24 F Heating
- Sacramento, CA
  - 100/70 F Cooling
  - 31 F Heating
- Palo Alto, CA
  - 93/67 F Cooling
  - 36 F Heating
U of Washington South Campus

- Options Studied
  - Business as Usual
    - Distributed Chilled Water Generation
    - Campus Steam Heating
  - Case 1
    - Conventional Central Chiller Plant
    - Maintain Campus Steam Use
  - Case 2
    - Heat Recovery Chiller for Base Heating and Cooling Loads
    - Conventional Chiller Plant for Chilled Water Peaks
    - Maintain Campus Steam for Heating peaks
  - Case 3
    - High-pressure steam biomass boilers
    - Backpressure steam turbine cogeneration
  - Case 4
    - Same as Case 3 with NG boilers
• Case 2 – Heat Recovery Chiller Option yields greatest savings relative to BAU
• Case 3 – Cogeneration with biomass also yields high savings
UCDSC - Utility Master Plan

• Options
  • Business as Usual
    • NG Turbine Cogeneration (25 MW)
    • Absorption chillers use excess steam, electric ch topping
    • All campus power generation by turbine
  • Option 1A
    • Optimize Existing Cogen System
  • Option 2
    • Decommission NG turbine
    • Conventional boiler chiller plant w/ utility power
  • Option 3A
    • Decommission turbine
    • Heat recovery chiller system for base heating and cooling
    • Conventional boilers and chillers for peak loads
    • Utility power
  • Option 3B
UCDSC - Utility Master Plan

- Option 1B (Optimize existing cogeneration) has lowest NPV cost
- Heat recovery chiller options better than existing cogen operating scenario (w/GHG cost included)
Cal EPA ARB Cap & Trade

- Applies to users over 25,000 MT CO2e/yr
- Allowances are made available at auction
- Allowance quantity is slowly reduced over time (3% per year)
CARB Cap & Trade

• UCDSC analysis assumed a steep upward trend after the initial startup period

• Initial trend in GHG allowance costs is relatively flat – no obvious trend
Stanford: Options Evaluated

- Cogen Options w/ Steam
  - Business as Usual
  - New CT
- Cogen Options w/ Hot Water
  - New CT
  - New CT + Heat Recovery
  - New IC Engine + Heat Recovery
- Grid Power Options w/ Hot Water
  - Grid + Heat Recovery
  - Grid + No Heat Recovery
- Grid Power + On-Site Solar w/ Hot Water
  - 20% Solar
  - 33% Solar
Why Heat Recovery is Possible

Stanford University
Central Energy Facility Replacement Options

- Steam Options
  - On-site Gas Cogeneration Options
    - 1. Business As Usual
    - 2. New Cogen (Steam)
    - 3. New Cogen (HW)
    - 4. Gas Power (Turbine) + Heat Recovery
    - 5. Gas Power (IC Engines) + Heat Recovery
  - Grid Power Options
    - 6. Grid + Heat Recovery
    - 7. Grid, No Heat Recovery
  - Grid + On-site PV Options
    - 8. Grid + 20% Photovoltaic Power + Heat Recovery
    - 9. Grid + 33% Photovoltaic Power + Heat Recovery

- Hot Water Options

- Heat Recovery Options

- Capital
- O&M
- Water used (ccf)
- Total GHG

NPV 2015-2050 (Millions) vs. GHG (million tons): Water (million ccf)

- Electricity
- Natural Gas
- Total GHG

- $1,593
- $1,356
- $1,392
- $1,399
- $1,333
- $1,290
- $1,371
- $1,276
- $1,267

- $153
- $435
- $549
- $579
- $546
- $474
- $449
- $546
- $593

- $1,700
- $1,600
- $1,500
- $1,400
- $1,300
- $1,200
- $1,100
- $1,000
- $0

- 10.0
- 9.4
- 8.8
- 8.2
- 7.6
- 7.0
- 6.4
- 5.8
- 5.2
- 4.6
- 4.0
- 3.4
- 2.8
- 2.2
- 1.6
- 1.0
- 0.4
- 0.2
- 0.0
- -0.2
Why Heat Recovery is Possible

Stanford University
Central Energy Facility Replacement Options

On-site Gas Cogeneration Options

Grid Power Options

Grid + On-site PV Options

Steam Options

Hot Water Options

Heat Recovery Options

NPV 2015-2050 (Millions)

GHG (million tons); Water (million ccf)

1. Business As Usual
2. New Cogen (Steam)
3. New Cogen (HW)
5. Gas Power (IC Engines) + Heat Recovery
6. Grid + Heat Recovery
7. Grid, No Heat Recovery
8. Grid + 20% Photovoltaic Power + Heat Recovery
9. Grid + 33% Photovoltaic Power + Heat Recovery

- $100
- $200
- $500
- $1,000
- $1,500
- $2,000

- 2.0
- 5.0
- 8.0
- 10.0

- Electricity
- Natural Gas
- O&M
- Capital
- Water used (ccf)
- Total GHG
Why Heat Recovery is Possible
Why Heat Recovery is Possible

- We heat & cool buildings at the same time
- Cooling is just the collection of unwanted heat

Stanford can recover 65% of the heat now discharged from the cooling system to meet 80% of campus heating demands.

**Stanford University**

Heat Recovery Potential at Central Energy Facility

Sample Date 7/23/2008

**Source:** Stanford University
Draft Energy & Climate Plan (April 2009)

- Summer
- Winter
- Spring & Fall
Why Heat Recovery is Possible

Stanford University

Cooling

Heat Recovery Potential

Heating
Why Heat Recovery is Possible

- Medical/Hospital: 120 MMBTU
- Science/Tech: 40 MMBTU
- Business/Athletics: 20 MMBTU
- Academics: 50 MMBTU
- Residential – East: 15 MMBTU
- Residential – South: 10 MMBTU
- Engineering: 35 MMBTU
- NEW CEF
- EXISTING CEF
Final Solution – New Plant
Final Solution – New Plant

- Distribution – 80%
- Building Conversions – 70%
- CEF
  - Heat Recovery – 80%
  - OSHPD – 50%
- Substation – 100%

Project Completion
Spring 2015
Final Solution – Heat Recovery Chillers
Final Solution – Heat Recovery Chillers
Final Solution – Heat Recovery Chillers
Conclusions

- Conclusions
  - State of existing infrastructure can affect outcome
  - GHG costs shift balances between options but not yet to an extreme extent
  - Climate and energy costs are significant drivers in system selection, but are overshadowed by overall system efficiency
Questions?