

Large solar thermal system performance

Domestic hot water and pool heating



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Solar Energy at Gustavus

Review of projects underway



Background

Twelve year effort to acquire a utility scale wind turbine

Carbon reduction and economic benefit

Blocked by county action in 2009

\$1 million dollar donor

President asked donor to shift funds to solar project

Part of LEED certification effort on new academic building (Beck Hall)

Beck Hall

New (2011) academic classroom and office building

Targeting LEED Platinum

Econ and Management, Communication Studies,
Psychology, Neuroscience, History, Sociology, and
Anthropology

LEED on-site renewable energy

60 flat plate solar thermal collectors

40 KW solar electric



Exploratory specification process



Overview of all projects

Beck Hall

60 flat plate solar thermal collectors

Summer reheat and winter heating load

40 KW solar electric (in process)

Olin Hall (Math and Physics)

Three 5 KW arrays (5 KW installed to date)

TenK, microinverters, central inverter

Lund athletic complex

24 flat plate collectors

Year round load—pool and water heating

Jackson Campus Center

Sixteen Next Generation NGE-224-TU panels

Ballast mounts

Year round water heating load

Focus on two solar thermal projects

Lund athletic complex

24 flat plate collectors

Year round load—pool and water heating

Jackson Campus Center

Sixteen Next Generation NGE-224-TU panels

Ballast mounts

Year round water heating load

Design and installation by Energy Concepts

Roof engineering by Lindau Companies,

Jackson Campus Center

Dining services

7 AM to 11 PM operation

Almost 365 days/year



Jackson Campus Center

Hot water load????

“Guesstimate” based on water use—10,000
gpd domestic hot water load

73 therms a day to provide hot water

Heat provided by central steam plant (est.
80% efficient)

System sizing based on available dollars and
available space

Jackson Campus Center

16 Next Generation Energy NGE-224-TU
evacuated tube solar thermal panels

True south orientation, 45° tilt angle

Located over serving area (open 14 hours per
day almost year round)

Access for roof mounting challenging

Solution: Ballast mount (Silverback racking
system)

Jackson Campus Center



Jackson Campus Center—additional notes

Fin tube radiator heat dump

Solar radiation monitor

Access for roof mounting challenging

Start-up bypass

PLC control and data logging by EOS
research

Jackson Campus Center



Jackson Campus Center—data monitoring

10 minute intervals

Temperature points, pump flow rates, and environmental data (irradiance and ambient temps)

March 23 to Nov 28, 2012 (245 days of operation)

244.5 days of data (internet connection issues caused loss of data)

Jackson Campus Center—overall performance

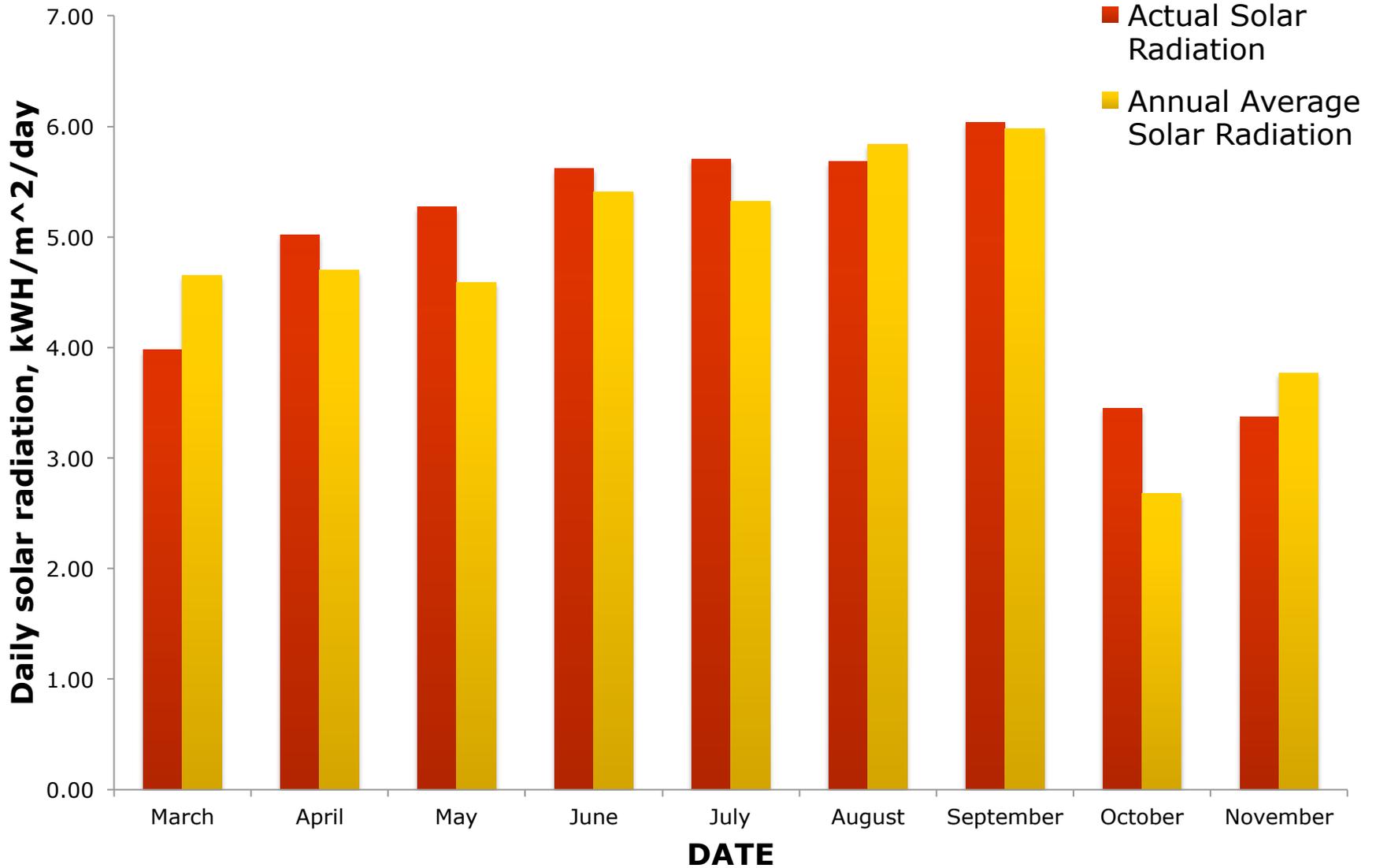
6.2 therms per day delivered to load

7.8 therms per day replaced (assume 80% steam system efficiency)

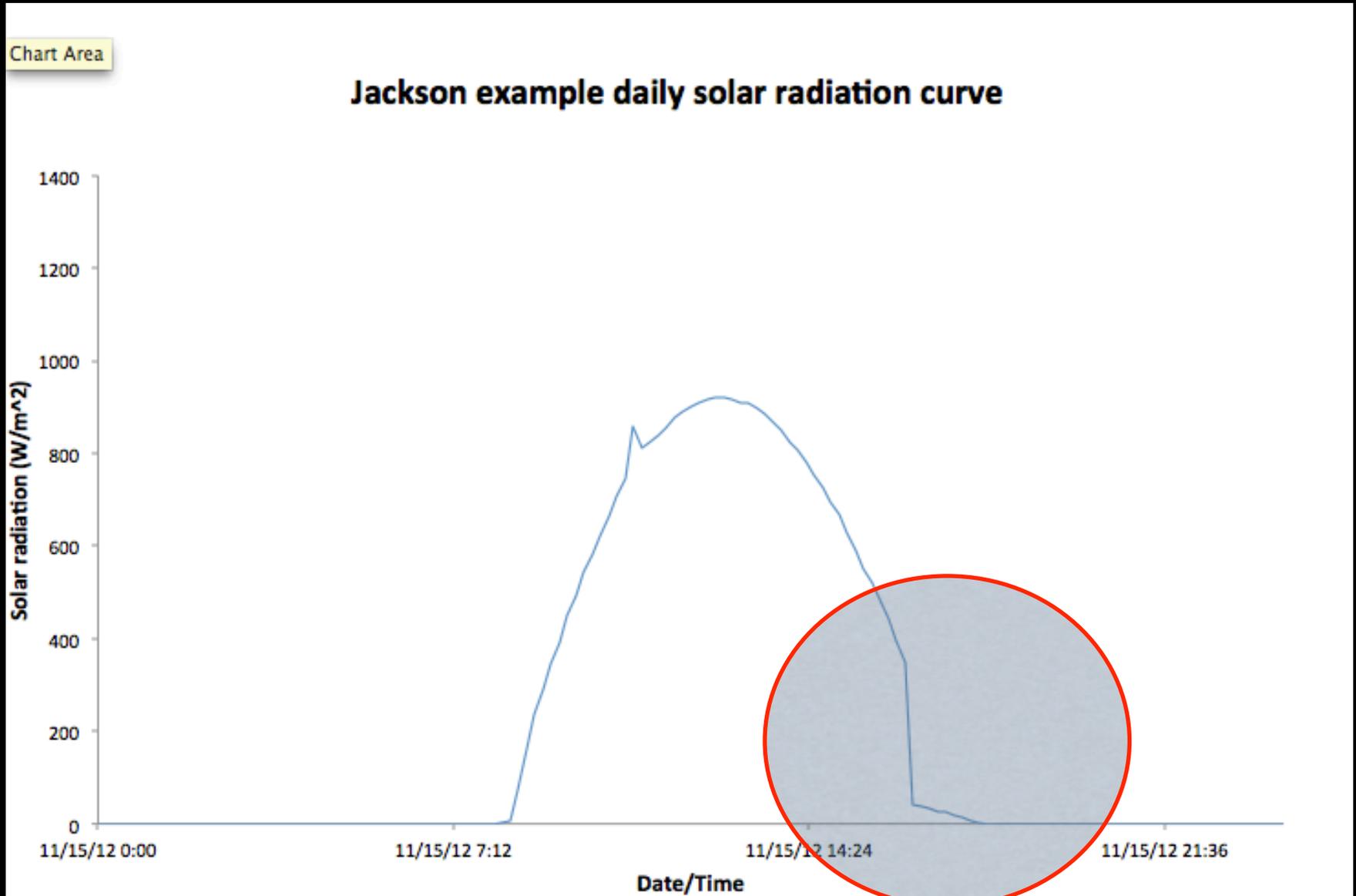
63% solar collection efficiency (based on gross collector area)

Solar radiation slightly above average

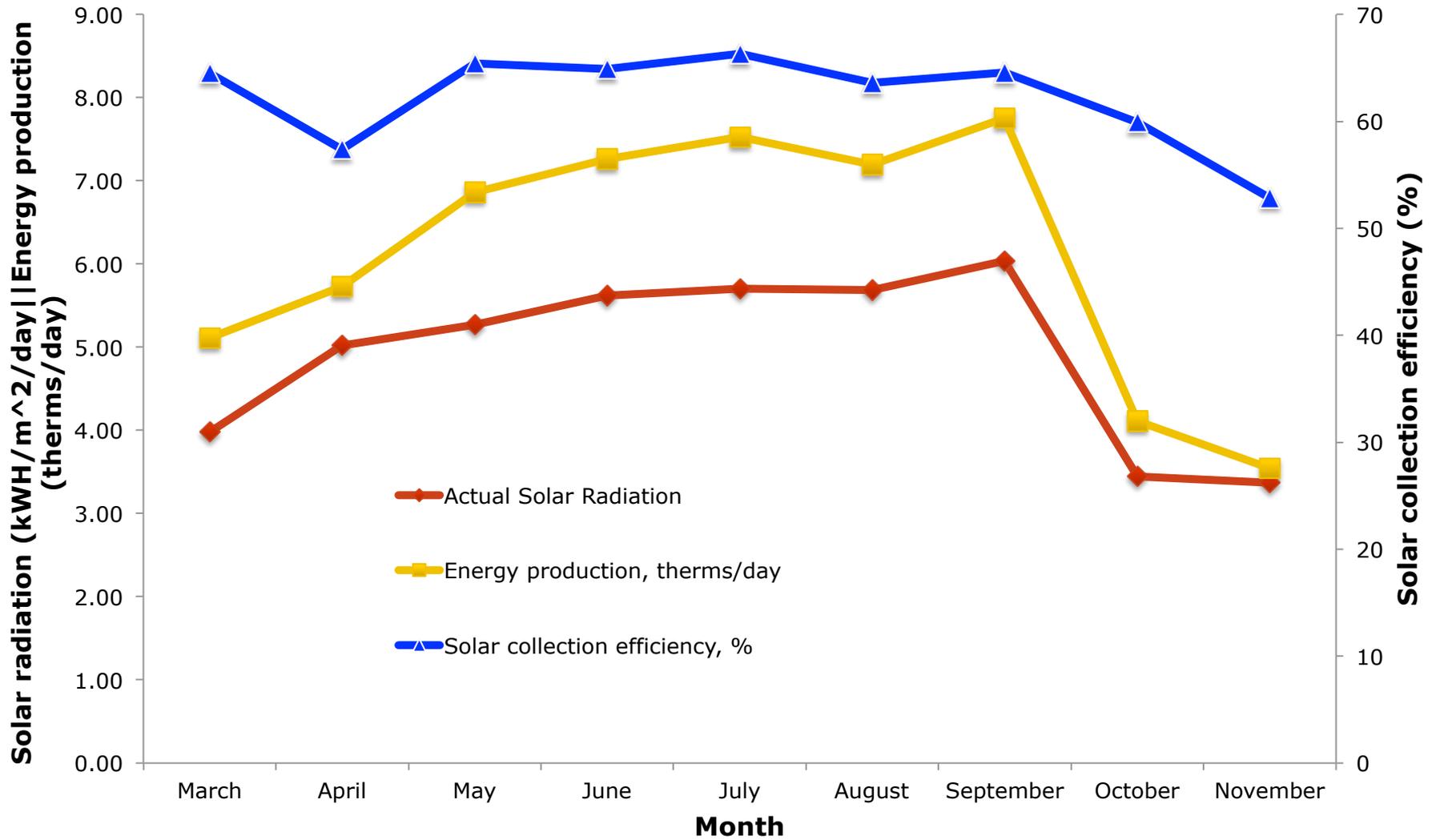
Actual versus average solar radiation



Possible solar radiation error (est. less than 1.5%)

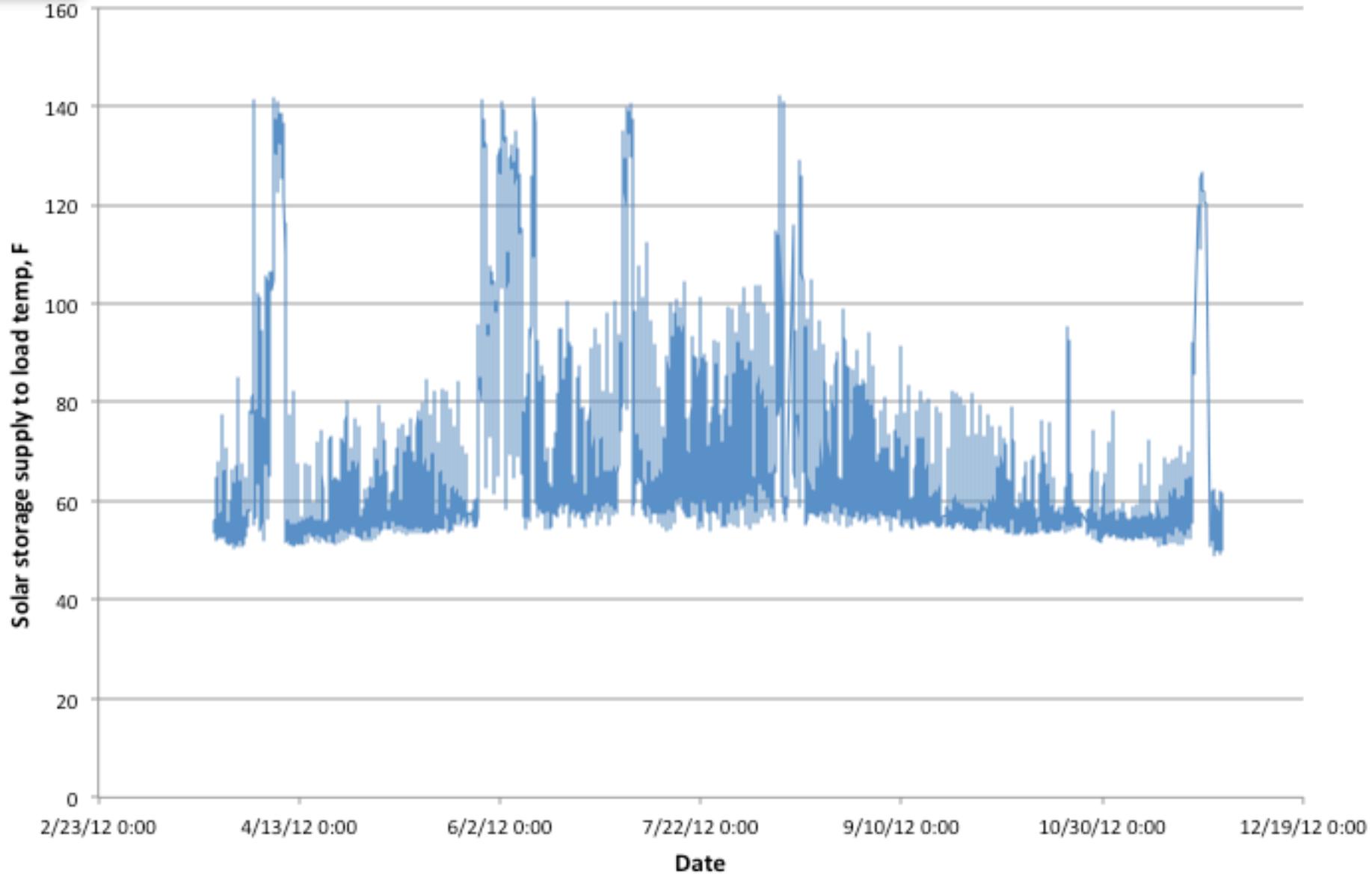


Jackson Center Monthly Performance



Solar storage output temperature versus date

Chart Area



Lund Athletic Center

Athletic Center

Hockey rink

Basketball court

Indoor track

Natatorium



Lund Center

Pool load uncertain—no separate water meter or steam meter

25 yards by 25 meters

348,000 gallons

Engineering estimates 4-5 therms/day

Heat provided by central steam plant (est. 80% efficient)

System sizing based on available dollars and available space



Lund Center

24 Solar Skies SS-40 panels (4' x 10')

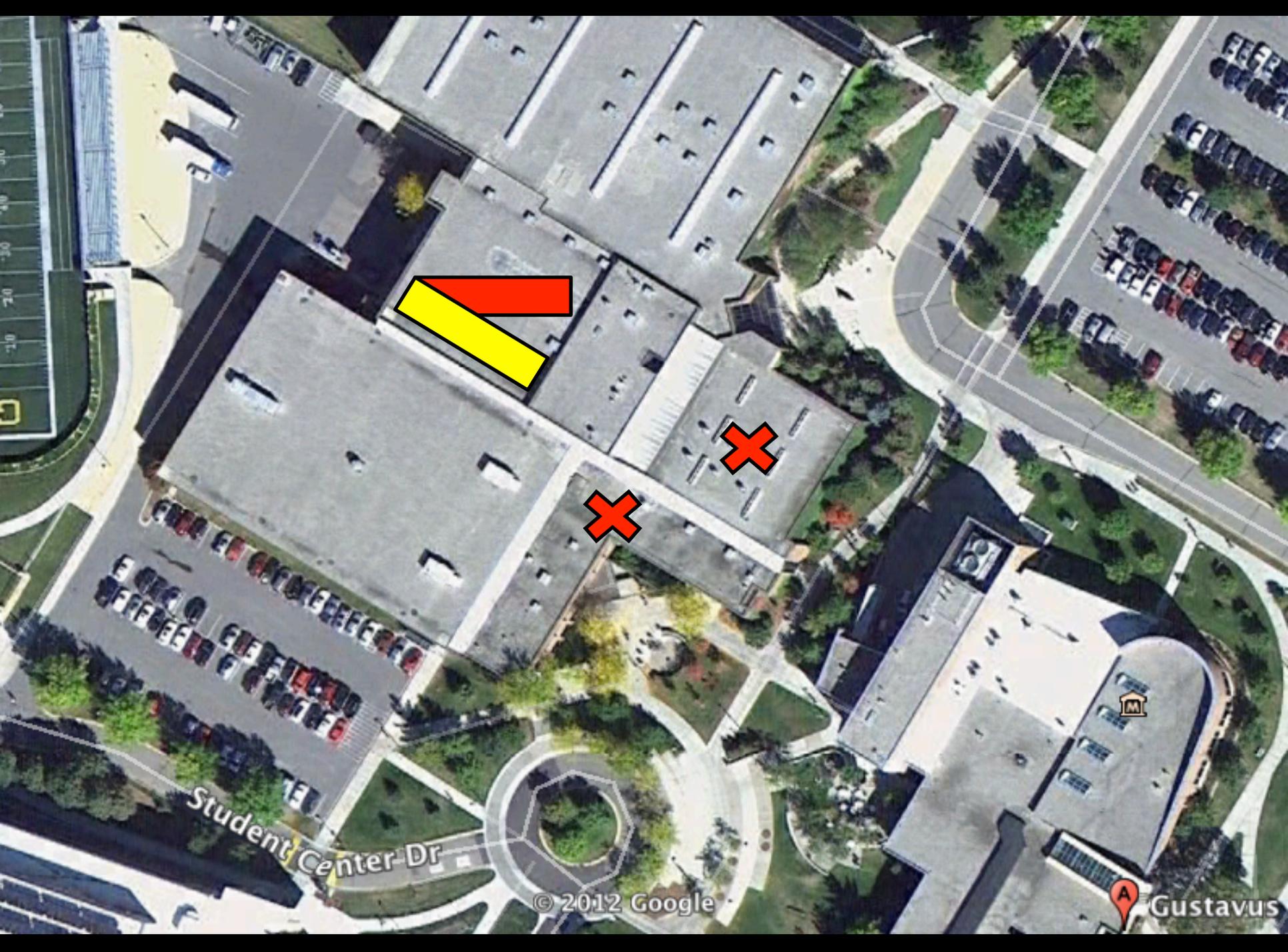
Roof load and access issues

Used existing storage tank (1980s preplanning)

30° west of south orientation, 45° tilt angle

Start-up bypass

PLC control and data logging by EOS research



Student Center Dr

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Gustavus





Lund Center—data monitoring

10 minute intervals

Temperature points, pump flow rates, and environmental data

March 23 to Nov 28, 2012 (245 days of operation)

245.5 days of data (internet connection issues caused loss of data)

Lund Center—overall performance

4.8 therms per day delivered to pool

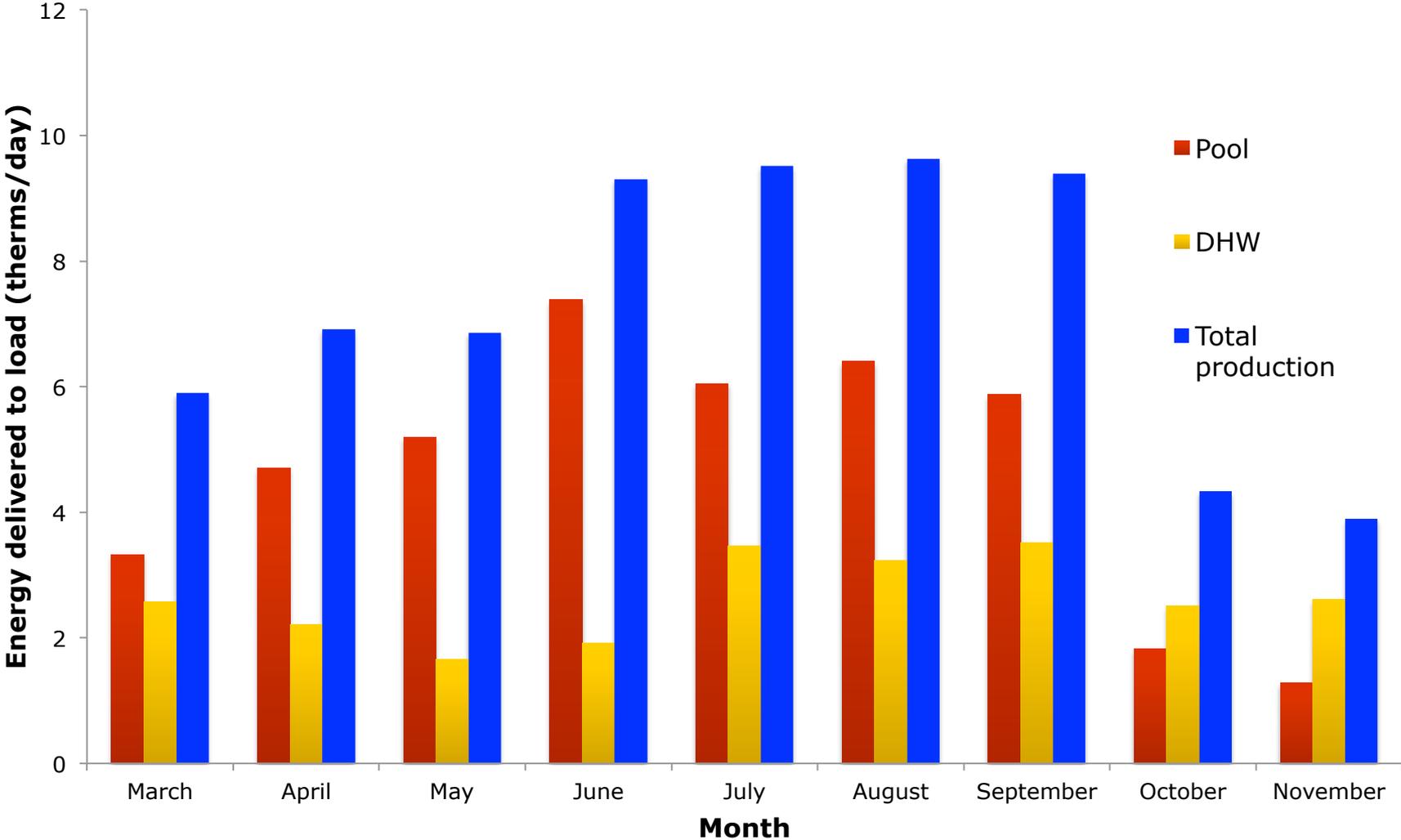
2.6 therms per day delivered to DHW load

9.3 therms per day replaced (assume 80% steam system efficiency)

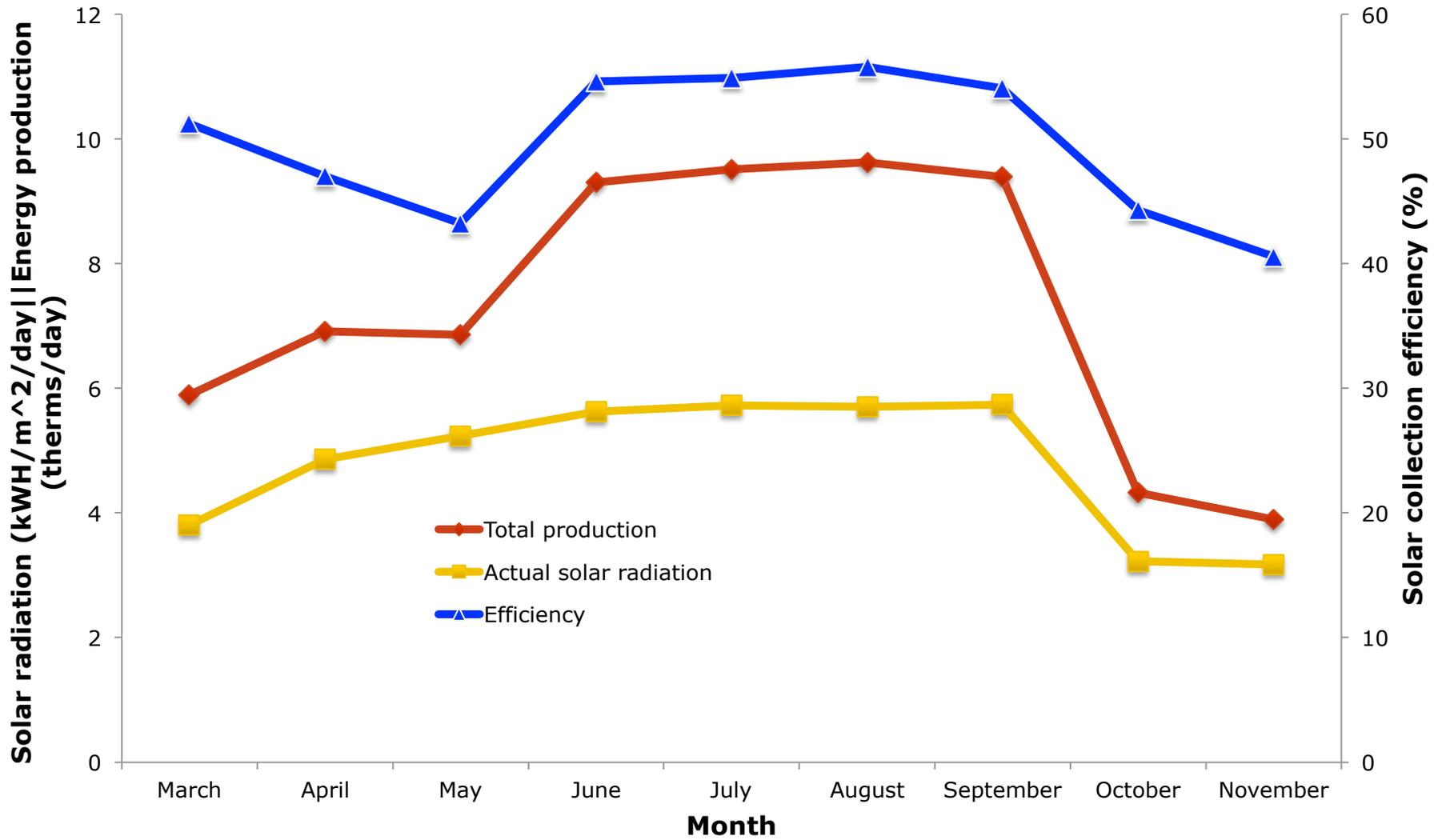
50% solar collection efficiency (based on gross collector area)

Solar radiation data from Jackson campus center adjusted for azimuth angle

Lund Center Monthly Production



Lund Center Monthly Performance



System	Cost/area	Efficiency corrected cost/area	Annual energy production value/area	Annual CO2e emission reduction/m²	20-year cash emission reduction cost \$/tonne/m²
<i>units</i>	<i>\$/m²</i>	<i>\$/m²</i>	<i>\$/m²</i>	<i>tonnes/m²</i>	<i>m²</i>
Lund (eff. = 50%, \$0.40/therm)	2695	5390	12.50	0.165	739
Jackson (eff. = 60%, \$0.40/therm)	2360	3934	15.50	0.205	500
PV (eff. = 11%, \$0.11/kWh, 1.64 m ² /235 watt panel)	716	6513	18.79	0.127	134

Gustavus Adolphus College Green House Gas Emissions Inventory

Source	2007-2008 FY Green House Gas Emissions (tonnes CO₂e)	2009-2010 FY Green House Gas Emissions (tonnes CO₂e)
Electricity	12474	11644
Heating (NG)	8316	7619
Air travel	2260	3132
Commuting	1837	1700
College vehicles	307	356
Bus/hired travel	64	41
Solid waste	-19	undetermined