Putting it all together
Agenda

1. Solar case studies
Solar case studies
Case Study - J. Craig Venter Institute

Architect: ZGF Architects LLP
Project Owner: J. Craig Venter Institute
Project Category: New Construction
Project Type: Laboratory
Building Gross Floor Area: 44,607 sf
Project Location: La Jolla, CA

“The client's vision was to build the most sustainable research building in the world, setting a new benchmark in environmental stewardship.” – ZGF Architects LLP

Photo credit: Steve Proehl
Case Study - J. Craig Venter Institute

Solar PV System Capacity: 481.3 kW
Annual kWh Production: 845,429 kWh

Photo credit: Nick Merrick
The first step was to establish the typical laboratory energy demand, and then determine the energy budget based on the area for the Photovoltaic array.

- Typical Laboratory Baseline Budget: 47%
- Target Energy Budget: 16%
- Other categories: 8%, 2%, 11%, 16%
Case Study - J. Craig Venter Institute

ARCHITECTURE

Initial reduction in energy use was achieved by architectural solutions (sunshades, building orientation, etc.).

- 7%
Case Study - J. Craig Venter Institute

MEP SYSTEMS
Additional energy savings was achieved through improvements to HVAC and lighting systems.

Graphic credit: ZGF Architects
Case Study - J. Craig Venter Institute

PLUG LOADS
By changing the culture of research (laptops, water-chilled freezers, green plugs) and measuring usage in existing JCVI laboratories, a 73 percent overall reduction from the baseline was achieved.
**Total Building Energy Cost Performance**

<table>
<thead>
<tr>
<th>Energy Type</th>
<th>Units</th>
<th>Process Subtotal</th>
<th>Section 1.6 Total Energy Cost</th>
<th>Section 1.6 Energy Cost</th>
<th>Section 1.7 Energy Savings</th>
<th>Section 1.8 Renewable Energy Savings</th>
<th>Total Energy Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electricity</td>
<td>$</td>
<td>27,837.6</td>
<td>123,658.33</td>
<td>54,848.31</td>
<td>0</td>
<td>72,706.89</td>
<td>-17,858.59</td>
</tr>
<tr>
<td>Natural Gas</td>
<td>$</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Totals</td>
<td>$</td>
<td>27,837.6</td>
<td>123,658.33</td>
<td>54,848.31</td>
<td>0</td>
<td>72,706.89</td>
<td>-17,858.59</td>
</tr>
</tbody>
</table>

Baseline process energy costs as percent of total energy costs (%): 22.51

Energy cost savings (%): 114.44

EA Credit 1 points documented: 19

**$141,243.92 under baseline**
Case Study - J. Craig Venter Institute

Graphic credit: ZGF Architects
Case Study - J. Craig Venter Institute

Photo credit: Nick Merrick
Case Study - Wayne Aspinall Federal Building

**Architect:** Westlake Reed Leskosky / The Beck Group

**Project Owner:** U.S. General Services Administration, Rocky Mountain Region

**Project Category:** Adaptive Reuse

**Project Type:** Courthouse, Office

**Building Gross Floor Area:** 41,562 sf

**Project Location:** Grand Junction, CO

Photo credit: Kevin G. Reeves

Powered by SunShot
U.S. Department of Energy
Case Study - Wayne Aspinall Federal Building

Two Solar PV Arrays:
1. Suspended canopy
2. Roof mounted

Site Plan + North-South Section
Wayne N. Aspinall Federal Building & U.S. Courthouse
Grand Junction, Colorado

Photo credit: Westlake Reed Leskosky
### Case Study - Wayne Aspinall Federal Building

**Energy Use Summary**

<table>
<thead>
<tr>
<th>Energy Type</th>
<th>Units</th>
<th>Baseline Case</th>
<th>Proposed Case</th>
<th>Total Energy Use</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Section 1.6 Energy Use</strong></td>
<td></td>
<td>Process</td>
<td>Section 1.6 Energy Use</td>
<td>Section 1.7 Energy Savings</td>
</tr>
<tr>
<td>Electricity</td>
<td>kWh</td>
<td>42,163</td>
<td>450,855.6</td>
<td>163,211.5</td>
</tr>
<tr>
<td>Natural Gas</td>
<td></td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Totals</td>
<td>MMBtu</td>
<td>143.86</td>
<td>1,538.32</td>
<td>556.88</td>
</tr>
</tbody>
</table>

**Energy use savings:** 102.31%  

**Solar PV System Capacity:** 123 kW  
**Annual kWh Production:** 173,608 kWh
## Energy Cost Summary

<table>
<thead>
<tr>
<th>Energy Type</th>
<th>Units</th>
<th>Baseline Costs</th>
<th>Proposed Costs</th>
<th>Total Energy Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Section 1.6 Energy Use</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Electricity</td>
<td>$</td>
<td>2,951.4</td>
<td>11,422</td>
<td>12,153 (-731)</td>
</tr>
<tr>
<td>Natural Gas</td>
<td>$</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Totals</td>
<td>$</td>
<td>2,951.4</td>
<td>11,422</td>
<td>12,153 (-731)</td>
</tr>
</tbody>
</table>

Baseline process energy costs as percent of total energy costs (%): 9.35%

Energy cost savings: 102.32%

EA Credit 1 points documented: 19

$32,281.75 under baseline
Case Study - Wayne Aspinall Federal Building

North Elevation after restoration and installation of photovoltaic array at canopy

North Elevation prior to restoration

Photovoltaic Array

Photo credit: Kevin G. Reeves
Case Study: H-E-B at Mueller

Architect: Lake|Flato Architects & H-E-B Design + Construction
Project Owner: H-E-B
Project Category: New construction
Project Type: Supermarket / grocery
Building Gross Floor Area: 83,587 sf
Project Location: Austin, TX

Photo credit: Lake|Flato Architects
Case Study: H-E-B at Mueller

Energy Reductions

- **LIGHTING**
  - 52% Reduction

- **SPACE CONDITIONING**
  - 31% Reduction

- **REFRIGERATION**
  - 43% Reduction

Measured Energy Performance

- **Modeled Energy**: 197 KBTU/SF/YR
- **Measured Net Energy**: 237 KBTU/SF/YR
- **Target Energy Benchmark**: 545 KBTU/SF/YR

- **57% Reduction**: 257,592,288 KBTU saved
- **334 Texas Houses Offset**

CBECs Typical Energy Use (MMBtu):

- HVAC: 10,022
- Plugs/Equip.: 13,210
- Refrigeration: 17,764
- Lighting: 4,555

Proposed Energy Use (MMBtu):

- HVAC: 5,302
- Plugs/Equip.: 6,437
- Refrigeration: 3,054
- Lighting: 1,656

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U.S. Department of Energy
Case Study: H-E-B at Mueller

Solar PV System Capacity: 169 kW
Annual kWh Production: 234,800 kWh
## Case Study: H-E-B at Mueller

### Total Building Energy Cost Performance

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<th>Section 1.8 Renewable Energy Savings</th>
<th>Total Energy Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electricity</td>
<td>$</td>
<td>$138,639.84</td>
<td>$274,144.88</td>
<td>$217,381.75</td>
<td>0</td>
<td>16,905.6</td>
<td>$200,476.15</td>
</tr>
<tr>
<td>Natural Gas</td>
<td>$</td>
<td>$6,990.23</td>
<td>$34,613.26</td>
<td>$26,374.74</td>
<td>0</td>
<td>0</td>
<td>$26,374.74</td>
</tr>
<tr>
<td><strong>Totals</strong></td>
<td>$</td>
<td>$145,630.07</td>
<td>$308,758.14</td>
<td>$243,756.5</td>
<td>0</td>
<td>0</td>
<td>$226,850.9</td>
</tr>
</tbody>
</table>

Baseline process energy costs as percent of total energy costs (%) = 47.17

Energy cost savings (%) = 26.53

EA Credit 1 points documented = 8

$73,668.73 under baseline
Case Study: Residential, Charleston, SC

**Project Type:** Residential

**Building Gross Floor Area:** 2,208 sf

**Project Location:** Charleston, SC

**System Capacity:** 5.886 kW

**# of Panels:** 18
ACCOUNT SUMMARY

Previous Bill Amount $31.24
Payment Received 05/15/17 THANK YOU
Current Charges

Amount Due on 6/16/17 $30.12
A late payment charge of 1.5% may be added to any balance remaining 25 days after billing.

SUMMARY OF CURRENT CHARGES

Electric Charges $11.46
Gas Charges 18.66
Total Current Charges $30.12

CURRENT CHARGES

Electric Charges
RATE PLAN 002 - Resid Low Use - Net Metering
METER READING Electric Meter read on 05/23/17 at 12:00 am
(Need scheduled read date 6/23/17)

TOTAL KWH USED
Basic Facilities Charge 10.00
KWH X $ 0.106550 0.00
Renewable Energy Resources 0.91
Franchise Fee 5.00% paid to the City of Charleston 0.55
Total Electric Charges $11.46
## Case Study: Residential, Charleston, SC

<table>
<thead>
<tr>
<th>How Energy Was Billed</th>
<th>kWh</th>
</tr>
</thead>
<tbody>
<tr>
<td>Energy from SCE&amp;G</td>
<td>517</td>
</tr>
<tr>
<td>Solar Excess Delivered to SCE&amp;G</td>
<td>-690</td>
</tr>
<tr>
<td>Net Energy Used by Customer</td>
<td>-173</td>
</tr>
<tr>
<td>Previous Month Excess Energy Credit</td>
<td>-645</td>
</tr>
<tr>
<td>Current Month Excess Energy</td>
<td>-818</td>
</tr>
<tr>
<td>Total Energy Billed to Customer</td>
<td>0</td>
</tr>
</tbody>
</table>
Design Exercises
Exercise 1: Site Layout

Sketch Exercise

1. What areas will be shaded from neighboring buildings?
2. Where should the building be placed?
3. Where are the good solar sites?
Exercise 1: Site Layout

Sketch Exercise

1. What areas will be shaded from neighboring buildings?
2. Where should the building be placed?
3. Where are the good solar sites?
Exercise 1: Site Layout

- Canopy
  Credit: Stephen Miller

- Rooftop
  Credit: CSE

- Carport
  Credit: CSE

- Facade
  Credit: Adroit Energy
Exercise 2: Choose the best inverter

Example System 1
- 1 south-facing array
- 1 west-facing array
- No shade

Option 1:
Micro inverters

Option 2:
2 string inverters
Exercise 2: Choose the best inverter

Example System 2

• 2 arrays, both facing south
• Minimal shade

Option 1:
String inverter

Option 2:
Micro inverters or DC power optimizers
Example System 3
• 2 arrays, both facing south
• 1 panel shaded during afternoon hours

Option 1: Micro inverters

Option 2: String inverter with DC power optimizers
Exercise 2: Choose the best inverter

String vs. Micro vs. String + DC Power Optimizer
<table>
<thead>
<tr>
<th>Mounting Method</th>
<th>Consideration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tilted rack</td>
<td>Flat roof, concern with drilling holes</td>
</tr>
<tr>
<td>Pole</td>
<td>Pitched roof</td>
</tr>
<tr>
<td>Ballast</td>
<td>Flat roof, concern with additional weight</td>
</tr>
<tr>
<td>Flush</td>
<td>Parking lot or field</td>
</tr>
</tbody>
</table>
Exercise 3: Choose the best mounting method

- **Tilted rack**: Flat roof, concern with drilling holes
- **Pole**: Pitched roof
- **Ballast**: Flat roof, concern with additional weight
- **Flush**: Parking lot or field
Exercise 3: Choose the best mounting method

- **Tilted rack**
  - Flat roof, concern with drilling holes

- **Pole**
  - Pitched roof

- **Ballast**
  - Flat roof, concern with additional weight

- **Flush**
  - Parking lot or field
Exercise 3: Choose the best mounting method

- **Tilted rack**: Flat roof, concern with drilling holes
- **Pole**: Pitched roof
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Exercise 3: Choose the best mounting method

- Tilted rack: Flat roof, concern with drilling holes
- Pole: Pitched roof
- Ballast: Flat roof, concern with additional weight
- Flush: Parking lot or field
Exercise 3: Choose the best mounting method

- Flush mounted
- Tilted rack mounted
- Pole mounted
- Ballasted
Exercise 4: Calculate area needed for PV system

How much space is needed for a 10 kW system?

**Example Panels:**
- Silicon monocrystalline
- 345 watt/panel
- 77" x 39" or approx. 21 sf/panel

**Step 1: Convert kilowatts to watts**

\[ 10 \text{ kW} \times 1,000 = \text{Watts} \]
Exercise 4: Calculate area needed for PV system

How much space is needed for a 10 kW system?

Example Panels:
• Silicon monocrystalline
• 345 watt/panel
• 77" x 39" or approx. 21 sf/panel

Step 2: Determine the # of panels needed

\[
\text{System capacity (Watts)} \div \text{Watts per panel} = \text{# of panels}
\]
Exercise 4: Calculate area needed for PV system

How much space is needed for a 10 kW system?

Example Panels:
• Silicon monocrystalline
• 345 watt/panel
• 77" x 39" or approx. 21 sf/panel

Step 3: Calculate the total area needed for the array

# of panels \times \text{sf per panel} = \text{Total array area}
Exercise 4: Calculate area needed for PV system

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**Step 1: Convert kilowatts to watts**

\[
10 \text{ kW} \times 1,000 = 10,000 \text{ Watts}
\]
Exercise 4: Calculate area needed for PV system

How much space is needed for a 10 kW system?

Example Panels:
- Silicon monocrystalline
- 345 watt/panel
- 77" x 39" or approx. 21 sf/panel

Step 2: Determine the # of panels needed

\[
\frac{10,000}{345} = 29
\]

- System capacity (Watts)
- Watts per panel
- # of panels
Exercise 4: Calculate area needed for PV system

How much space is needed for a 10 kW system?

Example Panels:
- Silicon monocrystalline
- 345 watt/panel
- 77" x 39" or approx. 21 sf/panel

Step 3: Calculate the total area needed for the array

\[
\text{Total array area} = \text{# of panels} \times \text{sf per panel}
\]

\[
\begin{align*}
29 \times 21 &= 609 \\
\text{# of panels} &\quad \text{sf per panel} &\quad \text{Total array area}
\end{align*}
\]
Exercise 5: Calculate dead load

How much dead load will the same 10 kW system add to the roof?

Racking only

\[ \text{sf} \times 2-4 \text{ lbs/sf} = \text{Dead load} \]

Example system:
- 10 kW
- 29 panels
- 609 sf
Exercise 5: Calculate dead load

How much dead load will the same 10 kW system add to the roof?

Ballasted mounted

\[ \text{sf} \times 5-9 \text{ lbs/sf} = \text{Dead load} \]

Example system:
- 10 kW
- 29 panels
- 609 sf
Exercise 5: Calculate dead load

How much dead load will the same 10 kW system add to the roof?

**Racking only**

\[
609 \times 2-4 \text{ lbs/sf} = 1,218 - 2,436 \text{ lbs}
\]

Dead load
Exercise 5: Calculate dead load

How much dead load will the same 10 kW system add to the roof?

**Ballasted mounted**

\[ 609 \text{ sf} \times 5-9 \text{ lbs/sf} = 3,045 - 5,481 \text{ lbs} \]

Dead load