Lincoln Public Schools
Potential PV Systems
Overall Site Plan

- School consists of many existing buildings and several new sections
- Much of the existing rooftop equipment will be removed
- Parking lots in the northeast and southwest will be redone
Insert all three videos

Winter Solstice Shading
10am to 2pm
Spring/Fall Equinox Shading
8am to 4pm
Summer Solstice Shading
8am to 4pm
Rooftop System Design Options

Design Criteria and Assumptions

- Flat roof edge setbacks are at 6’
- Tilted roof setbacks have 3’ edge and ridge setbacks
- Tilted roof systems were designed using an Ironridge rail system
- Two layouts were done for flat roofs:
  - Everst D-Dome: East-west system
  - Unirac RM5: South facing fixed tilt system
- Size and height of rooftop equipment are estimated
- Production values are estimated with PVWatts
- Ballast and weight calculations are from each racking manufacturers respective online tools
- Costs are rough estimates and are subject to change
Everest D Dome Railless²
Dual Tilt System

Unirac RM5
Fixed Tilt System

IronRidge Flush Mount Rail System
Unirac and Flush Mount, Full Layout

Totals
- Modules: 3,765
- DC Power: 1,129.50 kWdc
- AC Power: 941.25 kWac
- Energy Prod: 1,299,728 kWhr
Unirac and Flush Mount, Recommended Layout

**Totals**
- Modules: 3,330
- DC Power: 999.00 kWdc
- AC Power: 832.50 kWac
- Energy Prod: 1,172,198 kWhr

**Color Key**
- Red – Arrays removed due to poor azimuth/production
Unirac and Flush Mount, Recommended Layout with Tree Shade

Totals
- Modules: 2,338
- DC Power: 701.40 kWdc
- AC Power: 584.50 kWac
- Energy Prod: 827,303 kWhr

Color Key
- **Red** – Arrays removed due to poor azimuth/production
- **Purple** – Arrays removed due to shading from trees
- **Blue** – Arrays reduced in size due to shading from trees
Unirac Racking PSF’s
Everest and Flush Mount, Full Layouts

Totals
Modules: 4,042
DC Power: 1,212.6 kWdc
AC Power: 1,010.5 kWac
Energy Prod: 1,359,603 kWhr
Everest and Flush Mount, Recommended Layouts

| Modules: 3,607 | DC Power: 1,082.10 kWdc |
| AC Power: 901.75 kWac | Energy Prod: 1,240,005 kWhr |

**Color Key**
- Red – Arrays removed due to poor azimuth/production
**Total**

- Modules: 2,568
- DC Power: 770.40 kWdc
- AC Power: 642.00 kWac
- Energy Prod: 891,158 kWhr

---

**Color Key**

- **Red** – Arrays removed due to poor azimuth/production
- **Purple** – Arrays removed due to shading from trees
- **Blue** – Arrays reduced due to shading from trees
Canopy Design

Design Criteria and Assumptions

• Canopy will consist of two flat planes that tilt towards the center (similar to a shallow “v”)
• Canopy tilt will be 5°
• Center of canopy will be aligned with medians
  • This is done so water and snow shedding happen in a less traveled area
• Canopy is 20’ high above grade
RBI Inverted Parking Canopy

Inverted Truss Solution

<7° tilts standard (other tilts available upon request)
Parking Canopies, Standard 72 Cell Module

**Totals**
- Modules: 1,614
- DC Power: 556.83 kWdc
- AC Power: 464.03 kWac
- Energy Prod: 636,022 kWhr
## Preliminary Cost Estimate

### Roof Mount Systems

<table>
<thead>
<tr>
<th></th>
<th>Option 1 - Unirac &amp; Flush Mount</th>
<th>Option 2 - Everest &amp; Flush Mount</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Size (kWdc) Total Prod. (kWhr)</td>
<td>Price per Watt Total Price</td>
</tr>
<tr>
<td>Full System Layout</td>
<td>1,129.50 1,299,728</td>
<td>$4.50 - $5.50 $4,518,000 - $5,082,750</td>
</tr>
<tr>
<td>System w/o North &amp; Shade Modules</td>
<td>701.40 827,303</td>
<td>$4.50 - $5.50 $2,805,600 - $3,156,300</td>
</tr>
</tbody>
</table>

### Parking Canopy

<table>
<thead>
<tr>
<th></th>
<th>Total Prod. (kWhr)</th>
<th>Price per Watt Total Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>Size (kWdc)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>556.83</td>
<td>636022</td>
<td>$5.00 - $5.50 $2,784,150 - $3,062,565</td>
</tr>
</tbody>
</table>
Lumos Solar Modules

- Lumos modules are frameless, double-glass solar modules
- There are perfect for facades, walkway canopies and trellis structures
- Glass on both sides allows light to penetrate through to the area below
  - Density of cells in module can be modified to allow more light through
- Final structure can be made to be waterproof
- Modules do have a premium price associated with them
The Basics of SMART Program

- The SMART program pays the owner of the PV system for every kWhr that is generated by the PV system.
- The all-in incentive rate is made up of two components: a base rate and adders.
- The SMART program does not modify or interfere with the net-metering program.
- SMART Program will support 1600 MW of Solar in Massachusetts. This 1600MW of capacity has been divided among utilities based their historic usage
  - Only investor owned utilities are part of the SMART program (National Grid, Eversource & Unitil)
- Each utility will break down their allocated capacity into 8 equal sized blocks
- Once a block is filled with applicable solar projects, the base incentive rate will decline by 4% for the next block
- SMART program is currently scheduled to start at the beginning of September
### Solar Capacity Per Utility

<table>
<thead>
<tr>
<th>Distribution Company</th>
<th>2016 Distribution Load (MWh)</th>
<th>% Share of 2016 Distribution Load</th>
<th>Total MW AC Available Under SMART</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fitchburg Gas &amp; Electric d/b/a Unitil</td>
<td>462,444</td>
<td>1.0%</td>
<td>15.788</td>
</tr>
<tr>
<td>Massachusetts Electric d/b/a National Grid</td>
<td>21,094,198</td>
<td>45.0%</td>
<td>720.178</td>
</tr>
<tr>
<td>Nantucket Electric d/b/a National Grid</td>
<td>176,964</td>
<td>0.4%</td>
<td>6.042</td>
</tr>
<tr>
<td>NSTAR d/b/a Eversource Energy</td>
<td>21,443,702</td>
<td>45.8%</td>
<td>732.110</td>
</tr>
<tr>
<td>WMECO d/b/a Eversource Energy</td>
<td>3,687,124</td>
<td>7.9%</td>
<td>125.882</td>
</tr>
<tr>
<td>Total</td>
<td>46,864,432</td>
<td>100.0%</td>
<td>1,600.000</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Distribution Company</th>
<th>Block 1</th>
<th>Block 2</th>
<th>Block 3</th>
<th>Block 4</th>
<th>Block 5</th>
<th>Block 6</th>
<th>Block 7</th>
<th>Block 8</th>
<th>Total 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fitchburg Gas &amp; Electric d/b/a Unitil</td>
<td>3.947</td>
<td>3.947</td>
<td>3.947</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>15.788</td>
</tr>
<tr>
<td>Massachusetts Electric d/b/a National Grid</td>
<td>90.022</td>
<td>90.022</td>
<td>90.022</td>
<td>90.022</td>
<td>90.022</td>
<td>90.022</td>
<td>90.022</td>
<td>90.022</td>
<td>720.178</td>
</tr>
<tr>
<td>Nantucket Electric d/b/a National Grid</td>
<td>3.021</td>
<td>3.021</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>6.042</td>
</tr>
<tr>
<td>NSTAR d/b/a Eversource Energy</td>
<td>91.514</td>
<td>91.514</td>
<td>91.514</td>
<td>91.514</td>
<td>91.514</td>
<td>91.514</td>
<td>91.514</td>
<td>91.514</td>
<td>732.110</td>
</tr>
<tr>
<td>WMECO d/b/a Eversource Energy</td>
<td>15.735</td>
<td>15.735</td>
<td>15.735</td>
<td>15.735</td>
<td>15.735</td>
<td>15.735</td>
<td>15.735</td>
<td>15.735</td>
<td>125.882</td>
</tr>
</tbody>
</table>
## SMART Program Base Rates

### NSTAR d/b/a Eversource Energy

<table>
<thead>
<tr>
<th>Project Size</th>
<th>Base Rate Multiplier</th>
<th>Term Length</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low income less than or equal to 25 kW AC</td>
<td>230%</td>
<td>10-year</td>
<td>$0.39100</td>
<td>$0.37536</td>
<td>$0.36035</td>
<td>$0.34593</td>
<td>$0.33209</td>
<td>$0.31881</td>
<td>$0.30606</td>
<td>$0.29382</td>
</tr>
<tr>
<td>Less than or equal to 25 kW AC</td>
<td>200%</td>
<td>10-year</td>
<td>$0.34000</td>
<td>$0.32640</td>
<td>$0.31334</td>
<td>$0.30081</td>
<td>$0.28878</td>
<td>$0.27723</td>
<td>$0.26614</td>
<td>$0.25549</td>
</tr>
<tr>
<td>Greater than 25 kW AC to 250 kW AC</td>
<td>150%</td>
<td>20-year</td>
<td>$0.25500</td>
<td>$0.24480</td>
<td>$0.23501</td>
<td>$0.22561</td>
<td>$0.21658</td>
<td>$0.20792</td>
<td>$0.19960</td>
<td>$0.19162</td>
</tr>
<tr>
<td>Greater than 250 kW AC to 500 kW AC</td>
<td>125%</td>
<td>20-year</td>
<td>$0.21250</td>
<td>$0.20400</td>
<td>$0.19584</td>
<td>$0.18801</td>
<td>$0.18049</td>
<td>$0.17327</td>
<td>$0.16634</td>
<td>$0.15968</td>
</tr>
<tr>
<td>Greater than 500 kW AC to 1,000 kW AC</td>
<td>110%</td>
<td>20-year</td>
<td>$0.18700</td>
<td>$0.17952</td>
<td>$0.17234</td>
<td>$0.16545</td>
<td>$0.15883</td>
<td>$0.15247</td>
<td>$0.14638</td>
<td>$0.14052</td>
</tr>
<tr>
<td>Greater than 1,000 kW AC to 5,000 kW AC</td>
<td>100%</td>
<td>20-year</td>
<td>$0.17000</td>
<td>$0.16320</td>
<td>$0.15667</td>
<td>$0.15041</td>
<td>$0.14439</td>
<td>$0.13861</td>
<td>$0.13307</td>
<td>$0.12775</td>
</tr>
</tbody>
</table>
## Summary of Compensation Rate Adder Values by Type and Adder Tranche

<table>
<thead>
<tr>
<th>Adder Type</th>
<th>Generation Unit Type</th>
<th>Adder Tranche 1 (80 MW)</th>
<th>Adder Tranche 2 (TBD)</th>
<th>Adder Tranche 3 (TBD)</th>
<th>Adder Tranche 4 (TBD)</th>
<th>Adder Tranche 5 (TBD)</th>
<th>Adder Tranche 6 (TBD)</th>
<th>Adder Tranche 7 (TBD)</th>
<th>Adder Tranche 8 (TBD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Location Based</td>
<td>Building Mounted Solar Tariff Generation Unit</td>
<td>$0.02000</td>
<td>$0.01920</td>
<td>$0.01843</td>
<td>$0.01769</td>
<td>$0.01699</td>
<td>$0.01631</td>
<td>$0.01566</td>
<td>$0.01503</td>
</tr>
<tr>
<td></td>
<td>Floating Solar Tariff Generation Unit</td>
<td>$0.03000</td>
<td>$0.02880</td>
<td>$0.02765</td>
<td>$0.02654</td>
<td>$0.02548</td>
<td>$0.02446</td>
<td>$0.02348</td>
<td>$0.02254</td>
</tr>
<tr>
<td></td>
<td>Solar Tariff Generation Unit on a Brownfield</td>
<td>$0.03000</td>
<td>$0.02880</td>
<td>$0.02765</td>
<td>$0.02654</td>
<td>$0.02548</td>
<td>$0.02446</td>
<td>$0.02348</td>
<td>$0.02254</td>
</tr>
<tr>
<td></td>
<td>Solar Tariff Generation Unit on an Eligible Landfill</td>
<td>$0.04000</td>
<td>$0.03840</td>
<td>$0.03686</td>
<td>$0.03539</td>
<td>$0.03397</td>
<td>$0.03261</td>
<td>$0.03131</td>
<td>$0.03006</td>
</tr>
<tr>
<td></td>
<td>Canopy Solar Tariff Generation Unit</td>
<td>$0.06000</td>
<td>$0.05760</td>
<td>$0.05530</td>
<td>$0.05308</td>
<td>$0.05096</td>
<td>$0.04892</td>
<td>$0.04697</td>
<td>$0.04509</td>
</tr>
<tr>
<td></td>
<td>Agricultural Solar Tariff Generation Unit</td>
<td>$0.06000</td>
<td>$0.05760</td>
<td>$0.05530</td>
<td>$0.05308</td>
<td>$0.05096</td>
<td>$0.04892</td>
<td>$0.04697</td>
<td>$0.04509</td>
</tr>
<tr>
<td>Off-taker Based</td>
<td>Community Shared Solar Tariff Generation Unit</td>
<td>$0.05000</td>
<td>$0.04800</td>
<td>$0.04608</td>
<td>$0.04424</td>
<td>$0.04247</td>
<td>$0.04077</td>
<td>$0.03914</td>
<td>$0.03757</td>
</tr>
<tr>
<td></td>
<td>Low Income Property Solar Tariff Generation Unit</td>
<td>$0.03000</td>
<td>$0.02880</td>
<td>$0.02765</td>
<td>$0.02654</td>
<td>$0.02548</td>
<td>$0.02446</td>
<td>$0.02348</td>
<td>$0.02254</td>
</tr>
<tr>
<td></td>
<td>Low Income Community Shared Solar Tariff Generation Unit</td>
<td>$0.06000</td>
<td>$0.05760</td>
<td>$0.05530</td>
<td>$0.05308</td>
<td>$0.05096</td>
<td>$0.04892</td>
<td>$0.04697</td>
<td>$0.04509</td>
</tr>
<tr>
<td></td>
<td>Public Entity Solar Tariff Generation Unit</td>
<td>$0.02000</td>
<td>$0.01920</td>
<td>$0.01843</td>
<td>$0.01769</td>
<td>$0.01699</td>
<td>$0.01631</td>
<td>$0.01566</td>
<td>$0.01503</td>
</tr>
<tr>
<td>Energy Storage</td>
<td>Energy Storage Adder</td>
<td>Variable</td>
<td>Variable</td>
<td>Variable</td>
<td>Variable</td>
<td>Variable</td>
<td>Variable</td>
<td>Variable</td>
<td>Variable</td>
</tr>
<tr>
<td>Solar Tracking</td>
<td>Solar Tracking Adder</td>
<td>$0.01000</td>
<td>$0.00960</td>
<td>$0.00922</td>
<td>$0.00885</td>
<td>$0.00849</td>
<td>$0.00815</td>
<td>$0.00783</td>
<td>$0.00751</td>
</tr>
</tbody>
</table>
Lincoln is in Evesource territory, thus the block 1 base compensation rate is 0.17 $/kWhr

Block 1 and 2 are expected to fill up quickly, it is likely these projects would be submitted for block 3 or 4 which have a base compensation rate of $0.15667 and $0.15041 respectively

The proposed solar at the Ballfield Campus would consist of roof mounted solar arrays as well as solar on parking canopy structures

Project could qualify for a building mounted adder and a parking canopy adder

Each adder would only apply to the kWhr generated from each portion of the system that satisfies that adder

If the project is owned by or 100% of the electricity is credited to a public entity, then the project could qualify for the public entity adder as well
Excess Electricity from the Ballfield Campus

- Excess electricity from behind-the-meter solar systems historically has been net metered
  - Under net metering, excess electricity is credited to the host customer’s bill
- There are set capacities for net metering and once filled no other projects can apply
- Currently, in Eversource territory, there is 101.31MW left under the private cap and 181.94MW left under the public cap
- It is not known if there will still be capacity left when these projects are built
- If there is no net metering cap left when these solar arrays are built, they can export excess electricity as a qualifying facility
  - A qualifying facility is alternate way of exporting energy onto the grid from a renewable energy system. Additionally there are no caps for qualifying facilities. However the financial compensation is much less compared to net metering
  - But with the SMART program, the economic differences between net metering and a qualifying facility will be eliminated
Commonly Used Terms

- **Kilowatt-hour**: abbreviated as kWhr, unit of energy equivalent to one kilowatt of power being delivered for 1 hour
  - If you have a 1kW generator and have it run at full capacity for 1 hour, then it will have delivered 1 kWhr of energy
  - A 60 watt light bulb that has been on for 1 hour will have used 60 watt-hours of energy

- **kWdc**: Power rating of the DC side of a solar system, same as the nameplate capacity of aggregate of the solar panels

- **kWac**: Power rating of the AC side of a solar system, same as the nameplate capacity of the aggregate of the inverters

- **Standalone System**: A PV system is connected directly to utility distribution network and requires a new meter specifically for the PV system. This system does not serve any electrical load.

- **Behind-the-Meter**: PV system that is interconnected behind an existing utility meter, usually on a building’s main distribution panel. The electricity from the PV system feeds existing loads in the building before any excess is exported to the utility

- **Net Metering**: A program in Mass where any excess energy from a system is credited to the host customers electrical account
  - Excess electricity can also be credited to other electrical account(s) apart from the host customer’s account

- **Net Metering Credit**: A dollar value credit equal to the retail rate of electricity
  - Since April 2016, for most net metering systems, their excess kWhr’s have had their credit rate reduced by 40%

- **Retail Rate of Electricity**: Sum of the per kWhr charges a utility charges their customers, does not include monthly customer fee or demand charges
  - On your electric bill you’ll see charges called transmission, transition, distribution and basic service charge