master planning resilience and getting to net zero energy

spring 2023 iccfo conference
case study - net zero energy (designed) agriculture complex
presenters

letisha trepac
- heartland community college
- vice president, finance and administration

michael lundeen
- legat architects
- principal
- director of higher education

loren johnson
- legat architects
- senior architect
- sustainability lead
why a net zero energy building?
state of illinois: goal of 100% clean energy by 2050 and ending carbon-emitting power by 2030
climate and equitable jobs act, september 2021

ending carbon emitting power

one: slow the growth in energy grid demand (low draw new construction, renovations)
two: replacing current carbon sources with non-carbon sources (nuclear, wind, solar)

IL in 2022:
66.2% non-carbon sources
33.8% carbon sources
FACILITIES MASTER PLAN OBJECTIVES:

Academic Support Cluster
- Classroom Improvements
- Library Improvements

STEM Cluster
- Health Sciences
- Science
- Agricultural Program Complex

Career and Technical Cluster
- Career and Technical Education

Student Success Services Cluster
- Enrollment and Student Services
  - Fitness and Recreation
  - Student Life Improvements
  - Centralize Student Services and One-Stop Enrollment Center - Credit and Non-Credit

Community Engagement Cluster
- Child Development Lab
- Challenger Learning Center
- Event Space Improvements
- Performing Arts

Strategic Institutional Enhancements Cluster
- Building Maintenance and Interior Improvements
- Information Technology
- Landscape and Outdoor Improvements
- Public Safety
- Signage and Wayfinding
- Sustainability, Energy and Power (Infrastructure)
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To develop actual budgets, it is important to program in detail each discipline before designing or implementing a project. Additional input and utilization studies are preliminary and require careful consideration as new space and potential new programs are tracked. Overall, existing space and potential new space are being overutilized. Diagrams of existing spaces confirm which existing spaces need to be added or replaced due to functionality or space limitations. The meetings generated a series of program space diagrams that were tracked. Overall, the process to initially understand the requests for additional labs or program space, the design team led a series of pre-programming meetings to develop detailed budgets.
what is net zero energy?
net zero carbon?
campus decarbonization?
what is building net zero energy?

the goal of net zero energy is to produce as much or more energy as a building uses in a year.

after a year of use, the excesses of energy produced should be equal to or greater than the energy deficits.

--- monthly solar energy production

monthly energy use

energy deficit
energy excess

sep  oct  nov  dec  jan  feb  mar  apr  may  jun  jul  aug
what is building net zero carbon?

the goal of net zero carbon is to offset the embodied carbon of building construction, maintenance, and end of life through negative energy use during operations.
what is campus decarbonization?

the goal of “campus decarbonization” is to strategically convert existing fossil fuel energy sources to non-fossil fuel sources over time.

- fossil fuel - on site combustion
- fossil fuel - purchased
- clean energy - purchased
- clean energy - on site generation

year of implementation
designing a net zero energy building - how?
building location

ACRE QUANTITY
FARMLAND 95 ACRES
LANDSCAPE/POND/RETENTION PARKING LOTS/ROADS/OTHER BUILDINGS/CAMPUS/GROUNDS OTHER/UNASSIGNED 38.6 ACRES 23.6 ACRES 38.3 ACRES 63 ACRES

TOTAL SITE 258 ACRES

KEY
1. HOMESTEAD
2. NATIONAL GUARD
3. SPORTS FACILITIES
4. FARMLAND
5. MAIN CAMPUS
6. PROPERTY LINE

BODY OF WATER
GRASS/GREEN SPACE
PRAIRIE/WETLAND

existing farm
agriculture complex
existing homestead

LEGAT ARCHITECTS
HEARTLAND COMMUNITY COLLEGE
Option 1 - “Stem”
- most energy efficient, EUI 30 (+10-15%)%
- event space visible from Raab
- most feasible construction
- most feasible additions

Option 2 - “Petal”
- least energy efficient, EUI 38
- greatest connection to existing campus
- event space least connected to entrance
- shower/tlt not connected to lab space

Option 3 - “Root”
- middle energy efficiency, EUI 36
- greatest interaction between social areas and greenhouse
- greatest interaction between social areas and event space
- greatest connection between labs

OPTION RECOMMENDED BY STEERING COMMITTEE

pEUI: 30 kbtu/sf/yr
pEUI: 38 kbtu/sf/yr
pEUI: 36 kbtu/sf/yr
defining the energy team - roles & responsibilities
getting to zero

1. Integrative Process (box modeling, OPR and BOD (template), energy targeting

2. EUI Target: approx. 15-25 kbtu/sf/year

3. Passive Solar Design - orientation and glazing

4. Solid to Glazing Ratio (approx. 30%, optimize locations)

5. Continuous Envelope R Values (R30-40 Walls, R40-60 Roof, R10-20 under-slab, triple paned windows) - balance against mechanical system and PV output.

6. Light Use Density Reductions

7. Mechanical Systems (compare VRF, GSHP, WSHP)

8. Equipment Energy (energy efficient lab equipment, plug load management)

9. Renewable Energy (roof-mounted vs ground-mounted photovoltaics)

10. Maintenance and Operations. (design for simple controls, design team is involved more in operations, design team needs to be able to track energy use over time through commissioning)
energy modeling - real-time feedback on decision making
30 well ground source heat pump system

300 kw rooftop solar array 110% of predicted annual usage

Super-insulated envelope r34 walls, r60 roof

100% led lighting
daylight controls
occupancy controls

Exterior glazing triple glazed argon filled
superinsulated rainscreen system
horizontal exterior shades
native landscape plantings

student garden / test plots

outdoor classroom
100% LED lighting

exposed heavy timber deck (carbon negative)

concrete floors - thermal mass
building envelope strategy - superinsulation

roof: 11” roofing insulation, R60  
code minimum: 6”, R30

walls: 8” R34 mineral wool  
code minimum: 2.5” xps, r9

underslab: R10 xps  
code minimum: perimeter only

windows: triple glazed cw, R5  
code minimum: R3
construction photos
budgeting and available grants
project budgeting

<table>
<thead>
<tr>
<th>Description</th>
<th>Budget/Est</th>
<th>Bids</th>
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<tbody>
<tr>
<td>Site Development - 10 acres</td>
<td>$1,581,370</td>
<td>$2,124,634</td>
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<tr>
<td>Roads, Utilities, Demolition, Grading, Hardscape/Landscape</td>
<td></td>
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<tr>
<td>Building Costs -</td>
<td></td>
<td></td>
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<tr>
<td>Lab building and sustainable features (2020 CDB statewide avg. Labs $342-362/SF + Escalation)</td>
<td>$15,133,605</td>
<td>$14,561,822</td>
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<tr>
<td>Contractor OHP/General Conditions</td>
<td>$4,610,101</td>
<td>$2,286,544</td>
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<tr>
<td>Bid Contingency 5%</td>
<td>$847,250</td>
<td></td>
</tr>
<tr>
<td>Total Construction Estimate / Contractor Bid</td>
<td>$18,658,144</td>
<td>$18,561,000</td>
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<tr>
<td>Alternates 1-5 (Sitework / Hardscape)</td>
<td>$1,021,932</td>
<td>$901,000</td>
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<tr>
<td>Total Project Costs = $22,000,000 (need to check/refine)</td>
<td>$19,532,231</td>
<td>$19,394,000</td>
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<tr>
<td>Construction Contingency 5%</td>
<td>$847,250</td>
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Project Soft Costs (Not included above)
Furniture, Equipment Planning, Engineering, Surveys, Testing, Demolition, Haz Materials, Art, IT/Data, AV
project budgeting - net zero

Building envelope insulation: $592,396
Triple glazed window walls, thermally broken doors: $124,120
Roof overhang / solar shading: $540,576
Mechanical system efficiency improvements: $902,426
Electrical / pvs: $644,651
Soft costs (engineering, commissioning, design, energy modeling, grant submissions): $470,033
Total ze hard & soft costs: $3,274,202

ICECF grant: $2,000,000

estimate of additional costs (before grant)
raw costs for net zero: $3,274,202 (19% inc.)

pre-grant add per square foot for net zero: $111/sf

estimate of additional costs (after grant)
add’l costs for net zero: $1,274,202 (6.9% inc.)

post-grant to-owner cost for net zero: $43/sf

average electricity rate: 0.091 $/kWh
baseline
average annual predicted energy use: 1,215,081 kWh
average annual predicted energy use: $110,573

design - usage
average annual predicted energy use: 241,000 kWh
average annual predicted energy use: $21,931
design - generation
average annual pv generation: 279,649 kWh
average annual pv generation: $25,337

return on investment (with ICECF grant):
add investment after grant: 1.27 million
annual savings: $113,979
roi achieved: in year 11 of operation
building lifespan: 30-50 years
thank you!