UC Irvine’s Combined Heat and Power Plant
Combined Heat and Power Plant

- **High Pressure Natural Gas**
  - Gas Turbine
  - Generator
  - Southern California Edison
    - ~1 MW solar
    - 66 kV
  - University Substation
    - 12 kV
  - Campus Electric Load
    - 25 MW Peak
    - 15 MW Avg.

- **Heat Recovery**
  - Original Boilers 90,000 lbs/hr
  - Steam (recovered waste heat)
    - 52,000 lbs/hr (without duct fire)
    - 120,000 lbs/hr (with duct fire)
  - Steam Turbine Chiller 2,000 tons
  - Thermal Storage Tank
    - 4.5 million gallons of water
    - 90,000 ton-hours (average)

- **Campus Heat Load**
  - 60 MMBtu/hr
  - (average)

- **Heat Recovery Alternative Uses**:
  1. Campus heating load
  2. Steam turbine chiller to campus cooling load
  3. Steam turbine chiller to thermal storage tank
  4. Steam turbine generator for campus electric load
  5. Steam generator powers electric chillers (in addition to steam chiller) for (A) real-time cooling or (B) future cooling (via thermal storage)
  6. Any combination of the above

- **Electric Chillers**
  - 14,000 tons

- **Campus Cooling Load**
  - > 90,000 ton-hours/day
  - (average)
Heating and Cooling Plant
Boiler Data

• Boiler #1 & #2 – Babcox & Wilcox 250PSI
  – 29,000lbs/hr, 1964
  – Oil & Gas Burner

• Boiler #3 - Nebraska 300PSI
  – 30,000lbs/hr, 1970

• Boiler #4 - Trane Murray 300PSI
  – 30,000lbs/hr, 1978
Chiller Data

• Chiller #1 - Trane 1000Ton R-123
• Chiller #2 - Trane 1250Ton R-123
• Chiller #3 - Trane 1250Ton R-123
• Chiller #4 - York 2000Ton R-134a
  – Steam Turbine Driven
• Chiller #5 - Trane 2500Ton R-123
• Chiller #6 - Trane 2500Ton R-123
• Chiller #7 - York 3000Ton R-134a
• Chiller #8 - York 3000Ton R-134a
Total Chiller Capacity of 16,500 Tons
Steam Turbine Chiller
Process Heat Exchangers

- Two exchangers supply 365F High Temperature Hot Water for campus heating, steam generators, industrial hot water, domestic hot water, cage washers, and autoclaves.

- Titanium tube and shell exchangers
- Rated at 50MM BTU at 1000GPM
Thermal Energy Storage
TES Tank Data

- Tank hold 4.5 million gallons of chilled water
- Tank is 107ft. tall and 88ft. in diameter
- Tank is rated at 53,000 ton hours
- Tank is chilled to 39F
Cooling Towers
Cooling Tower Data

• Four two-cell towers rated at 4000 tons per tower
  – Total Capacity – 32,000 tons

• CoGen cooling tower two cell rated at 4000 tons per tower
  – Total Capacity – 8000 Tons
Solar Titan 130 Combustion Turbine 13.5 MW at 12,000 volts
Solar Turbine assembly before being placed into enclosure
Starter Drive Motor
Steam Turbine Generator

- Dresser-Rand Murray Steam Turbine
- Rated at 5.6 MW at 12,000 Volts
Heat Recovery Steam Generator

Steam Production Unfired – 56,000lbs/hr
Steam Production Fired – 128,000lbs/hr
Urea Injection
Urea Tank
Maintenance

- Solar Service Contract
- Water Wash
- Air Inlet
- Oil Filters
CTG Injector Maintenance
Injector
Water Wash Tank
Air Inlet
Inlet Air Filters
Oil Filters
Combined Heat and Power Plant

Original Boilers 90,000 lbs/hr

Heat Recovery

Gas Turbine

High Pressure Natural Gas

Steam (recovered waste heat)
52,000 lbs/hr (without duct fire)
120,000 lbs/hr (with duct fire)

Steam Turbine
Generator

Southern California Edison
~1 MW solar
66 kV

University Substation
12 kV

Campus Electric Load
25 MW Peak
15 MW Avg.

Electric Chillers
14,000 tons

Steam Turbine Chiller
2,000 tons

Thermal Storage Tank
4.5 million gallons of water
(60,000 ton-hours)

Campus Heat Load
60 MMBtu/hr
(average)

Campus Cooling Load
> 90,000 ton-hours/day
(average)

Heat Recovery Alternative Uses:
1. Campus heating load
2. Steam turbine chiller to campus cooling load
3. Steam turbine chiller to thermal storage tank
4. Steam turbine generator for campus electric load
5. Steam generator powers electric chillers (in addition to steam chiller) for (A) real-time cooling or (B) future cooling (via thermal storage)
6. Any combination of the above
Rule 21
GENERATING FACILITY INTERCONNECTIONS

- Governs the way we operate in parallel with SCE
- Right now, we operate under the minimum import agreement.
  - We a minimum 5% of nameplate rating at all times.
  - 970 kW of imported power.
  - To ensure that we don’t go below that we operate at no less than 1200 kW of imported electricity.
- In the future we operate under the minimum export concept
  - No minimum import requirement
  - May export very small amount for 2 seconds before protective relay trips the plant off the line.
  - To ensure no tripping we will still import at least 200 kW.
UCI’s Operating Challenge

1. Meet the campus load
2. Operate as cost effectively as possible
3. Comply with SCE operating agreements
4. Minimize imported electricity
5. Reduce greenhouse gas emissions
## Strategic Energy Program

### STRATEGIC ENERGY PARTNERSHIP SUMMARY

<table>
<thead>
<tr>
<th>SEP Program Year</th>
<th>2009</th>
<th>2010</th>
<th>2011</th>
<th>Total</th>
<th>Forecast 2012</th>
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<tr>
<td>Electric Savings (kWh/Yr)</td>
<td>15,835,000</td>
<td>7,780,000</td>
<td>10,600,000</td>
<td>34,215,000</td>
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<td>Natural Gas Savings (therms/Yr)</td>
<td>467,000</td>
<td>869,000</td>
<td>425,000</td>
<td>1,761,000</td>
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<td>GHG Reduction (CO2e Ton/Yr)</td>
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<td>7,000</td>
<td>5,300</td>
<td>19,700</td>
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<td>Incentive Received</td>
<td>$ 4,000,000</td>
<td>$ 2,700,000</td>
<td>$ 3,000,000</td>
<td>$ 9,700,000</td>
<td>$ 4,355,000</td>
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<td>Energy Cost Savings/Yr</td>
<td>$ 1,937,000</td>
<td>$ 1,343,000</td>
<td>$ 1,316,000</td>
<td>$ 4,596,000</td>
<td>$ 1,890,000</td>
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</table>

### Solar PV

895 kW comprised of 11 rooftop installations 2009
113 kW CPV dual axis tracking installation 2011-2012
Can you save too much energy?

UCI Installs Combined Heat and Power Plant and then Implements a Strategic Energy Plan

Utility Costs

- Total Variable Costs w/o SEP
- Total Variable Costs with SEP
- Campus GSF


Co-Gen Installed
UCI Begins SEP Program
Energy Cost Without Projects
Energy Cost with Projects
The Math

Must import 1.2 MW
Generator Minimum is 7.5 MW
Max Solar PV 1 MW

\[ 9.7 \text{ MW} \]
Total Campus Load CoGen Output Plus Imported for September 1 2011 Through May 1 2012
Minimum Load Change Due To Expanding Utilities and New Loads

- Amonix Solar Added
- Fuel Cell On-Line 350kW
- SEP Projects Decrease Load
- Added what UCI used to import, Gottschalk, MRI, Buildings
- SEP Projects Decrease Load
- Minimum Import to Inadvertent Export
- SEP Projects Decrease Load

Years: 2010 to 2016

Utilities: Solar, Fuel Cell, CoGen, 66kV
How do we maintain the balance?

• True team effort
• Analyze the data, explore options, communicate the vision to the plant operators.
• Monitor and verify the results and make adjustments when necessary.
2011 vs 2012 Electricity Import
Hotter Temperatures Lower Import
### kWh Import 2011 vs 2012

#### Consumption Comparison Report - 3-012-8063-59

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<th>Date</th>
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<th>Total(kWh)</th>
<th>Date</th>
<th>Time</th>
<th>Total(kWh)</th>
<th>Variance</th>
<th>Variance(%)</th>
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2011-12 vs 2009-10 Natural Gas for Co-Gen

![Bar chart showing DGS purchased gas for Co-Gen comparison between 2011-12 and 2009-2010 across months from July to March.](chart.png)
Financial Analysis

1. The September 66kV rate was $0.1332 kWh
2. The Co-Gen Rate was $0.0740 kWh without debt service and M&O
3. The Co-Gen Rate was $0.1022 kWh with debt service and M&O

Co-Gen saves the campus millions of dollars in purchased utilities but negatively affects our greenhouse gas emissions
Emissions Data

UC Irvine CO2E Emission History

<table>
<thead>
<tr>
<th>Year</th>
<th>Main Campus</th>
<th>Main Campus 2014 Target</th>
<th>Main Campus 2020 Target</th>
<th>Medical Center</th>
<th>Medical Center 2014 Target</th>
<th>Medical Center 2020 Target</th>
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<td>25,419</td>
<td>16,174</td>
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• UC Irvine will have to participate in the November auction.
• UC Irvine is exploring ways to get under the 25,000 ton cap
• The answer may be sourcing bio-gas in the long term.
Thank You

Questions?