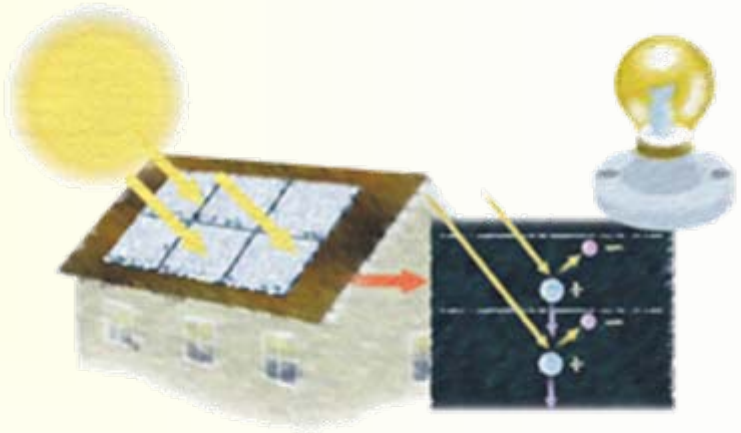
Capture The Power of Photovoltaics



IEEE Power Engineering Society Meeting

May 2005

ComEd
An Exelon Company

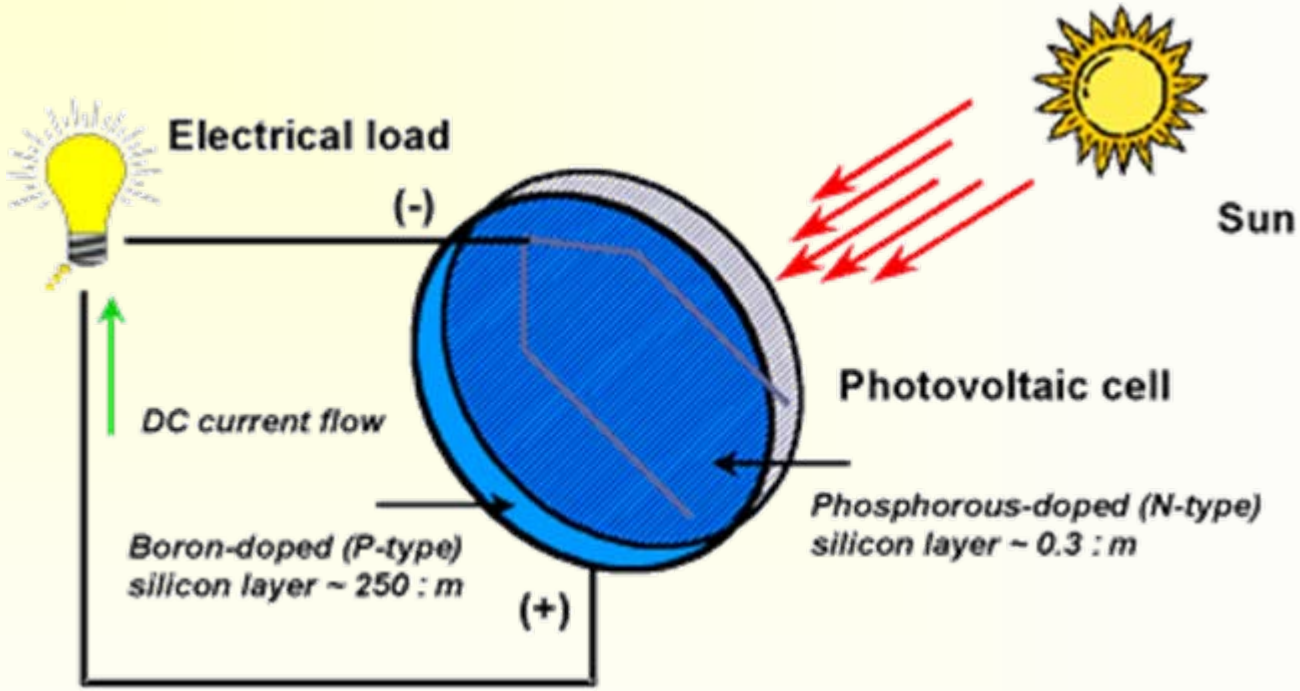
Agenda

- Photovoltaic Basics
  - Applications
  - Economics
- Grid Interconnection and “Net Metering”
  - Grid-Tied System Components
  - Net Metering
- Chicago Area PV Systems
  - ComEd Chicago North
  - Millennium Park Exelon Pavilions
  - Harold Washington Social Security Building

Photovoltaic Basics

Applications and Economics

What are Photovoltaics (PV)?



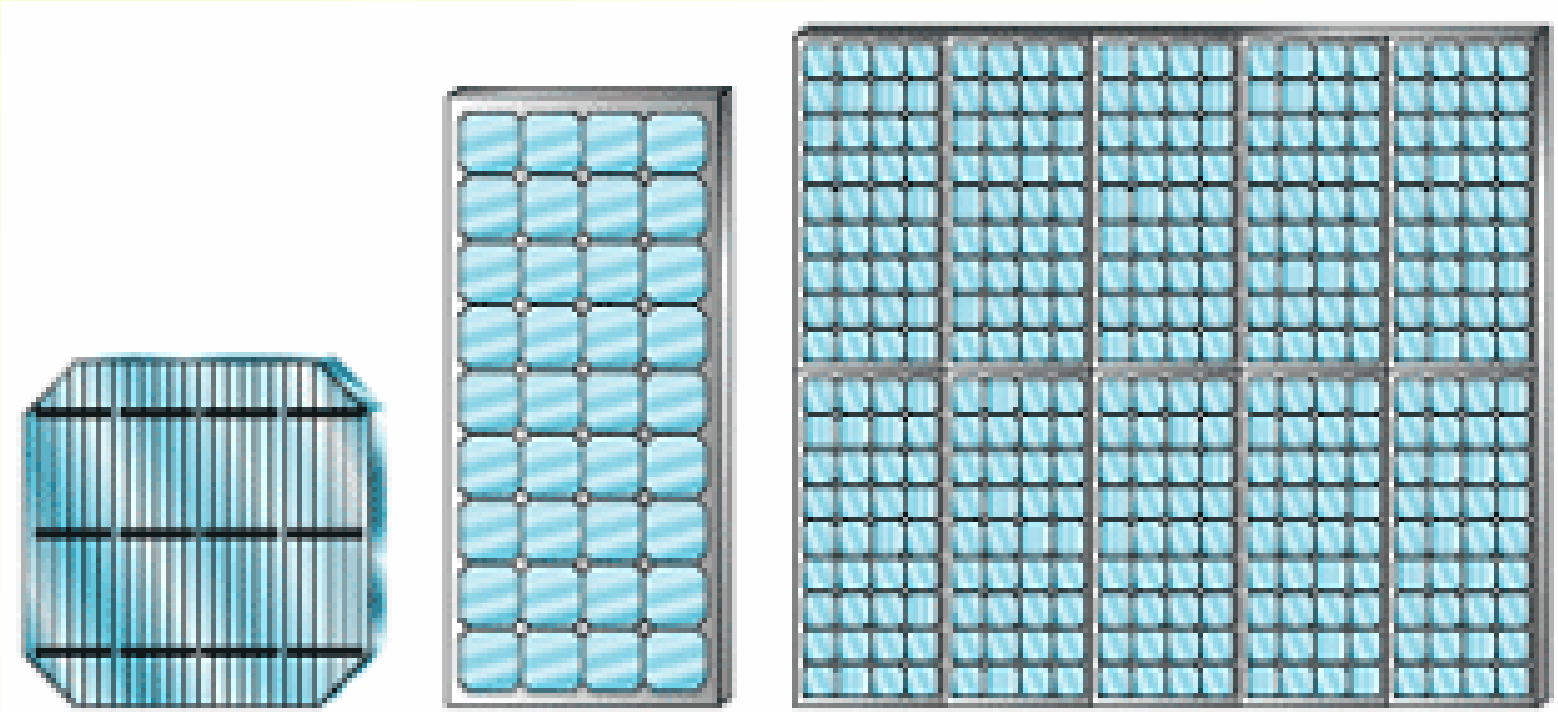
Semiconductor devices that convert sunlight into direct-current (DC) electricity

Picture: source unknown

Photovoltaic Cells

- Cell structure can be
  - Single crystal
  - Multiple crystal
  - Thin film
- Silicon (Si)
  - Single crystal, multi-crystal, and amorphous
- Polycrystalline thin films
  - including copper indium diselenide (CIS), cadmium telluride (CdTe), and thin-film silicon
- Single-crystalline thin films
  - including high-efficiency material such as gallium arsenide (GaAs)

Photovoltaic Configuration



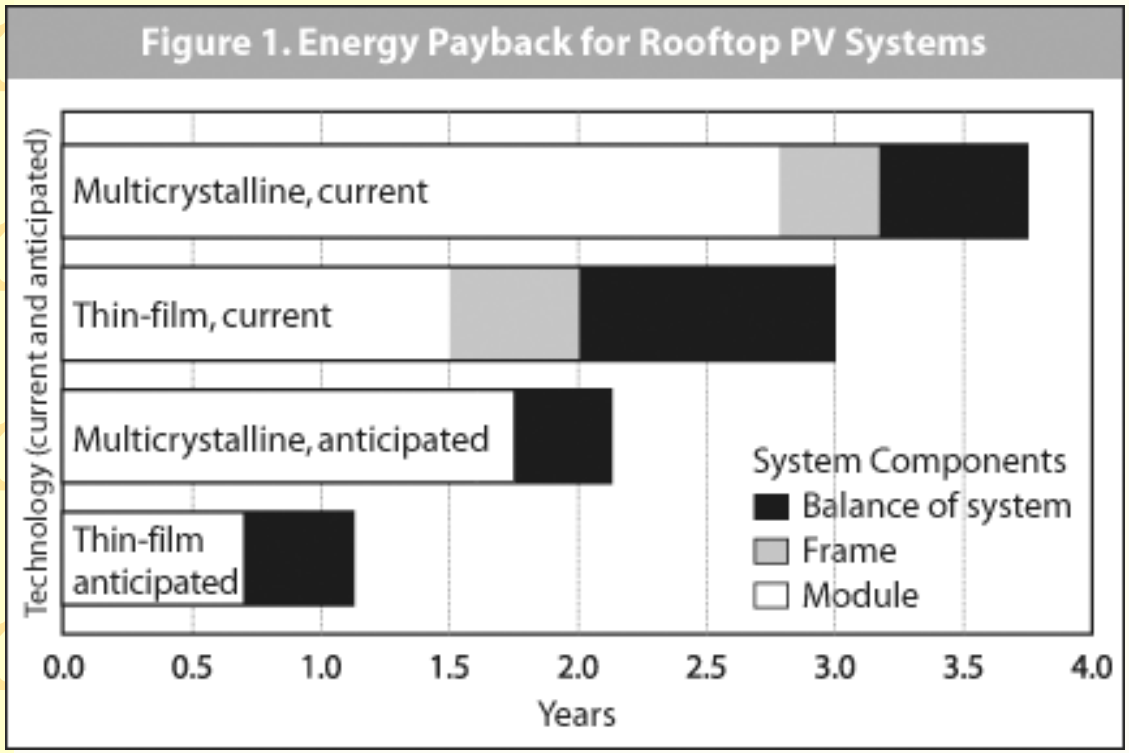
Cell → Module (or Panel) → Array

Picture: http://www.eere.energy.gov/solar/pv_systems.html

Efficiency

- A typical commercial single/multiple crystal cell is about 15% efficient at converting sunlight into electricity
  - Photon energy levels
  - Cell and air temperatures
  - Electric resistance
  - Reflection within cell
- Thin film efficiency is slightly lower

Energy Considerations



- 3 to 4 years of operation for energy pay back
- Normal operating life for PV system 20 to 30 years

Source: U.S. Department of Energy
National Center for Photovoltaics
http://www.nrel.gov/ncpv/

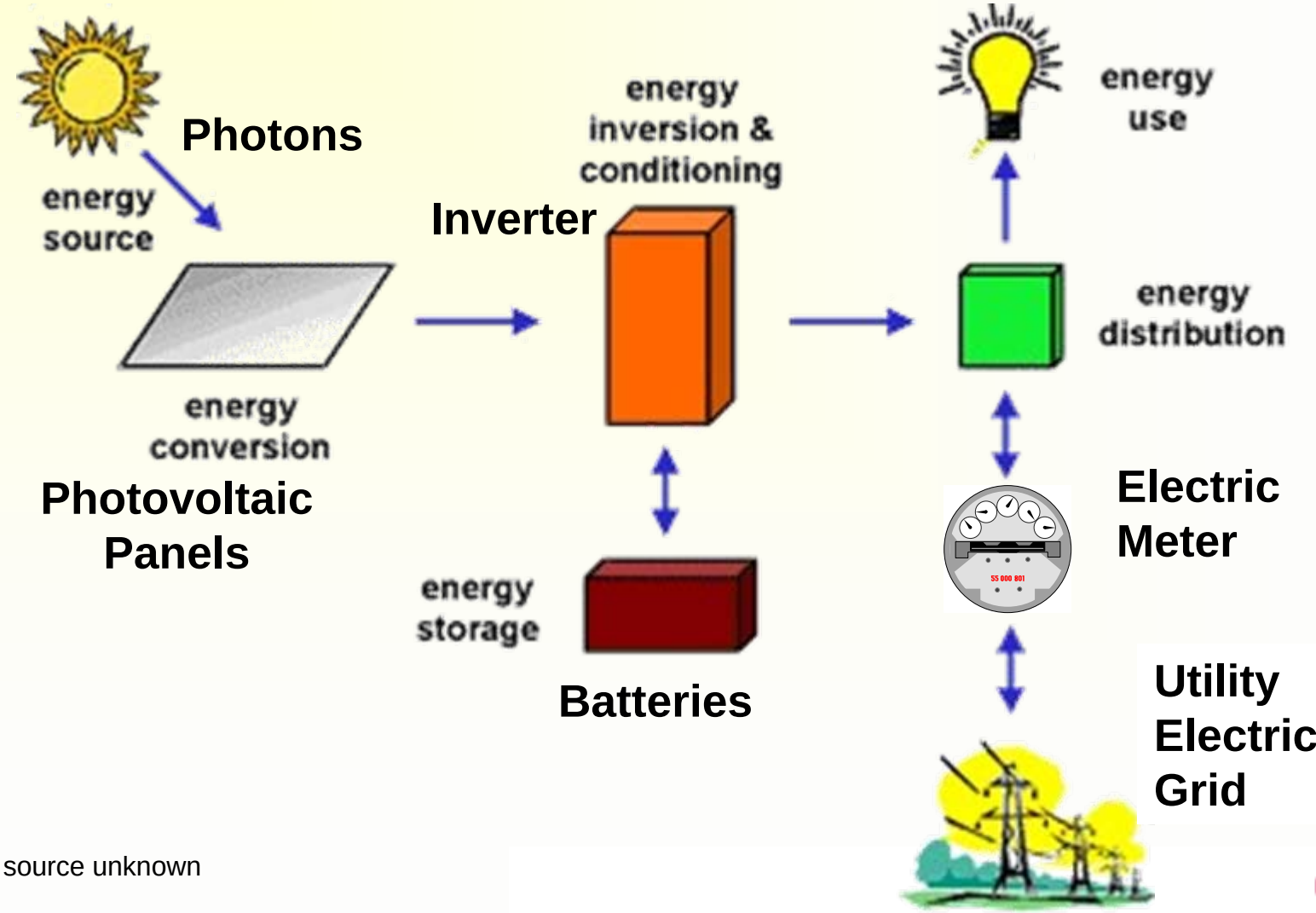
Photovoltaic Applications

- Aerospace
  - satellites, planet “rovers”
- Consumer electronics
  - calculators, watches
- Electric power generation
  - Utility
  - Distributed (grid connected)
  - Remote / off grid

Picture:
http://marsrovers.jpl.nasa.gov/gallery/

PV System Components

Grid connected system

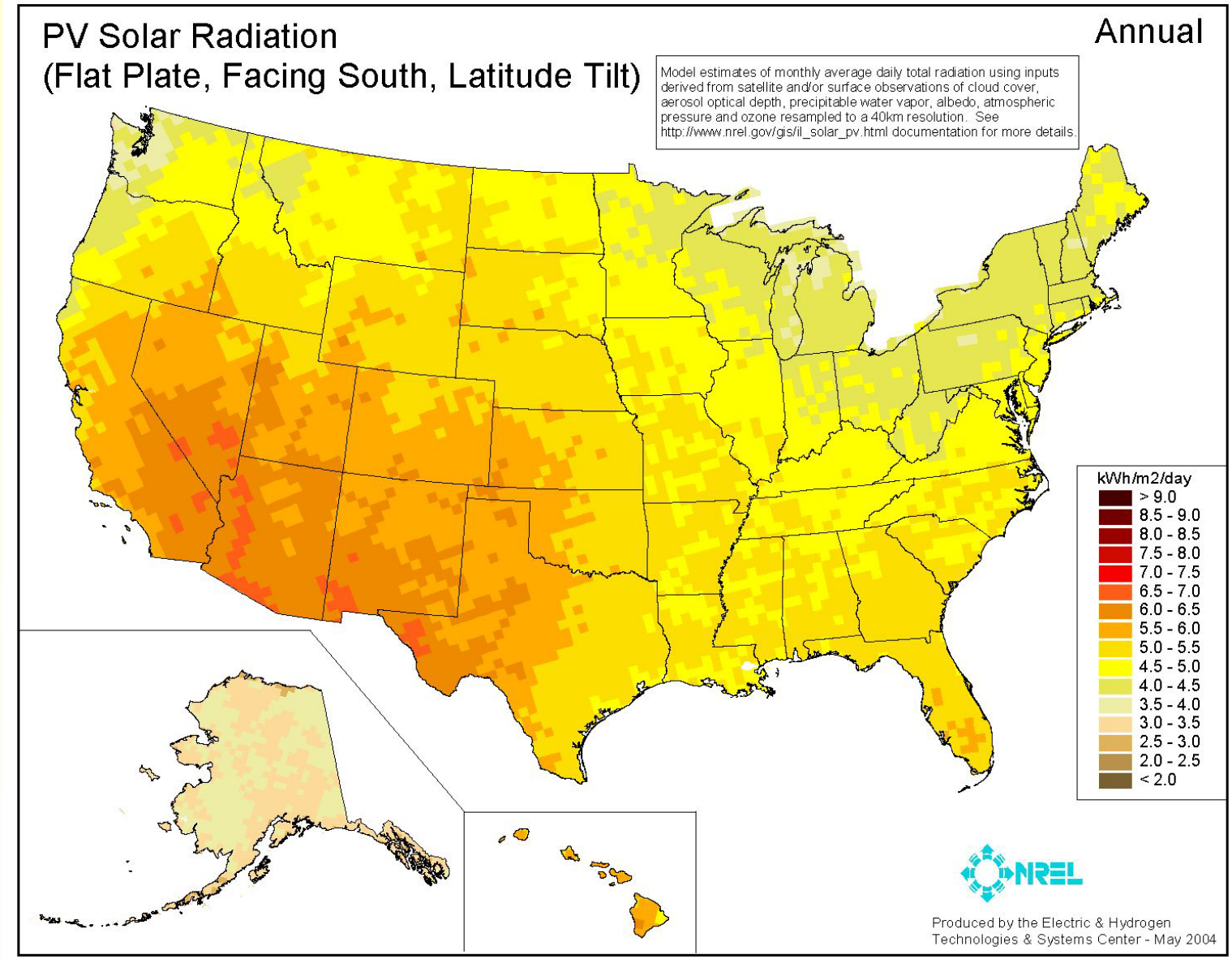


Picture: source unknown

Inverter

- A device that converts direct current (DC) power to alternating current (AC)
- Uses electronics to generate a sine wave
- Regulates the voltage (V) and frequency (Hz) of the power from the PV system
- Provides protection against irregular conditions

Geographic Considerations



Source: http://www.nrel.gov/gis/il_solar_pv.html

Energy and Cost Considerations

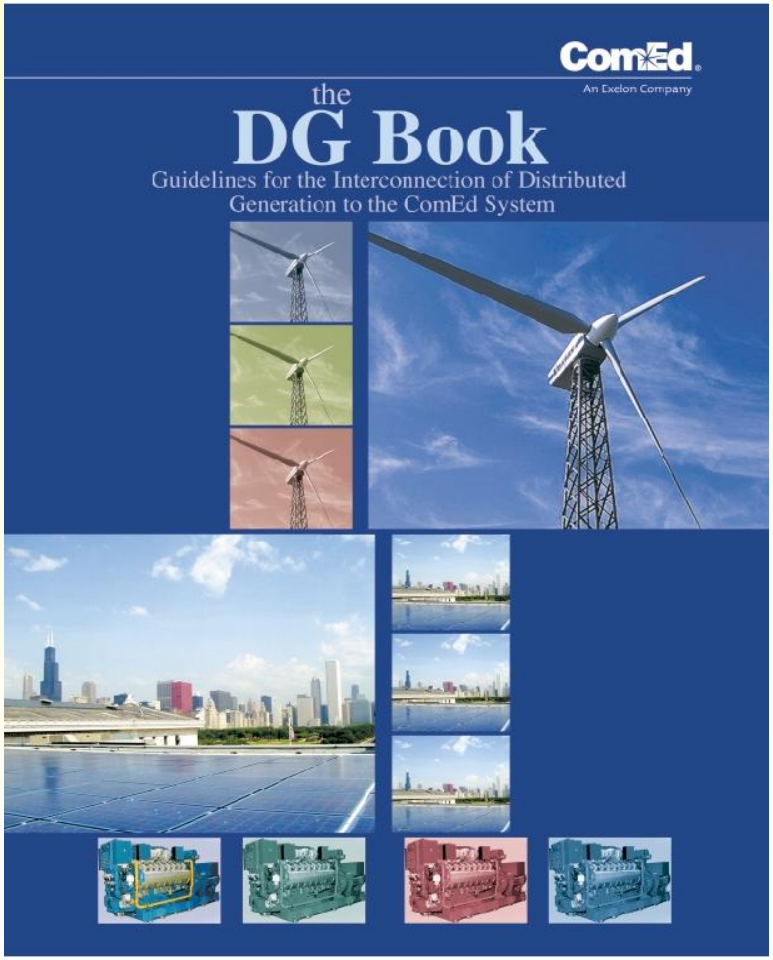
In Northern Illinois:

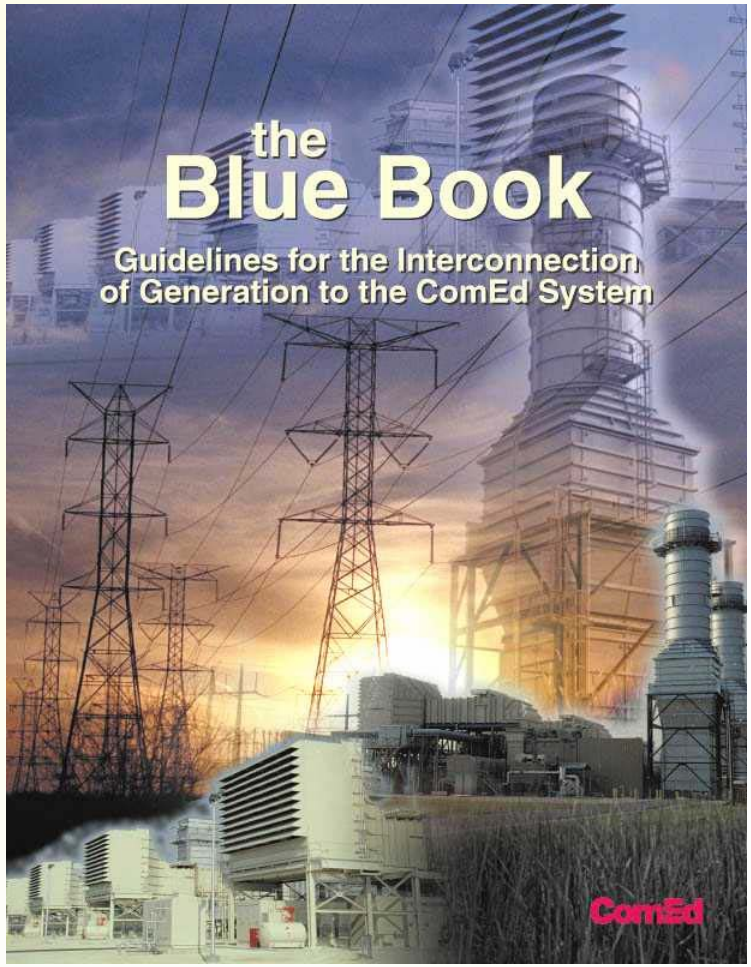
- A 1 kilowatt (kW) photovoltaic system will typically provide 1,500 kilowatt-hours (kWh) annually
- The cost to install a photovoltaic system is approximately $10 per watt
  - 2 kW = 2000 W x $10/W = $20,000
- State of Illinois currently offering rebate program

Grid Interconnection

"Net Metering" and
Interconnection Requirements

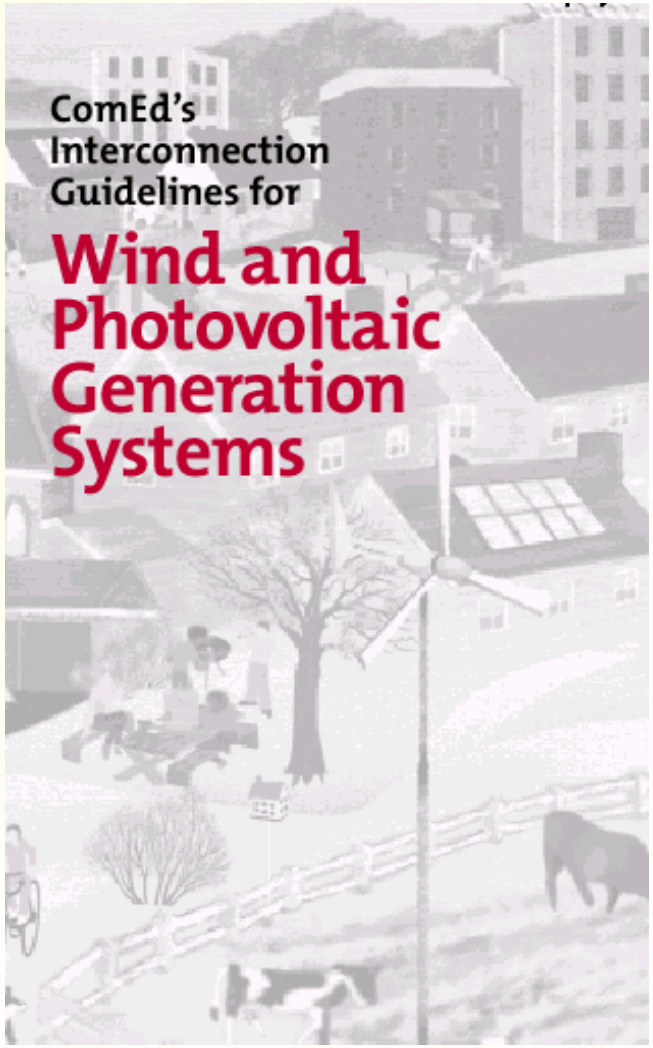
Interconnection Guidelines





“Net Metering” and Interconnection Guidelines

- Wind and photovoltaic systems of 40 kW and smaller
- Available from on the Chicago Solar Partnership website
  www.chicagosolarpartnership.com



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“Net Metering” – What is it?

- Excess electricity sold to utility
- Credit for excess electricity generated
  - Monthly or annual basis
- Use the utility grid as a “battery”
- Each utility and state has specific rules and requirements

“Net Metering”- ComEd Territory

- Requires utility approval
- Requires special metering
  - A 2 channel meter must be installed
  - Standard residential meter does not record outflow of kilowatt-hours
- Credit on monthly bill for electricity sold back to utility based on wholesale rate
- Annual incentive payment to simulate “net metering” for 5 years

Interconnection Requirements <40kW

- Photovoltaic systems must:
  - Comply with all applicable codes, laws, and regulations
  - Not adversely affect the power quality, reliability, or safety of electric grid
  - Automatically disconnect from the grid when the source of electricity is lost
  - Meet IEEE 929 standards (<10 kW systems)
  - Inverters must be UL 1741 listed
  - Have a lockable manual disconnect switch
  - Receive ComEd approval prior to operation

Chicago Area PV Installations

Distributed Grid Connected Photovoltaic Applications

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ComEd Chicago North Building

25 kW DC

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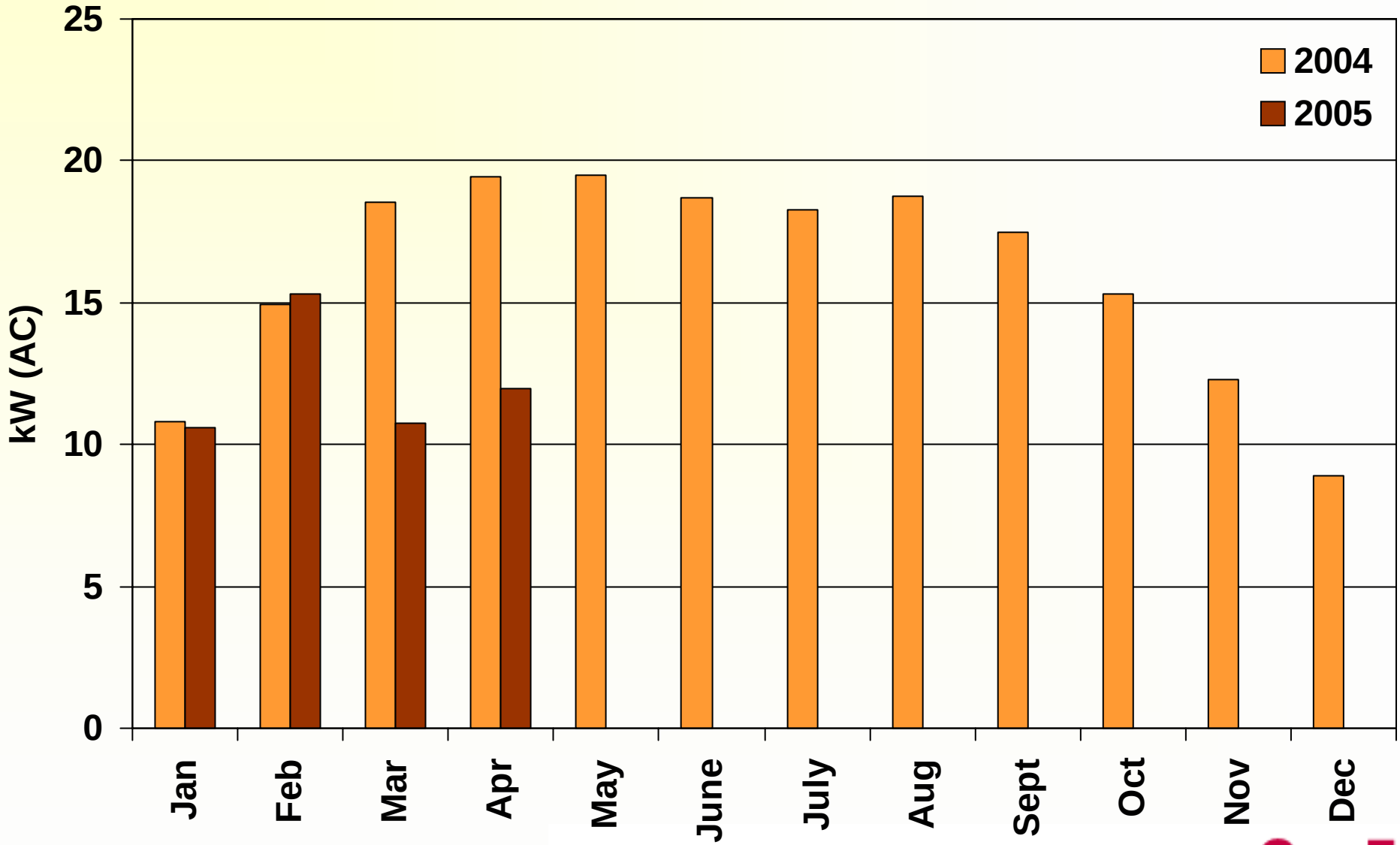
Exterior Combiner Boxes

DC Disconnects

15 kW and 10 kW Inverters

AC Disconnects/Data Acquisition

Monthly Maximum Power Output



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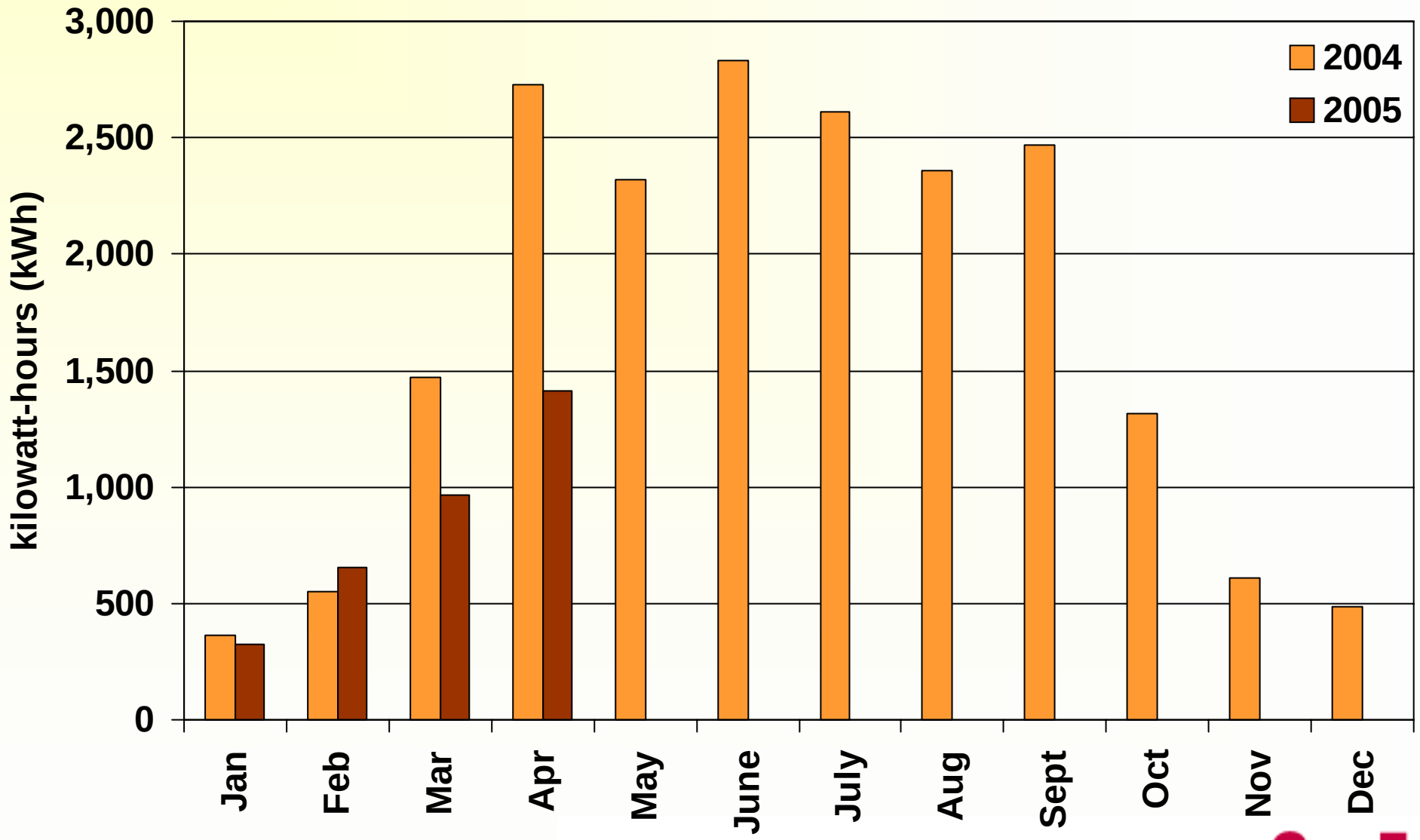
Monthly Electricity Generation



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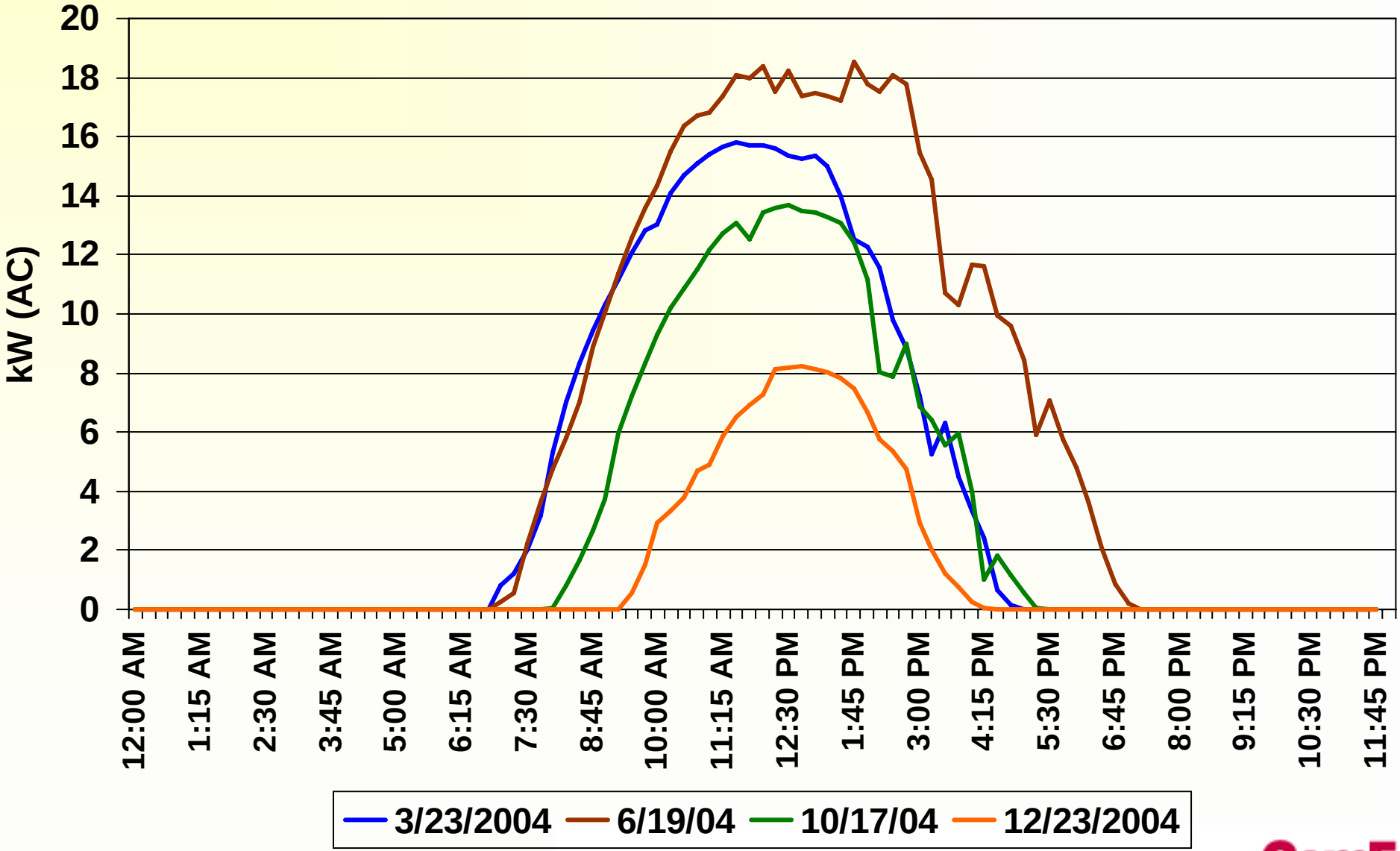
Seasonal Daily Electric Output



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Exelon Pavilions at Millennium Park

Randolph Street
32.6 kW
Building Integrated PV
(BIPV)

Monroe Street
1.8 kW
Roof Top PV

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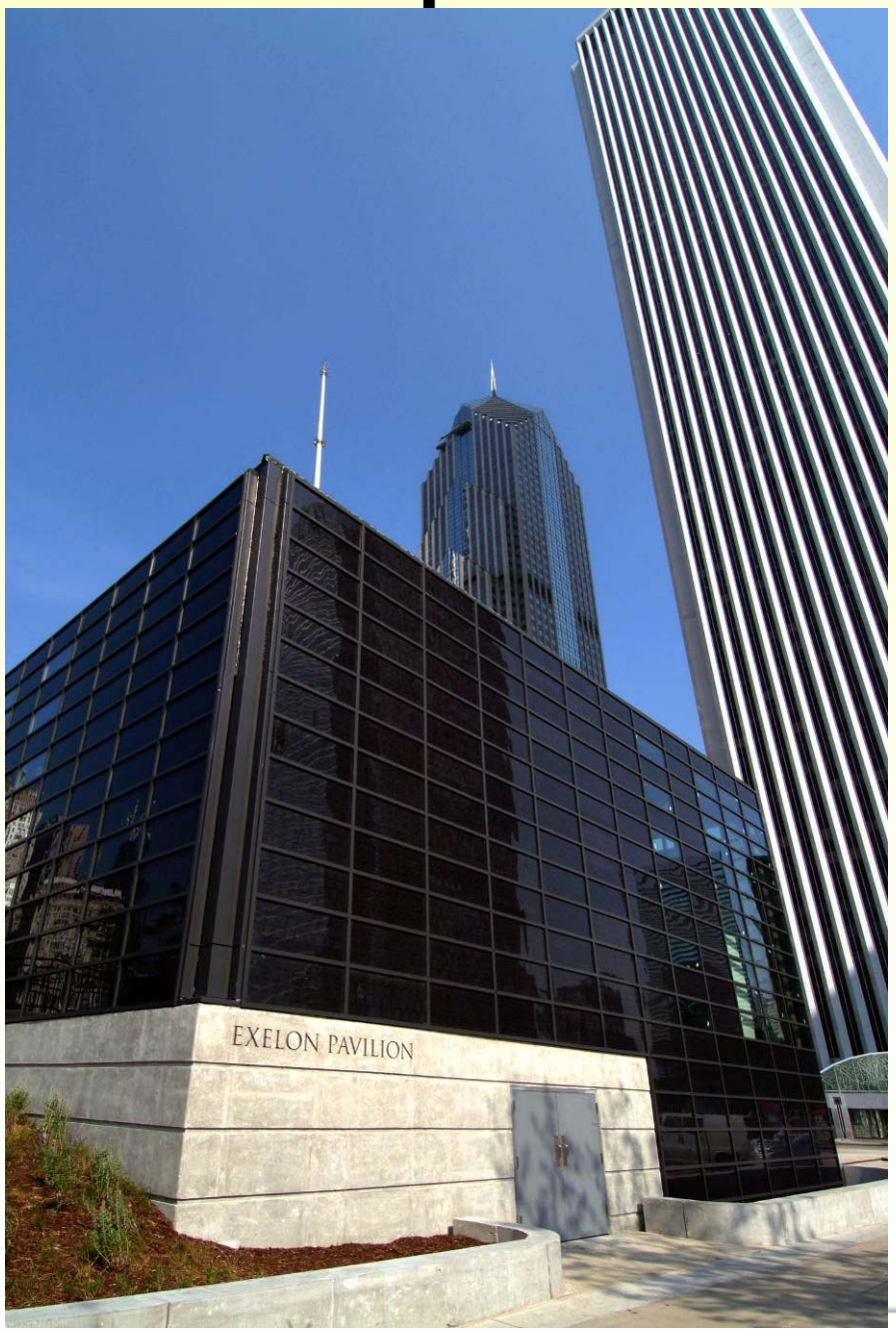
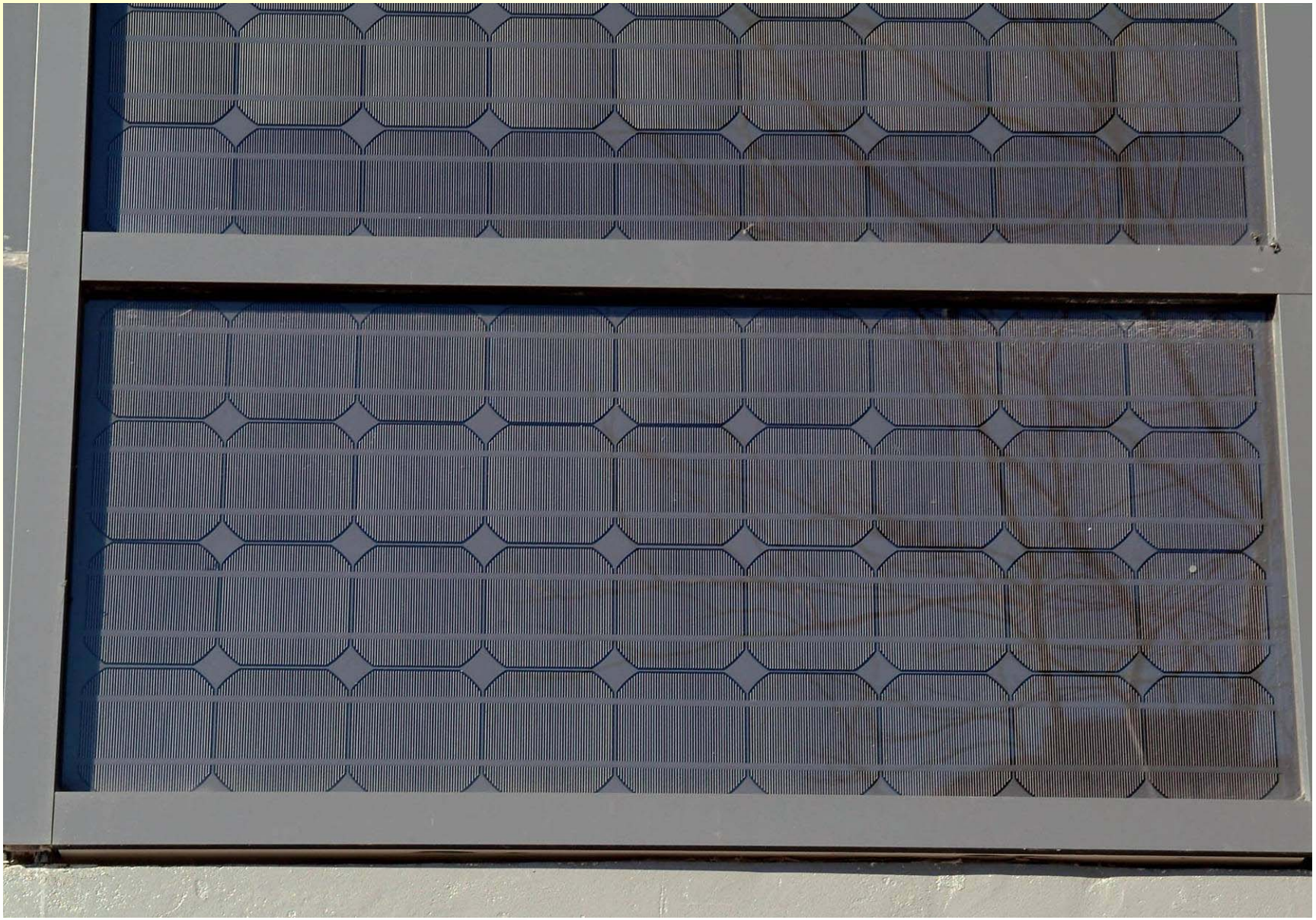
Randolph Street Pavilions



- Northwest Pavilion houses the Millennium Park Welcome Center
- 459 building integrated 75 W PV panels

BIPV Close-up



Exelon Pavilion Inverters

- 8 each 2.5 kW (AC) inverters
- 7 each 1.8 kW (AC) inverters

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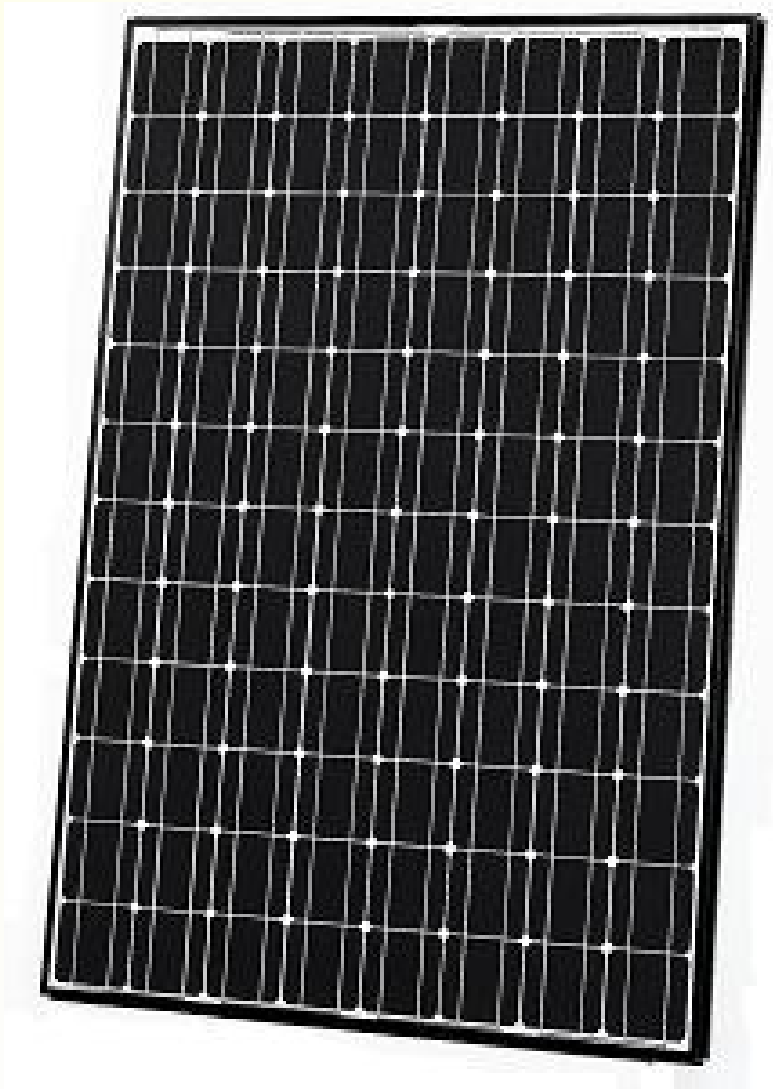
Harold Washington SSA

- Horizontal panels covering roof area of 7,920 ft^2
- 528 PV panels rated at 190 W
- 100.3 kW DC
- Foam backed modules will add insulation value of R20 to roof
- 100 kW (AC) rated inverter
- Peak system power of 81.4 kW (AC)
- Per ComEd DG Book, system requires a protective relay

SSA – Solar Panels

- Cells made of single crystal Si wafer and thin layer of amorphous Si
- Cell efficiency of 18.5%
- Module Efficiency of 16.1%
- 190 Watt module
- Modules are 52” x 35” in dimension



Source: http://www.nrel.gov/gis/il_solar_pv.html

SSA - Inverter

- 100 kW commercial utility interactive inverter
- Three-phase
- 208 VAC transformed to 480 VAC

Source: http://www.xantrex.com/

Summary

- PV research is continuing
- Utility interconnection guides available
- PV is viable in Illinois
- Both public and private sectors are showing interest in PV

Web Resources

- US DOE Energy Efficiency and Renewable Energy

http://www.eere.energy.gov/solar/photovoltaics.html

- Chicago Solar Partnership

http://www.chicagosolarpartnership.com

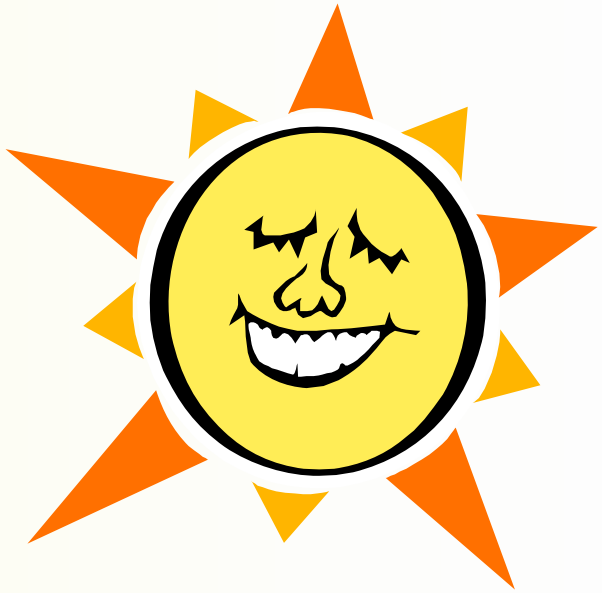
- National Renewable Energy Lab

http://www.nrel.gov/solar/

- Database of State Incentives for Renewable Energy

http://www.dsireusa.org/

Thank You



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