

### Allies for Efficiency: Daimler Trucks North America

October 13, 2016





## About Energy Trust

- Independent nonprofit
- Serving 1.5 million customers of Portland General Electric, Pacific Power, NW Natural and Cascade Natural Gas
- Providing access to affordable energy
- Generating homegrown, renewable power
- Building a stronger Oregon and SW Washington



# New Buildings Events

### Allies for Efficiency Training Series (AFE)

- Trainings on high-performance design and construction
- Takes place 3 times per year in Portland + regional events
- Registration priority for New Buildings Program Allies

### AFE 2.0

- Advanced training series for designers and architects
- Takes place 2 3 times per year
- Content is focused on specific techniques or technologies

### **Building Energy Simulation Forum (BESF)**

- Advance energy modeling presentations
- Takes place every other month

# Upcoming Allies for Efficiency Trainings

**December 7: Allies for Efficiency 2.0** *High Performance Design in Oregon* Portland, OR

Presenting two regional case studies, energy efficiency and design at Cowhorn Vineyard and Unitarian Universalist Fellowship of Central Oregon





# Upcoming Building Energy Simulation Forum Trainings

BESF takes place the third Wednesday of every other month at the Ecotrust Building at noon.

- October 19: "Understanding Building Infrastructure and Energy Efficiency Through the Department of Energy's Asset Score Tool"
- December 14: \*Date Changed\*
  NREL Open Studio Presentation





# **Training & Education Webpage**

## energytrust.org/commercial/training-and-events/



# Net Zero Fellowship

- Up to two fellowship grants, not to exceed a combined total of \$50,000, to support net-zero energy research over 12 to18 months
- Funding for new research to advance design best practices, technologies and policies, and the overall net-zero community in Oregon
- Application deadline January 9, 2017
- Learn more at energytrust.org/zero



# **Questions?**

Have questions about upcoming training and education opportunities *or* about becoming an Energy Trust New Buildings Ally?

Contact Amanda.Davidowitz@clearesult.com



# Allies for Efficiency: Daimler Trucks North America

Presentation 2:30-4:00 p.m.

- Matthew Markstaller, Real Estate
  Manager, Daimler Trucks North America
- Michael Great, Managing Principal, Connie Hotovec, Associate, and Jeff Wilder, Senior Associate - Ankrom Moisan Architects
- Mitchell Dec, Associate Principal, Glumac

Building Tour 4:00 – 5:00 p.m.







# Allies for Efficiency: Daimler Trucks North America



Learning Objectives:

- Understand how the collaborative process with the design team and building owner led to effective decision-making strategies and a successful project.
- Learn how early energy analysis impacted the orientation, site placement and occupant health of the building.
- Learn how the design team created synergies between building systems to meet the RFP requirements. The course will cover how parametric analysis of envelope systems, HVAC energy consumption, thermal comfort, indoor air quality, and onsite renewable energy were utilized together.
- See how the design team and owners evaluated the building's performance during the post-occupancy measurement and verification period.
- Learn important tips for designing around dedicated outside air systems with radiant comfort systems in the occupied space.

## Thank You

Amanda Davidowitz Market Outreach Specialist Amanda.Davidowitz@clearesult.com



## **Daimler Trucks North America – Corp HQ**



October 13, 2016

# A Subsidiary of Daimler AG





#1 Heavy and Medium Duty Truck Manufacturer in NAFTA

## Energy efficiency is at the core of our business, we offer the most fuel efficient truck on the road

### **Freightliner Cascadia Evolution**





# Today's Freightliner Cascadia is 17.2% more fuel efficient than in 2010, largely due to an integrated powertrain

#### Fuel Consumption - Portland to Pendelton route

average miles per gallon





## Daimler Trucks North America We bring the materials to your buildings...efficiently!



It only makes sense that our buildings are efficient and sustainable too

**Daimler Trucks** 

# LEED Platinum exemplifies our commitment to waste-free, resource-optimized and $CO_2$ -neutral production

### Only 6% of LEED certified buildings have achieved Platinum



### **Project Achievements**

- Will be in the top 1% in energy efficient office buildings nationwide
- 96% of materials during demolition kept out of landfill
- 13% of entire building energy use will be powered from onsite renewable energy

## **Project Aspirations**

- Deliver an environmentally friendly and efficient building that aligns with DTNA's market position as the technology and fuel efficiency leader.
- Achieve LEED Platinum Certification.
- Send a strong and positive message to the public about DTNA's presence in Portland and serves as a vehicle to attract and retain top talent.
- Deliver an aesthetically exceptional and state-of-the-art building that contains workspaces and amenities that encourage and enhance employee/management productivity, collaboration and job satisfaction.

## Going green is a good investment

### **Efficient Technologies Used:**

- Highly efficient HVAC with dedicated outside air system
- Alternative energy such as solar hot water and solar panels
- Low water use fixtures
- LED lighting and daylight controls
- Radiant slab floor
- Green roof to reduce heat generation and manage storm water
- Green building and finish materials



Impact: \$200,000 per year in savings relative to a new building under today's code, and substantial savings relative to existing headquarter building

Features and attributes that contribute to employees' health, satisfaction and productivity:

- Ample natural light and access to outdoor spaces
- Smart HVAC systems to heat and cool discrete spaces (not a one size fits all approach)
- Low VOC emitting paint, carpet and furniture
- A multitude of different types of spaces where employees can work ("your workspace is no longer just your desk")
- Cubicle areas in small "pods" or "communities" limited to 16-18 people
- Comfortable and ergonomic furniture, including sit to stand desks
- Intelligent outdoor air delivery
- Fitness room & interior bike storage



### Project Nova





## DAIMLER TRUCKS NORTH AMERICA

ALLIES FOR EFFICIENCY PRESENTATION

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TYPICAL TOWER FLOORPLAN



### Modeled vs. Actual Office Building Performance



GLUMAC engineers for a sustainable future

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### **ASHRAE 90.1 Baseline System Definition**

TABLE G3.1.1A Baseline HVAC System Types						
Building Type	Fossil Fuel, Fossil/Electric Hybrid, and Purchased Heat	Electric and Other				
Residential	System 1—PTAC	System 2—PTHP				
Nonresidential and 3 Floors or Less and <25,000 ft <sup>2</sup>	System 3—PSZ-AC	System 4—PSZ-HP				
Nonresidential and 4 or 5 Floors and <25,000 ft <sup>2</sup> or 5 Floors or Less and 25,000 ft <sup>2</sup> to 150,000 ft <sup>2</sup>	ential and 4 or 5 Floors and $<25,000 \text{ ft}^2 \text{ or}$ ors or Less and 25,000 ft <sup>2</sup> to 150,000 ft <sup>2</sup> System 5—Packaged VAV with Reheat					
Nonresidential and More than 5 Floors or >150,000 ft <sup>2</sup>	System 7—VAV with Reheat	System 8—VAV with PFP Boxes				

#### Notes:

Residential building types include dormitory, hotel, motel, and multifamily. Residential space types include guest rooms, living quarters, private living space, and sleeping quarters. Other building and space types are considered nonresidential.

Where no heating system is to be provided or no heating energy source is specified, use the "Electric and Other" heating source classification.

Where attributes make a building eligible for more than one baseline system type, use the predominant condition to determine the system type for the entire building.

For laboratory spaces with a minimum of 5000 cfm of exhaust, use system type 5 or 7 and reduce the exhaust and makeup air volume to 50% of design values during unoccupied periods. For all-electric buildings, the heating shall be electric resistance.



### **ASHRAE 90.1 Baseline System Definition**

System No.	System Type	Fan Control	Cooling Type	Heating Type
1. PTAC	Packaged terminal air conditioner	Constant volume	Direct expansion	Hot-water fossil fuel boiler
2. PTHP	Packaged terminal heat pump	Constant volume	Direct expansion	Electric heat pump
3. PSZ-AC	Packaged rooftop air conditioner	Constant volume	Direct expansion	Fossil fuel furnace
4. PSZ-HP	Packaged rooftop heat pump	Constant volume	Direct expansion	Electric heat pump
5. Packaged VAV with Reheat	Packaged rooftop VAV with reheat	VAV	Direct expansion	Hot-water fossil fuel boiler
6. Packaged VAV with PFP Boxes	Packaged rooftop VAV with reheat	VAV	Direct expansion	Electric resistance
7. VAV with Reheat	Packaged rooftop VAV with reheat	VAV	Chilled water	Hot-water fossil fuel boiler
8. VAV with PFP Boxes	VAV with reheat	VAV	Chilled water	Electric resistance





## **Energy Use Comparisons**



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### **Energy Efficiency Measures – Decision Making**

Energy Encloses      Neurose for Constitution      Exercer Val      13,867      3,765      55,400      1.6%        1A      Increase will includion caloring and private of 0.00. Constitution within the same of the same of same or s	EEM#	Individual Energy Efficiency Measure	Location	See Note #	Additional Electricity Savings <sup>6</sup> (kWh/yr)	Additional Natural Gas Savings <sup>6</sup> (therms/yr)	Additional Energy Cost Savings	Additional Energy Cost Percent Savings <sup>7</sup>
11.4      Increase well and/or to achieve and or adde of 0.8.9. Constructions would be adde of 0.9.9. Constructions would be adde of 0.9.9.1. Constructions would be adde of 0.9.1. Constructio	Energy Efficiency	Measures for Consideration						
Bit is a problem of a set and a schlere an overall U-able of 0.000. Construction works and used of the analysis of 1-1 bit	1A	Increase wall insulation to achieve an overall U-value of 0.048. Construction would utilize 2.5* of XPS exterior of steel studs and R-13 batt insulation within the steel stud.	Exterior Wall		13,967	3,785	\$5,490	1.6%
Increase will includent in achieral under low and order low and order low and increase will includent in achiera in overall low and increase will includent in achiera in overall low and increase will includent in achiera in overall low and increase will increase will include the R-D continuous includion over of deck.      Rod      Bod      Bod <td>1B</td> <td>Increase wall insulation to achieve an overall U-value of 0.040. Construction would utilize 2.5° of polystyrene exterior of steel studs and R-13 batt insulation within the steel stud.</td> <td>Exterior Wall</td> <td></td> <td>16,761</td> <td>5,442</td> <td>\$7,578</td> <td>2.2%</td>	1B	Increase wall insulation to achieve an overall U-value of 0.040. Construction would utilize 2.5° of polystyrene exterior of steel studs and R-13 batt insulation within the steel stud.	Exterior Wall		16,761	5,442	\$7,578	2.2%
Abs      Increase ord installants in R-30 cantinuous installation over ord leck.      Rod      9.078      (3.247)      (3.240)      (1.054)        26      Increase ord installants in R-40 continuous installation over ord leck.      Rod      9.078      2.297      53.911      1.1%        31.      Specific installation in R-40 continuous installation over ord leck.      Rodo      2.0532      3.266      \$5.543      1.984        32.      Rodox instand installation over ord leck.      Windows      2.0532      3.266      \$5.543      1.984        33.      Rodox instand installation over ordination over ordination over ordination installation over ordination o	1C	Increase wall insulation to achieve an overall U-value of 0.029. Construction would utilize 1° of Dow Corning Vacuum Insulated Panel (VIP) insulation within curtainwall assembly.	Exterior Wall		19,582	7,267	\$9,854	2.8%
Base      Increase roll mutation to R -0 continuous insulation ever nod deck.      Rodf      Rodf      2.37      \$3.400      1.0%        2C      breases not insulation to R -0 continuous insulation ever nod deck.      Rodf      111,103      2.597      \$3.911      1.1%        3A      preases not insulation ever nod deck.      Rodf      2.0512      3.266      \$5.543      1.6%        3A      prease not insulation ever consult ever nod states in bother social even of the insulation even of the insulatis even even of the insulatis even even of the insulatio	2A	Increase roof insulation to R-30 continuous insulation over roof deck.	Roof		8,062	1,947	\$2,908	0.8%
2C      Increase root insulation to R-80 continuous insulation new root dock.      Root      11,103      2.597      \$3,911      1.1%        3A      Sectors writed Vursion Fon A6 to 0.32 using thy thermal branks in tocking insure with ensistic in a thermal branking in minum thanks in tocking in minum thanks in the FCO SSOC.      Windows      50,716      10,731      \$17,477      5.0%        3C      tracking in program thanks in tocking in minum thanks in the FCO SSOC.      Windows      50,716      10,731      \$17,477      5.0%        4A      Robice windows      73,996      -1,662      \$5,201      1.5%        4B      Robice service of the application of the application of to 2.2 (PFG Solathan      Windows      73,996      -1,662      \$5,201      1.5%        5B      Robice service of the Size 2.07 or 10,22 (PFG Solathan      Windows      98,861      -2,218      \$8,435      7.0%        6      reploremark in size 0.70 or 0,216 werges for offices. <td>2B</td> <td>Increase roof insulation to R-40 continuous insulation over roof deck.</td> <td>Roof</td> <td></td> <td>9,678</td> <td>2,337</td> <td>\$3,490</td> <td>1.0%</td>	2B	Increase roof insulation to R-40 continuous insulation over roof deck.	Roof		9,678	2,337	\$3,490	1.0%
Reduce wiredu Uvalue from 0.4 to 0.38 using fully memal Instails in double SOCX entimient and intercept ages (-Consider products such as EFCO SOCX entimient and intercept ages (-Consider products such as EFCO SOCX entimient and intercept ages (-Consider products such as EFCO SOCX entimient ages (-Consider productsuch ages (-Consider products such as EFCO SOCX entimient ages (-C	2C	Increase roof insulation to R-50 continuous insulation over roof deck.	Roof		11,103	2,597	\$3,911	1.1%
Bit      Reduce whole transformed status built curtainwall assendy.      Windows      97,131      6,065      \$10,199      2.9%        Consider whole transformed at the status ball curtainwall assendy.      Windows      97,131      6,065      \$10,199      2.9%        Consider whole transformed at the status ball curtainwall assendy.      Windows      97,131      6,065      \$10,731      \$17,477      5.0%        Consider whole transformed at the status ball curtainwall system.      Status assendy.      Windows      98,716      10,731      \$17,477      5.0%        Consider status assendy.      Consider status assendy.      Status assendy.      Windows      98,661      1-,662      \$50,211      1.5%        Assence and adjusting power density to 0.7 W/SF average for offices.      Lighting      220,477      4,115      \$16,416      4.7%        SB      Reduce overhead ighting power density to 0.7 W/SF average for offices.      Lighting      328,421      -6,738      \$24,443      7.0%        B      Reduce overhead ighting power density to 0.3 W/SF average for offices.      Lighting      328,338      -341      \$3,419      1.0%        8      coccopassencorosto 50 % fortightintes areases.      Light	3A	Reduce window U-value from 0.45 to 0.38 using fully thermal breaks in double pane curtain wall system and intercept spacer. Consider products such as EFCO 5500X curtainwall assembly.	Windows		20,532	3,266	\$5,543	1.6%
Sector      Reduce window U-value from 0.5 to 0.22 using either a fibring lass frame or using or equination	3B	Reduce window U-value from 0.45 to 0.32 using advanced stick built curtainwall system with elimination of all thermal bridging in aluminum frame. Consider products such as Schucco curtainwall assembly.	Windows		37,131	6,065	\$10,199	2.9%
4AReduce SHGC from 0.39 (PPG Solution 10 0.27 (PPG Solution Reduce SHGC from 0.39 (PPG Solution 0.027 (PPG Solution Reduce SHGC from 0.39 (PPG Solution 0.027 (PPG Solution Loss (PGG Solution 0.027 (PPG Solution) Loss (PGG Solution 0.027 (PPG Solution)Windows98,661-1,662\$5,0352,0%5AReduce overhead lighting power density to 0.7 W/SF average for offices. LightingLighting220,447-4,115\$16,4164.7%5BReduce overhead lighting power density to 0.5 W/SF average for offices. UN station plug and reduction - searce for annul on, automatic of controls. LightingLighting335,421-512\$11,1723.2%7Uilize vacancy sensors for all office areas - manual on, automatic of controls. vork station plug and reduction - searce hyphithess and insitu occupancy controled plug strip to shull of non-critical plug loads when employees areaw from threads.Pug Loads100,211-1,744\$7,7922.2%8RefigerationFreezer Energy Use Reduction - use dybub reade on condenser transmature. Advanced VAV with DOAS.Office HVAC346,34718,763\$53,54215.3%108QDAS with Child Salis of Radiant Panels, DOAS served through overhead air databation. Condensing BolenOffice HVAC90,77334,368\$10,76830,7%110Condensing BolenContral Plant23,42116,630\$10,768\$35,4215.8%108QDAS with Child Salis of Radiant Panels, DOAS served through overhead air databation.Office HVAC90,77334,368\$12,4135\$3,4%113Condensing BolenContral Plant	зC	Reduce window U-value from 0.45 to 0.22 using either a fiberglass frame or using triple pane glass within a high perfromance aluminum frame like the EFCO 5500X, or equivalent, curtainvall system	Windows		59,716	10,731	\$17,477	5.0%
4B      Reduce SHGC from 0.38 (PPG Solarban f0 equivalent) to 0.23 (PPG Solarban f0 equivalent) to 0.5 W/SF everage for offices.      Uppting      220.47      4-115      \$16.16      4.7%        5B      Reduce overhead lighting power density to 0.5 W/SF everage for offices.      Lighting      333.421      4-0.738      \$24.453      7.0%        6      Implement daylight dimming controls for the first 20 for all perimeter spaces.      Lighting      339.421      4.738      \$24.453      7.0%        7      Ulitze vacancy sensors for all office areas - manual on, automatic of controlls.      Lighting      39.395      -341      \$3.19      1.0%        8      areaxy from their dest.      Lighting      102.211      -1.744      \$7.792      2.2%        9      temperature, use VPG on compreservicondeneraterial mis, and reject mis, and reje	4A	Reduce SHGC from 0.39 (PPG Solarban 60 equivalent) to 0.27 (PPG Solarban 70XL equivalent).	Windows		73,996	-1,662	\$5,201	1.5%
SAReduce ownehael lighting power density to 0.7 W/SF average for offices.Lighting220,477-4.115S16.4164.7%BBReduce ownehael lighting power density to 0.5 W/SF average for offices.Lighting338.421-6.738S24.4537.0%6Implement dayling diaming controls for the first 20 fail pairneter specification.Lighting123.531-512S11.1723.23.007Ulitz vacancy sensors for all office areas - manual on, automatic off controls.Lighting39.938-341S3.4191.0%8Work station plug lead reduction - set monitors to 50% brightness and install occupancy controlled plug sights when then plug leads when memory are away from their des.No.2,782S20,160S2,782S20,160S2,9769Ridingeation/Frazer Energy Use Reduction - use drybub rest on condenser finant des.Note HVAC346.34718.873S50.54215.3%108DOAS with Chilled Salis or Radiant Panels, DOAS served through ownerhead and differ HVAC90.73329.868S107.66330.7%110Condensing BoliesCondital PanelContral Panel90.873.06S104.6330.7%111Condensing BoliesCondital PanelContral Panel23.612S104.6330.7%112Panelum Efficiency Chiller, Lingeting average efficiency around 0.40.45 W/hot.Central Panel23.612S104.6330.7%113Cooling Linger With PDS and reduced approach.Central Panel23.612S10.8584.8%114To-kW PV Aray (target 10% for EAc2)Romeables <t< td=""><td>4B</td><td>Reduce SHGC from 0.39 (PPG Solarban 60 equivalent) to 0.23 (PPG Solarban R100 equivalent).</td><td>Windows</td><td></td><td>98,661</td><td>-2,216</td><td>\$6,935</td><td>2.0%</td></t<>	4B	Reduce SHGC from 0.39 (PPG Solarban 60 equivalent) to 0.23 (PPG Solarban R100 equivalent).	Windows		98,661	-2,216	\$6,935	2.0%
58Reduce overhead lighting power density to 0.5 W/SF average for offices.Lighting100335.421-6.738\$24.4337.0%6Implement daylight dimming controls for the firs 20 for all perimeter spaces.Lighting20.531-512\$11.1723.2%7Ulilize vacance yearoos for all office areas - manual on automatic of 050% brightees and installLighting39.936-3411\$3.4191.0%8Most station plag bad reduction - set montors to 50% brightees and installFue days for their desk.100.211-1.7.44\$7.7922.2%9Refregeration/Feerz Ferry Use Reduction - use double treat on concenter temperature, use VPDs on compressors/condensers/air units, and reject wasts heat to a hard schanger for kichne domestic hot water preheating.Office HVAC346.347188.763\$53.54215.3%108DOAS with Chiled Salis or Radiant Panels, DOAS served through owerhead air distribution.Office HVAC6346.347188.763\$35.4522.8%110Conferring EditesContral PlantContral Plant8.862\$107.663\$35.74235.4%120Penhium Efficiency Chiler, targeting average efficiency around 0.40.45 KW /no.Central Plant8.862\$8.62\$8.2782.8%131Coofing tower with VFDs and reduced approach.Central Plant8.862\$8.62\$8.2780.6%14340-WV V Aray (target 10% for EAc2)Central Plant8.862\$8.60\$8.282.8%14430-WV V Aray (target 0% for EAc2)Central Plant8.862\$8.	5A	Reduce overhead lighting power density to 0.7 W/SF average for offices.	Lighting		220,447	-4,115	\$16,416	4.7%
6      Implement daylight dimming controls for the first 20 for all perimeter spaces.      Lighting      123,531      -512      \$11,172      3.2%        7      Utilize vacancy sensors for all office areas - manual on, automatic off controls.      Lighting      39,938      -341      \$3,419      1.0%        8      Work station plug load reduction - set monitors to 50% bightness and install occupancy controlled plug strip to shut off non-critical plug loads where employees are away from ther desk.      Pug Loads      102,211      -1,744      \$7,792      2.2%        9      Refrigeration/Freezer Energy Use Reduction - use drybub reset on condense thremperature, use VPC Do no critical plug loads where employees draw for the desk.      100,000      2,782      \$20,160      5.8%        10B      Advanced VAV with DOAS.      Office HVAC      346,347      18,783      \$53,542      15.3%        10B      OAAs with Chilled Salis or Radiant Panels, DOAS served through overhead air distribution.      Office HVAC      908,736      34,368      \$124,135      35.4%        11C      Condensing Bolers      Contral Plant      8,962      \$28,285      2.3%        12      Permium Efficiency around 0.4-0.45 KV/Lon.      Central Plant      8,962      \$38,381      2.3% <tr< td=""><td>5B</td><td>Reduce overhead lighting power density to 0.5 W/SF average for offices.</td><td>Lighting</td><td></td><td>335,421</td><td>-6,738</td><td>\$24,453</td><td>7.0%</td></tr<>	5B	Reduce overhead lighting power density to 0.5 W/SF average for offices.	Lighting		335,421	-6,738	\$24,453	7.0%
7      Utilize vacancy sensors for all office areas - manual on, automatic off controlls.      Lighting      39,936      -341      \$3,419      1.0%        8      occupancy controlled puig total reduction - set monitors to 50% brightness and install are away from their desk.      Puig Loads      102,211      -1.744      \$7,792      2.2%        9      Refigreration/Freezer Energy Use Reduction - use drybub reset on condenser temperature, use VFDs on compressors/condensers/air units, and reject water temperature, use VFDs on compressors/condensers/air units, and reject water distribution.      100,000      2,782      \$20,160      5.8%        108      OOAS with Chilled Salis or Radiant Panels, DOAS served through underfloor air distribution.      Office HVAC      787,135      29,896      \$107,663      30.7%        100      Condensing Bolers      Contral Plant      86,452      \$8,213      2.3%        112      Premium Efficiency Chiller, targeting average efficiency around 0.4-0.45 KW fon.      Central Plant      23,57,000	6	Implement daylight dimming controls for the first 20 for all perimeter spaces.	Lighting		123,531	-512	\$11,172	3.2%
Work station plug load reduction - set monitors to 50% brightness and install are away from their desk.      Pug Loads      102,211      -1,744      \$7,792      2.2%        9      Refrigeration/Freezer Energy Use Reduction - use dybub reset on condenser temperature, use VFDs on compressors/air units, and reject waste heat to a heat exchanger for kitchen domestic hot water preheating.      Mitchen      180,000      2,782      \$20,160      5.8%        10A      Advanced VAV with DOAS.      Office HVAC      346,347      18,763      \$53,542      15.3%        10B      DOAS with Chilled Salis or Radiant Panels, DOAS served through overhead air distribution.      Office HVAC      787,135      29,896      \$107,663      30.7%        10C      DOAS with Chilled Salis or Radiant Panels, DOAS served through underfloor air distribution.      Office HVAC      908,736      34,388      \$124,135      35.4%        11      Conding Bollers      Contral Plant      68,642      \$8,213      2.3%        12      Premium Efficiency Chiller, targeting average efficiency around 0.4-0.45 W/ton.      Central Plant      23,212      \$33,915      9.7%        14B      340-KW PV Array (target 10% for EAc2)      Renewables      357,000      \$33,915      9.7%        17	7	Utilize vacancy sensors for all office areas - manual on, automatic off controlls.	Lighting		39,936	-341	\$3,419	1.0%
Refigeration/Freezer Energy Use Reduction - use drybub reset on condenser temporature, use VFDs on compressors/arunds, and reject waster heat to a heat exchanger for kitchen domestic hot water preheating.      Kitchen      180,000      2,782      \$20,160      5.8%        100      Advanced VAV with DOAS.      Office HVAC      346,347      18,763      \$53,542      15.3%        108      DOAS with Chilled Sails or Radiant Panels, DOAS served through overhead air distribution.      Office HVAC      787,135      29,896      \$107,663      30.7%        100      DOAS with Chilled Sails or Radiant Panels, DOAS served through underfloor air distribution.      Office HVAC      908,736      34,368      \$124,135      35.4%        110      Condensing Dollers      Contral Plant      86,452      \$8,213      2.3%        12      Premium Efficiency Chiller, targeting average efficiency around 0.40.45 kWton.      Central Plant      86,452      \$8,213      2.3%        13      Cooling tower with VFDs and reduced approach.      Central Plant      86,452      \$8,213      2.3%        14A      170-KW PV Array (target 10% for EA.2)      Onsite Renewables      357,000      \$33,915      9.7%        15      400-KW Fuel Cell from ClearEdge Power      Onsite Renew	8	Work station plug load reduction - set monitors to 50% brightness and install occupancy controlled plug strip to shut off non-critical plug loads when employees are away from their desk.	Plug Loads		102,211	-1,744	\$7,792	2.2%
10A      Advanced VAV with DOAS.      Office HVAC      346,347      18,763      \$53,542      15.3%        10B      DOAS with Chilled Sails or Radiant Panels, DOAS served through overhead air distribution.      Office HVAC      787,135      29,896      \$107,663      30.7%        10C      DOAS with Chilled Sails or Radiant Panels, DOAS served through underfloor air distribution.      Office HVAC      908,736      34,368      \$124,135      35.4%        11      Condensing Boliers      Contral Plant      86.652      \$8,213      2.3%        12      Premium Efficiency Chiller, targeting average efficiency around 0.4.0.45 kW/too.      Central Plant      86.452      \$8,213      2.3%        13      Cooling tower with VFDs and reduced approach      Ornsite      787,000      \$12.000      \$56,958      4.8%        148      340-kW PV Arary (target 10% for EA.2)      Ornsite      357,000      \$33,915      9.7%        15      40-kW FV arary (target 20% for EA.2)      Preneum Efficiency Chiller Araget 10%      Central Plant      79,000      12.000      \$56,852      1.8%        16      Ground source heat pump loop to connect central plant heating and cooling.      Central Plant      79,000	9	Refrigeration/Freezer Energy Use Reduction - use drybulb reset on condenser temperature, use VFDs on compressors/condensers/air units, and reject waste heat to a heat exchanger for kitchen domestic hot water preheating.	Kitchen		180,000	2,782	\$20,160	5.8%
U08      DOAS with Chilled Salis or Radiant Panels, DOAS served through overhead air distitution.      Office HVAC      787,135      29,896      \$107,663      30.7%        100      DOAS with Chilled Salis or Radiant Panels, DOAS served through underfloor air distitution.      Office HVAC      908,736      34,368      \$124,135      35.4%        11      Condensing Bolles      Contral Plant      8,862      \$9,858      2.8%        12      Premium Efficiency Chiller, targeting average efficiency around 0.40.46 kW/no.      Central Plant      86,452      \$8,213      2.3%        13      Cooling tower with VFDs and reduced approach.      Central Plant      23,212      \$2,205      0.6%        14A      170-kW PV Array (target 10% for EAc2)      Onsite Renewables      357,000      \$16,958      4.8%        14B      340-kW PV Array (target 20% for EAc2)      Onsite Renewables      357,000      \$33,915      9.7%        15      400-kW Fuel Cell from ClearEdge Power      Onsite Renewables      3153,600      -33,985      \$262,209      74.8%        17      Solar Hot Water - 40 panel array      Central Plant      -79,000      12,000      \$5,695      1.6%        20	10A	Advanced VAV with DOAS.	Office HVAC		346,347	18,763	\$53,542	15.3%
100c distribution.      DOAS with Chilled Salis or Radiant Panels, DOAS served through underfloor air distribution.      Office HVAC      908,736      34,368      \$124,135      35.4%        11      Condensing Bolies      Contral Plant      8,962      \$9.858      2.8%        12      Premium Efficiency Chiller, targeting average efficiency around 0.40.45 kW/non.      Central Plant      86.452      \$8.213      2.3%        13      Cooling tower with VFDs and reduced approach.      Central Plant      23.212      \$2.205      0.6%        14A      170-kW PV Array (target 10% for EAc2)      Onsite Renewables      357,000      \$18,958      4.8%        14B      340-kW PV Array (target 20% for EAc2)      Onsite Renewables      357,000      \$33,915      9.7%        15      400-kW Fuel Cell from ClearEdge Power      Onsite Generation      3,153,600      -33,985      \$262,209      74.8%        17      Solar Hot Water - 40 panel array      Central Plant      -79,000      12,000      \$5,695      1.6%        20      Low Flow Flumbing Fixtures (0.5 gpm lav sinks, 1.5 gpm showers for bike 20      Dentral Plant      -2,894      \$3,183      0.9%        21      Condensing Domest	10B	DOAS with Chilled Sails or Radiant Panels, DOAS served through overhead air distribution.	Office HVAC		787,135	29,896	\$107,663	30.7%
11      Condensing Boliers      Contral Plant      end      8,962      \$9,858      2.8%        12      Premium Efficiency Chiller, targeting average efficiency around 0.4.0.45 kW/no.      Central Plant      86,452      \$8,213      2.3%        13      Cooling tower with VFDs and reduced approach.      Central Plant      23,212      \$2,205      0.6%        14A      170-kW PV Array (target 10% for EAc2)      Onsite Renewables      178,500      \$16,958      4.8%        14B      340-kW PV Array (target 20% for EAc2)      Onsite Renewables      357,000      \$33,955      9.7%        15      400-kW Fuel Cell from ClearEdge Power      Onsite Generation      3,153,600      -33,985      \$262,209      74.8%        16      Ground source heat pump loop to connect central plant heating and cooling.      Central Plant      -79,000      12,000      \$5,695      1.6%        17      Solar Hot Water - 40 panel array      Central Plant      -79,000      12,000      \$5,695      1.6%        20      Low Flow Flumbing Fixtures (0.5 gpm lav sinks, 1.5 gpm showers for bike commuters)      DHW      1,960      \$2,156      0.6%        20      Low Flow Flumbing Fixtures (0.5	10C	DOAS with Chilled Sails or Radiant Panels, DOAS served through underfloor air distribution.	Office HVAC		908,736	34,368	\$124,135	35.4%
12      Premium Efficiency Chiller, targeting average efficiency around 0.40.45 kW/ton.      Central Plant      86.452      \$8.213      2.3%        13      Cooling tower with VFDs and reduced approach.      Ornite      23.212      \$2.205      0.6%        14A      170-kW PV Array (target 10% for EAc2)      Onsite      23.212      \$2.205      0.6%        14B      340-kW PV Array (target 20% for EAc2)      Onsite      357.000      \$33.915      9.7%        15      400-kW Fuel Cell from ClearEdge Power      Onsite      357.000      -33.985      \$262.209      74.8%        16      Ground source hest pump loop to connect central plant heating and cooling.      Central Plant      -79.000      12.000      \$55.685      1.6%        17      Solar Hot Water - 40 panel array      Onsite      Onsite      6.500      \$7.150      2.0%        18      Sever Heat Recovery      Central Plant      1.960      \$2.168      0.6%        20      Low Flow Plumbing Fixtures (0.5 gm lav sinks, 1.5 gm showers for bike commuters)      DHW      1.960      \$2.168      0.6%        20      Low Flow Plumbing Fixtures (0.5 gm lav sinks, 1.5 gm showers for bike commuters)      DHW	11	Condensing Boilers	Contral Plant			8,962	\$9,858	2.8%
13    Cooling tower with VFDs and reduced approach    Central Plant    23.212    \$2.205    0.6%      14A    170-KW PV Array (target 10% for EAc2)    Onsite Renewables    178,500    \$18,958    4.8%      14B    340-KW PV Array (target 20% for EAc2)    Onsite Renewables    357,000    \$33,915    \$33,915    9.7%      15    400-KW Fuel Cell from ClearEdge Power    Onsite Generation    3,153,600    33,985    \$262,209    74.8%      16    Ground source heat pump loop to connect central plant heating and cooling.    Central Plant    -79,000    12,000    \$5,685    1.6%      17    Solar Hot Water - 40 panel array    Onsite Renewables    6,500    \$7,150    2.0%      18    Sever Heat Recovery    Central Plant    -79,000    1960    \$2,156    0.6%      20    Condensing Domestic Hot Water Heaters    DHW    1960    \$2,156    0.6%      20    Condensing Domestic Hot Water Meaters    DHW    2.492    \$2,711    0.8%      116    Steware Heat Recovery    Demoters of DM with 108    -    1,150,617    28,016    \$140,126    40,0%      20    Comfering	12	Premium Efficiency Chiller, targeting average efficiency around 0.4-0.45 kW/ton.	Central Plant		86,452		\$8,213	2.3%
14A      170-KW PV Aray (target 10% for EAc2)      On Stell Ranewables      178,500      \$16,958      4.8%        14B      340-KW PV Aray (target 20% for EAc2)      On site Ranewables      357,000      \$33,915      9,7%        115      40-KW Fuel Cell from ClearEdge Power      On site Generation      3,153,600      -33,985      \$262,209      74,8%        16      Ground source heat pump loop to connect central plant heating and cooling.      Central Plant      -79,000      12,000      \$56,895      1.6%        17      Solar Hot Water - 40 panel array      On site Ranewables      6.500      \$71,150      2.0%        18      Sewer Heat Recovery      Central Plant      -79,000      12,000      \$56,955      1.6%        19      Condensing Domestic Hot Water Heaters      DHW      -      2.894      \$3,183      0.9%        20      Low Flow Plumbing Future (0.5 gpm law sinks, 1.5 gpm showers for bike Contral Plant      1.960      \$2,156      0.6%        20      Low Flow Plumbing Future (0.5 gpm law sinks, 1.5 gpm showers for bike Contral Plant      1.960      \$2,156      0.6%        20      Low Flow Plumbing Future (0.5 gpm law sinks, 1.5 gpm showers for bike Contrule (0.5 gpm la	13	Cooling tower with VFDs and reduced approach	Central Plant		23,212		\$2,205	0.6%
148      340	14A	170-kW PV Array (target 10% for EAc2)	Renewables		178,500		\$16,958	4.8%
15      400-kW Fuel Cell from ClearEdge Power      Onsite Generation Generation Generation Generation Certral Plant      3,153,600      3,3,985      \$262,209      74.8%        16      Ground source heat pump loop to connect central plant heating and cooling.      Certral Plant      -79.000      12,000      \$56.695      1.6%        17      Solar Hot Water - 40 panel array      Onsite Renewables      Onsite Renewables      6.500      \$7,150      2.0%        18      Sewer Heat Recovery      Certral Plant      Certral Plant      2.894      \$3,183      0.9%        20      Condensing Domestic Hot Water Heaters      DHW      Certral Plant      2.492      \$2,156      0.6%        20      Conford Pumping Fixtures (0.5 gpm law sinks, 1.5 gpm showers for bike commuters)      DHW      Certral Plant      2.492      \$2,156      0.6%        10      Conford Pumping Fixtures (0.5, gpm law sinks, 1.5 gpm showers for bike commuters)      DHW      Els 14, 2A, 3A, 4A, 5B, 6, 7, 8, 910A, 11, 12, 13      1.150, 617      2.8,016      \$140,026        B      Package A but replace 10A with 10B	14B	340-kW PV Array (target 20% for EAc2)	Onsite Renewables		357,000		\$33,915	9.7%
16      Ground source heat pump loop to connect central plant heating and cooling.      Central Plant      -79,000      12,000      \$5,695      1.6%        17      Solar Hot Water - 40 panel array      Onsite Renewables      Onsite Renewables      6,500      \$7,150      2.0%        18      Sever Heat Recovery      Central Plant      2.894      \$3,183      0.9%        19      Condensing Domestic Hot Water Heaters      DHW      1.960      \$2,156      0.6%        20      Low Flow Pumbing Fibtures (0.5 gpm lav sinks, 1.5 gpm showers for bike commuters)      DHW      1.960      \$2,156      0.6%        10      EEMs 18, 2A, 3A, 4A, 5B, 6, 7, 8, 9 10A, 11, 12, 13      -      1.150,617      28,016      \$140,126      40.0%        8      Package A but replace 10A with 10B      -      1.525,287      37,479      \$186,129      53,1%        C      Package B but replace 10A with 10C      -      1.628,648      41,280      \$200,130      57.1%        D      Package B + 14A      -      1.703,787      37,479      \$200,087      57.9%	15	400-kW Fuel Cell from ClearEdge Power	Onsite Generation		3,153,600	-33,985	\$262,209	74.8%
17      Solar hot Water - 40 panel array      Offer Renewables Renewables      Offer Renewables      66,500      \$7,150      2.0%        18      Sewer Heat Recovery      Central Plant      2.894      \$3,183      0.9%        19      Condensing Domestic Hot Water Heaters      DHW      1960      \$2,166      0.6%        20      Low Flow Plumbing Flottres (0.5 gpm lav sinks, 1.5 gpm showers for bike commuters)      DHW      106      2,492      \$2,741      0.8%        20      Low Flow Plumbing Flottres (0.5 gpm lav sinks, 1.5 gpm showers for bike commuters)      DHW      1150.617      28,016      \$140,126      0.8%        Notescative combinitions in the design	16	Ground source heat pump loop to connect central plant heating and cooling.	Central Plant		-79,000	12,000	\$5,695	1.6%
18      Sever Heat Recovery      Central Plant      2.894      \$3.183      0.9%        19      Condensing Domestic Hot Water Heaters      DHW      1980      \$2,492      \$2,741      0.8%        20      Low Flow Plumbing Flutures (0.5 gpm lav sinks, 1.5 gpm showers for bike commuters)      DHW      20      \$2,492      \$2,741      0.8%        M      Etem 1A, 2A, 3A, 4A, 5B, 6, 7, 8, 910A, 11, 12, 13      -      1,150,617      28,016      \$140,126      40.0%        B      Package A but replace 10A with 10B      -      1,525,287      37,479      \$186,129      53.1%        C      Package A but replace 10A with 10C      -      1,628,648      41,280      \$20,0130      57.1%        D      Package B + 14A      -      1,882,287      37,479      \$20,043      62.8%	17	Solar Hot Water - 40 panel array	Onsite Renewables			6,500	\$7,150	2.0%
Dot      Flow Flow Plumbing Flotures (0.5 gpm lav sinks, 1.5 gpm showers for bike      DHW      1.300      2.492      \$2,741      0.8%        Interactive combinations in the design      0	18	Sewer Heat Recovery Condensing Domestic Hot Water Heaters	Central Plant DHW			2,894	\$3,183 \$2,156	0.9%
A      EEMs 1A, 2A, 3A, 4A, 5B, 6, 7, 8, 9 10A, 11, 12, 13      -      1,150,617      28,016      \$140,126      40.0%        B      Package A but replace 10A with 10B      -      1,525,287      37,479      \$166,129      53.1%        C      Package A but replace 10A with 10C      -      1,628,648      41.280      \$200,130      57.1%        D      Package B + 14A      -      1,703,787      37,479      \$200,047      57.9%        E      Package B + 14B      -      1,882,287      37,479      \$220,044      62.8%	20	Low Flow Plumbing Fixtures (0.5 gpm lav sinks, 1.5 gpm showers for bike	DHW			2,492	\$2,741	0.8%
A      EEMs 1A, 2A, 3A, 4A, 5B, 6, 7, 8, 9 10A, 11, 12, 13      -      1, 150, 617      28,016      \$140,126      40.0%        B      Package A but replace 10A with 10B      -      1,525,287      37,479      \$188,129      53,1%        C      Package A but replace 10A with 10C      -      1,628,648      41,280      \$200,130      57.1%        D      Package B + 14A      -      1,703,787      37,479      \$200,087      57.9%        E      Package B + 14B      -      1,882,287      37,479      \$220,044      62.8%								
B      Package A but replace 10A with 10B      -      1.525.287      37,479      \$186,292      53.1%        C      Package A but replace 10A with 10C      -      I      1.628,648      41,280      \$200,130      57.1%        D      Package B + 14A      -      I      1.703,787      37,479      \$203,087      57.9%        E      Package B + 14B      -      I      1.882,287      37,479      \$220,044      62.8%	А	EEMs 1A, 2A, 3A, 4A, 5B, 6, 7, 8, 9 10A, 11, 12, 13	-		1,150,617	28,016	\$140,126	40.0%
C      Package A but replace 10A with 10C      -      1,628,648      41,280      \$200,130      57.1%        D      Package B + 14A      -      4      1,703,787      37,479      \$203,087      57.9%        E      Package B + 14B      -      1,882,287      37,479      \$220,044      62.8%	В	Package A but replace 10A with 10B	-		1,525,287	37,479	\$186,129	53.1%
D      Package B + 14A      -      1,703,787      37,479      \$200,087      57.9%        E      Package B + 14B      -      1,882,287      37,479      \$220,044      62.8%	С	Package A but replace 10A with 10C	-		1,628,648	41,280	\$200,130	57.1%
E Package B + 14B - 1.882.287 37.479 \$220.044 62.8%	D	Package B + 14A	-		1,703,787	37,479	\$203,087	57.9%
	E	Package B + 14B	-		1,882,287	37,479	\$220,044	62.8%

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### SOLAR HEAT GAIN AND GLARE STUDIES







### **PV Sizing for 10% Onsite Renewable**



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## **LEED Point Contribution By System**

			Vestas Building	Vestas Building (Actual	Advanced VAV	Advanced VAV	
	Historical Portland Office Building (mix	LEED Version 3	(Modeled Data w/out	Metered Data w/out	with DOAS (Shut	with DOAS (FPBs	DOAS with
nd Use	of VAV, Multizone, and Double Duct)	Baseline Building	PV)	PV)	Off Dampers)	at perimeter)	Radiant/Beams/Sails
pace Heating	37.7	30.2	5.8	11.1	22.6	17.0	4.7
pace Cooling	5.3	4.2	4.6	3.0	3.2	2.7	3.6
ans & Pumps	6.7	6.4	3.5	3.4	5.6	6.6	2.3
ighting	16	11.2	8.8	4.4	4.4	4.4	4.4
Plug Loads	16.4	7.0	7.0	6.0	6.0	6.0	6.0
DHW	1.8	1.8	1.1	1.5	1.1	1.1	1.1
otal w/out PV	83.9	60.7	30.7	29.4	42.9	37.7	22.1
Annual Operating Cost, per sq. ft.	\$ 1.76	\$ 1.17	\$ 0.69	\$ 0.61	\$ 0.79	\$ 0.74	\$ 0.53
EED, EAc1 Percent Savings	n/a	n/a	41%	48%	32%	37%	55%
	10%	PV Offset Contribution -	Assuming 265,000 SF Bui	Iding			
ite Annual Energy Cost			\$ 182,623	\$ 162,559	\$ 209,350	\$ 196,100	\$ 140,450
Annual Electricity Offset Required, kWh			202,915	180,621	232,611	217,889	156,056
V Size Required, kW			193	172	222	208	149
V Area Required, sq. ft.			12,883	11,468	14,769	13,834	9,908
ite Area Required, sq. ft.			25,767	22,936	29,538	27,668	19,817
stimated Cost of PV Array			\$ 1,014,574	\$ 903,103	\$ 1,329,206	\$ 1,245,079	\$ 780,278
			EAc1: 19 points HVAC accounts for 14 points		EAc1: 11 points HVAC accounts for 8 points	EAc1: 13 points HVAC accounts for 10 points	EAc1: 19 points HVAC accounts for 15 points

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## **Design Challenges & Lessons Learned**



### **Design Challenges & Lessons Learned**



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### **Design Challenges & Lessons Learned**



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## **LESSONS LEARNED**

- MANAGING OCCUPANT EXPECTATIONS

> - SYSTEM COMPLEXITY

> **QUESTIONS?**



