

Power Market and System Operating Impacts of Solar Development in Massachusetts

Presented by

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to the

New England Energy and Commerce Association
Renewables and Distributed Generation Committee

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LEVITAN & ASSOCIATES, INC.
MARKET DESIGN, ECONOMICS AND POWER SYSTEMS

Agenda

- ◆ Solar Development in Massachusetts
 - Conducive to evaluating in-state impacts
 - Wholesale power market and system impacts – LAI
 - Regional and state-wide socio-economic impacts – REMI

LAI Presentation

- ◆ Introduction to the Massachusetts RPS
 - Context for renewable development
 - 400 MW assumed in-state by year-end 2018
- ◆ Power Market and Operational Impacts
 - Capacity and energy markets
 - System operations
- ◆ Solar Development and Cost Inputs
 - Required by REMI

Massachusetts RPS

◆ Class I (new)

- 5% in 2010, rising by 1% / yr to 15% by 2020
- 2000 MW wind by 2020
- Solar PV carve-out goal of 250 MW by 2017
- 400 MW DOER target and sunset provision

◆ Class II (existing)

- 7.1% in 2009 (3.6% renewables; 3.5% waste-to-energy)

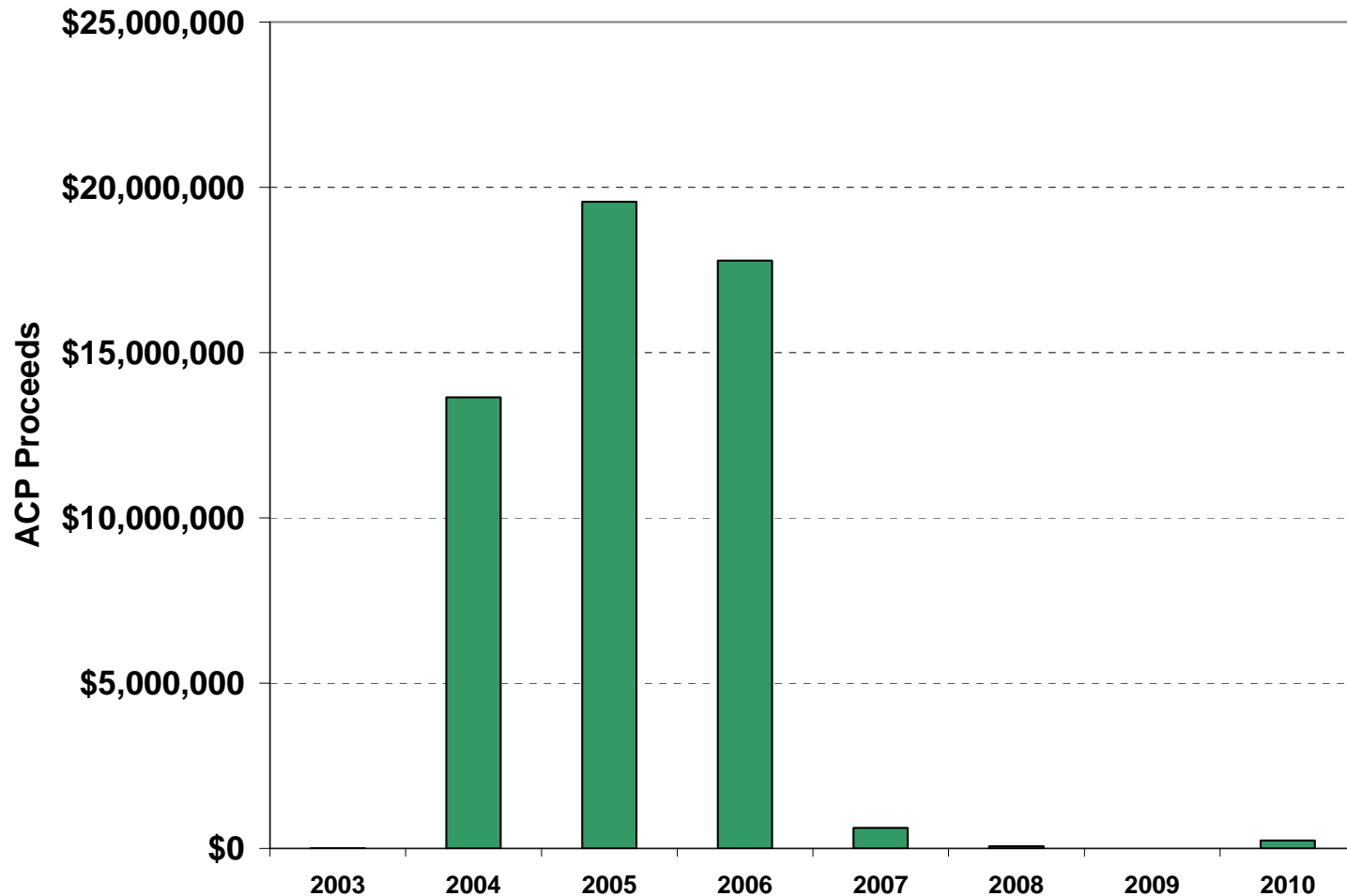
◆ ISO-NE Installed and Queued Resources in MA

	<u>Installed</u>	<u>Queued</u>
• Wind	44 MW	558 MW (+2000 MW in rest of NE)
• Solar	95 MW	5 MW

Plus landfill gas, wood, wood waste, etc.

MA RPS – Class I Alt. Compliance Payments

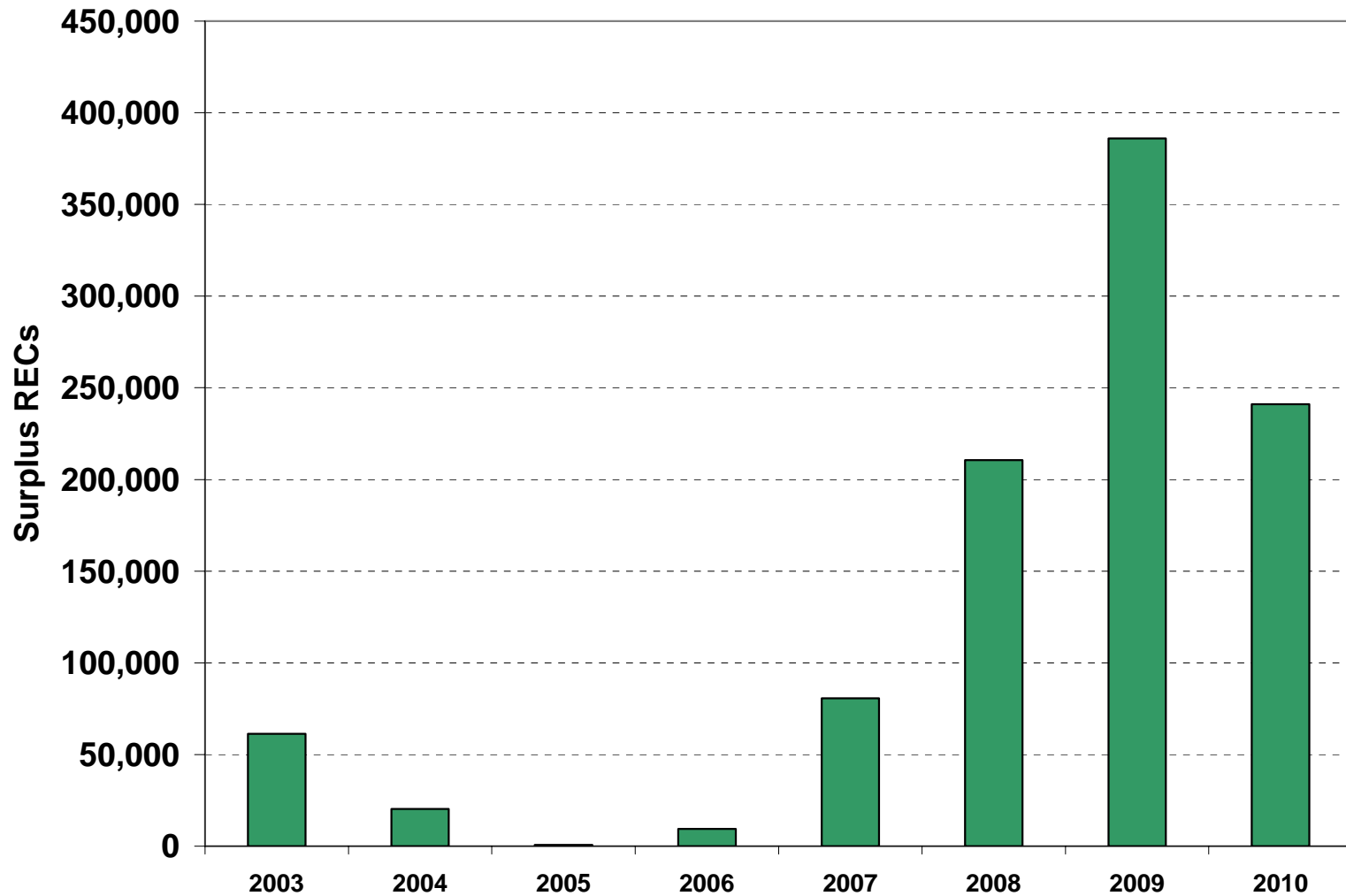
- ◆ Low ACP Proceeds Indicate Achieving RPS Goal
 - Solar Carve-Out was added for Class I in 2010



Source: MA DOER

MA RPS – Surplus RECs Banked Forward

- ◆ More RECs Generated than Needed in Recent Years



Source: MA DOER

Massachusetts Solar Development

◆ SREC Prices

- SACP rate: \$550 / MWh through 2013, reduced by 5% / yr thereafter
- MA consumers pay \$179 million / yr @ \$300 SREC floor at 400 MW
- Clearinghouse price mechanism

Power Market Impacts

◆ Capacity Prices

- UCAP value approximately 20% of nameplate rating
- Minimal price suppression

◆ Energy Prices

- On-peak load trimmed up to 400 MW
- ISO-NE can avoid dispatching high-cost resources

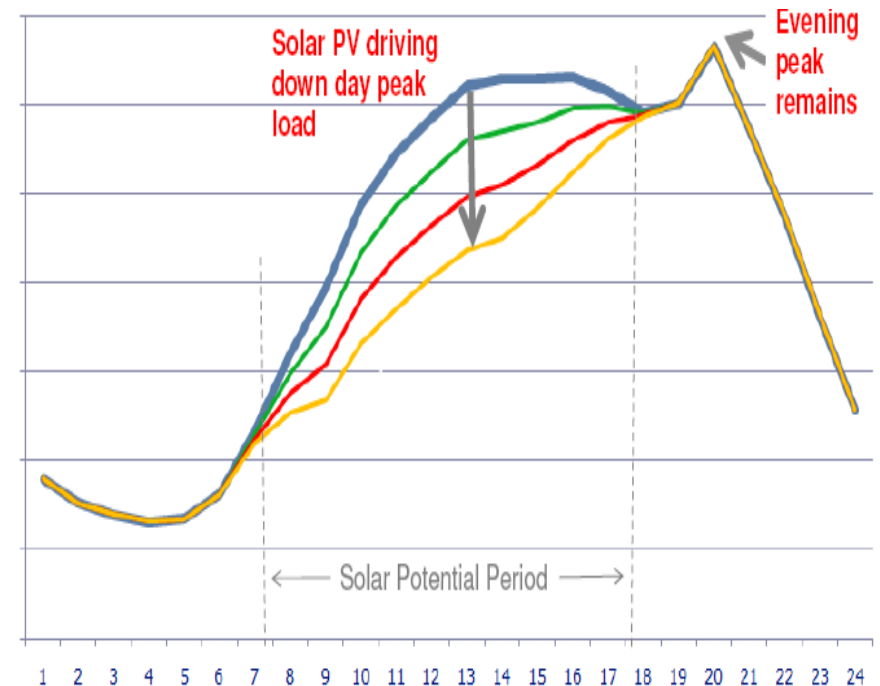
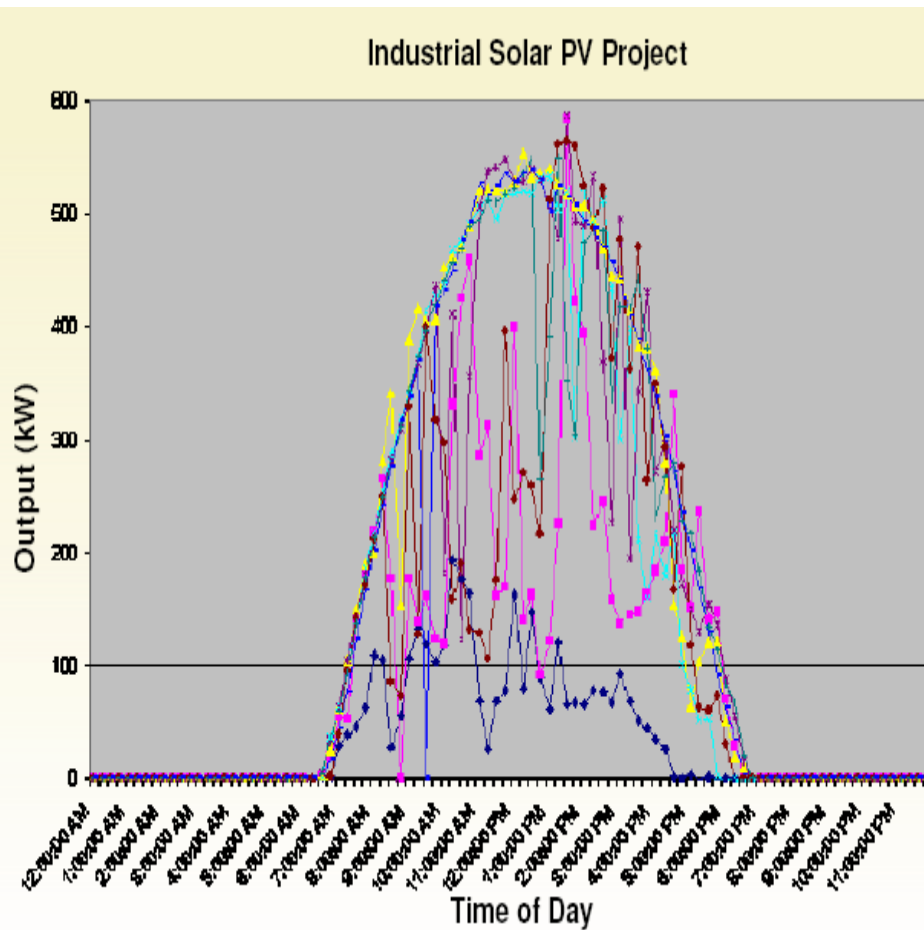
◆ System Operations

- Minimal changes expected, especially compared to wind

MA Solar Development – Energy Load Impacts

◆ Mid-Day Peak Loads “Trimmed”

- Actual “negawatts” depend on weather conditions
- Limited impact on evening peak



MA Solar Development – Energy Price Impacts

◆ Chronological Dispatch Simulation Model

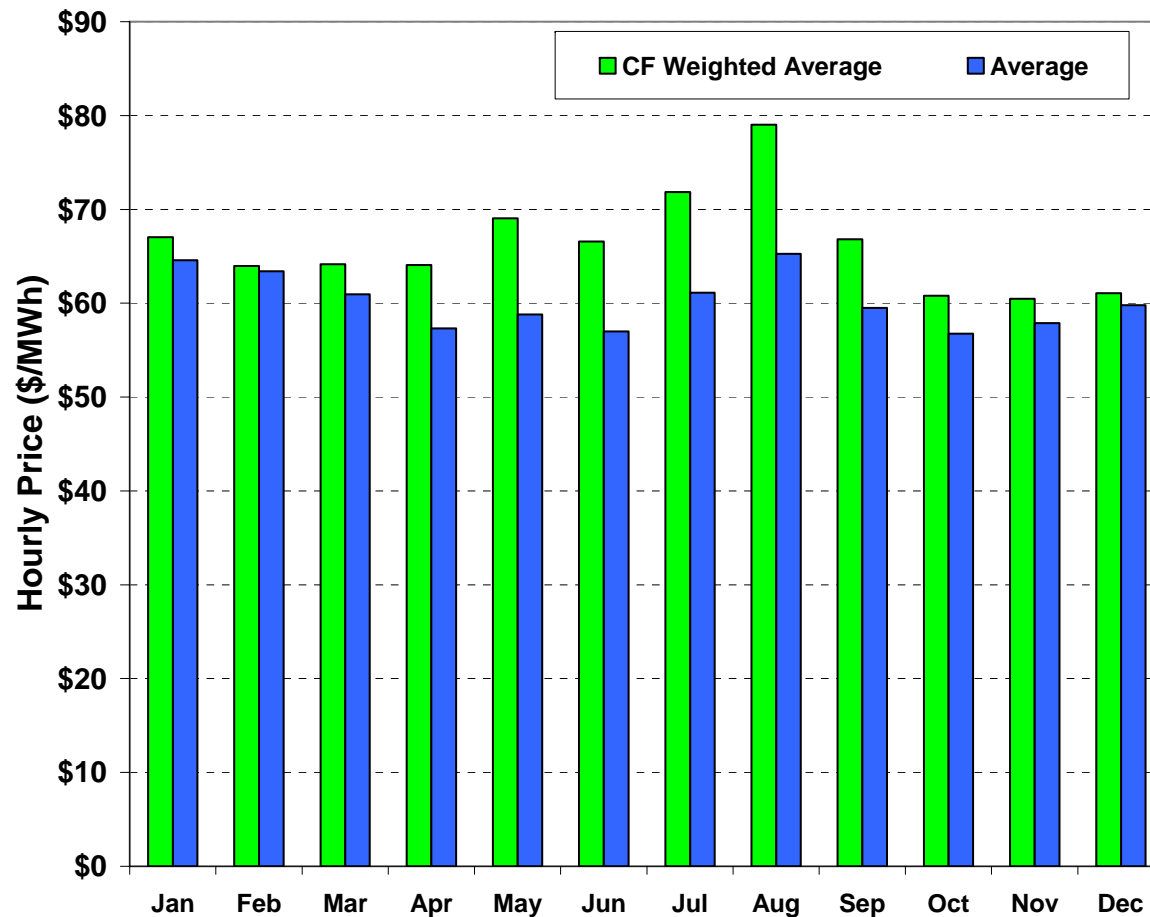
- Powerful tool required to capture system impacts
- Actual ISO-NE hourly load curves and solar production
- +50 MW / yr up to 400 MW by 2018
- Continued low gas and market energy prices
- Simulated 2013-2030 with and without new solar

◆ Simulation Model Results

- MA ratepayers will save ~\$2 million in 2013
- MA energy savings will grow to ~\$12 million by 2018
- Other New England ratepayers will save ~\$8 million / yr
Other “uplift” savings from reduced commitment costs, etc. are small

MA Solar Development – Energy Price Impacts

- ◆ 2019 Solar versus Average Hourly Prices
- ◆ ISO-NE Wholesale Power Market
 - 400 MW of in-state solar



MA Solar Dev't – System Operation Issues

- ◆ Wholesale Power Market Planning
 - Weather and net load forecasting
 - DA load planning

- ◆ System Operations
 - Load-following resources
 - Power conditioning / reactive power control
 - May not be critical at low penetration rates*

- ◆ Distribution Level Operations
 - Unintended islanding / reverse power flow
 - Customer subsidization / capping
 - Voltage regulation, harmonics

- ◆ Reduced Powerplant Emissions
 - Not addressed in this analysis

MA Solar Development – Project Definition

◆ Solar Carve-Out of Class I RPS

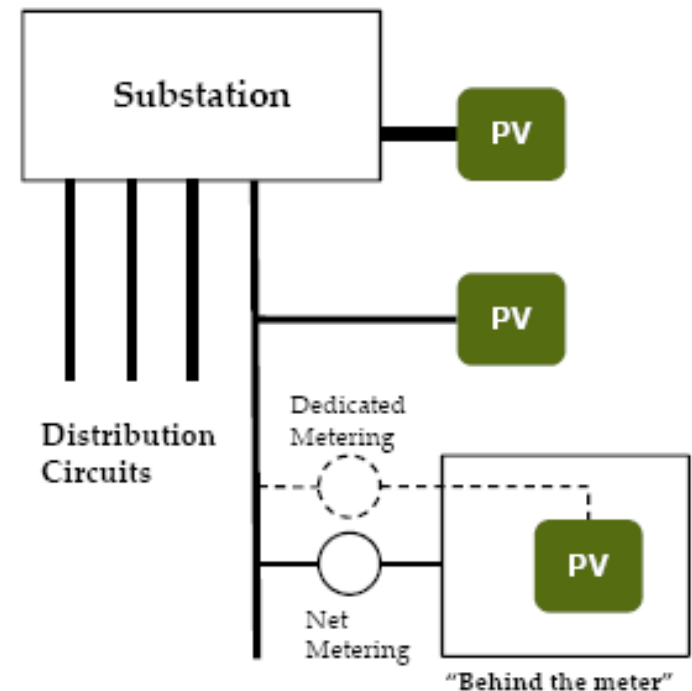
- Min standard as % of retail load
- ≤ 6 MW per parcel of land
- Auction clearinghouse pricing

◆ Three Levels of Integration

- Utility scale
- Distribution-level
- Behind-the-meter (net metering)

◆ Capital Costs Drivers

- Economies of scale
- Crystalline silicon or thin film
- Fixed-axis or single-axis



Source: Navigant, "Integrating PV on Distribution", 2011

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MA Solar Development – In-State Breakdown

◆ Solar Developed to Date

	Avg.	Totals	
	<u>Size (kW)</u>	<u>(MW)</u>	<u>Percent</u>
Residential	5.4	5.0	11.0%
Commercial / Office	70.9	13.4	29.3%
Municipal / Gov't	71.2	3.1	6.7%
College / Schools	139.2	7.8	17.1%
Agricultural	147.5	1.0	2.3%
Other	308.0	0.8	1.7%
Industrial	523.4	9.4	<u>20.6%</u>
Sub-Total			77.7%
<u>Utilities</u>	1,030.8	<u>5.1</u>	<u>11.3%</u>
Total		45.7	100.0%

Based on MA DOER data for Qualified Solar Projects as of Dec 22, 2011

MA Solar Development – Future Spending

- ◆ From 95 MW to 400 MW by 2018
 - Current panel prices and 2% escalation
 - Total investment of \$773.5 million over 6 years
 - Assumed future development:

Residential

5 kW

behind-the-meter

15% of market

~ \$45 million / yr

Commercial

216 kW

behind-the-meter

30% of market

~ \$70 million / yr

Utility-Scale

6 MW

interconnected

55% of market

~ \$125 million / yr

MA Solar Development – Capital Costs

◆ Breakdown by Project Type

	Residential <u>5 kW</u>	Commercial <u>216 kW</u> <i>(millions)</i>	Utility-Scale <u>6 MW</u> <i>(millions)</i>
• Hardware	\$16,350	\$0.60	\$16.74
• Labor	\$ 5,800	\$0.16	\$ 4.02
• <u>Indirects</u>	<u>\$ 3,200</u>	<u>\$0.10</u>	<u>\$ 2.73</u>
• Sub-total	\$25,350	\$0.86	\$23.49
• <u>Owner, misc.</u>	<u>\$ 3,042</u>	<u>\$0.10</u>	<u>\$ 2.82</u>
• Total installed	\$28,392	\$0.96	\$26.31
<i>Cost / kW</i>	<i>\$5,678</i>	<i>\$4,458</i>	<i>\$4,385</i>

Source : NREL, adjusted by Levitan & Associates, Inc.

Consistent with MA DOER data for Qualified Solar Projects as of Dec 22, 2011.

Informal discussions indicate 2012 commercial / utility costs could be \$4,000/kW.

MA Residential Solar – Costs and Revenues

◆ 5 kW Behind-the-Meter

◆ Capital Cost

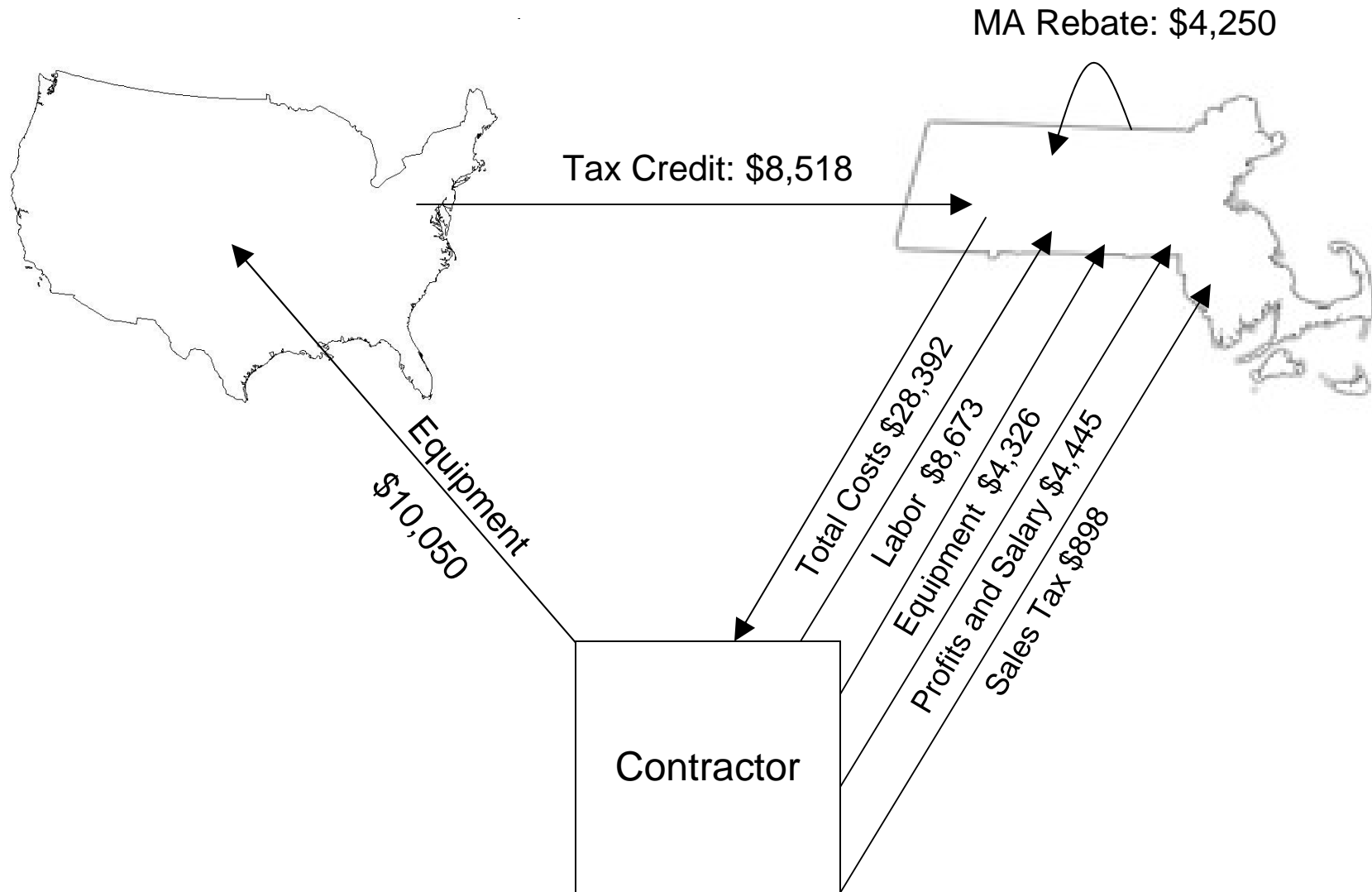
- Cost estimate \$28,392
- Federal 30% solar tax credit \$ 8,518
- MA solar rebate (max) \$ 4,250
- Net cost \$15,624

◆ Annual Revenues

- Energy gen @ 17% c.f. 7,400 kWh/yr
- Savings @ 15.3¢/kWh* \$1,142 / yr
- SREC rev.s @ \$300/MWh \$2,234 / yr
- Total (first year) \$3,376 / yr

** Assumes full retail value of solar generation*

MA Residential Solar – Capital Cost Flows



MA Commercial Solar – Costs and Revenues

◆ 216 kW Behind-the-Meter

◆ Capital Cost

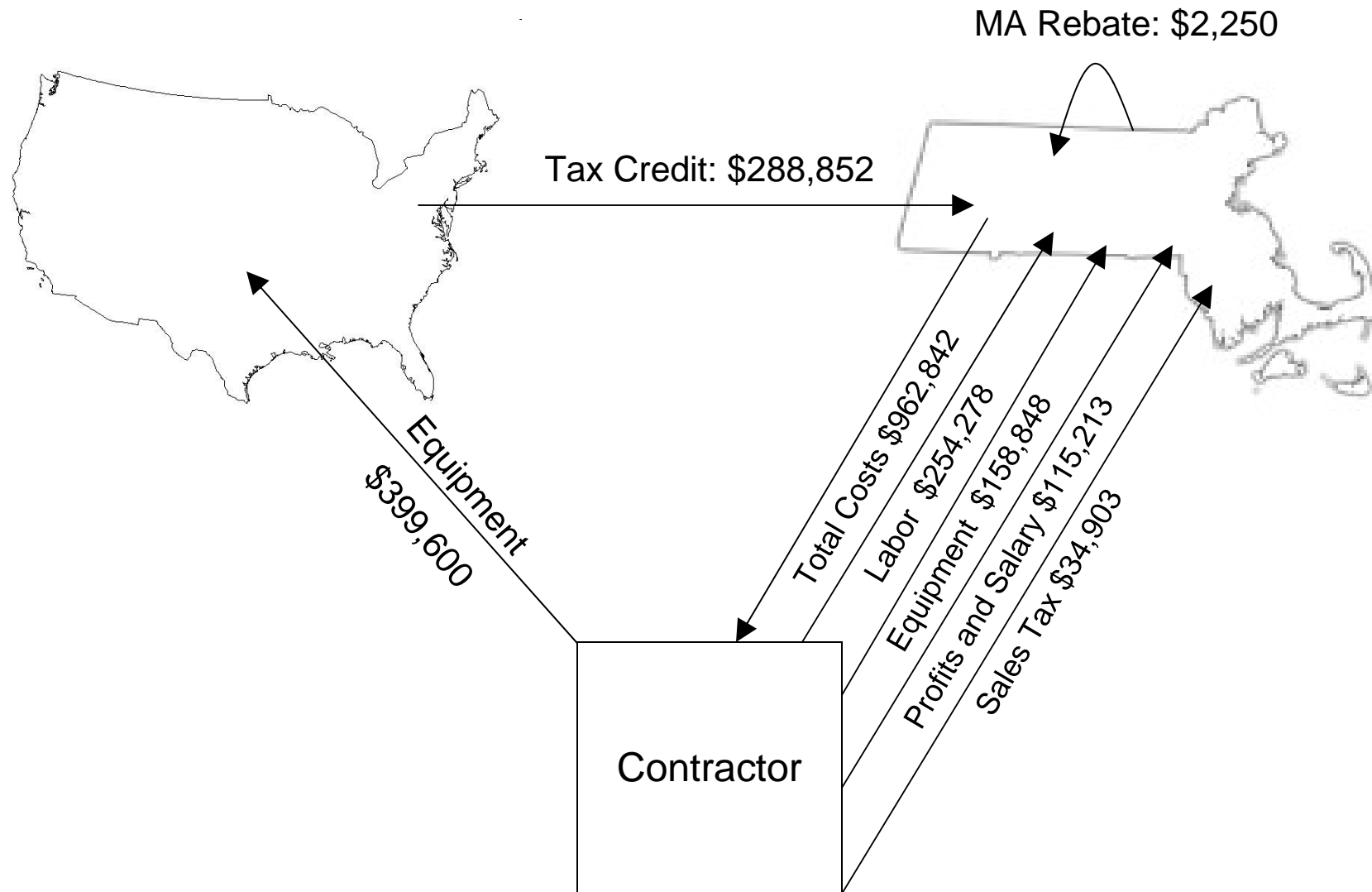
• Cost estimate	\$ 962,842
• Federal 30% solar tax credit	\$ 288,852
• MA solar rebate (max)	<u>\$ 2,250</u>
• Net cost	\$ 671,739

◆ Annual Revenues

• Energy gen @ 17% c.f.	321.7 MWh/yr
• Savings @ 9.42¢/kWh*	\$ 30,301 / yr
• SREC rev.s @ \$300/MWh	<u>\$ 96,500 / yr</u>
• Total (first year)	\$ 126,801 / yr

* Assumes full retail value of solar generation

MA Commercial Solar – Capital Cost Flows



MA Utility-Scale Solar – Costs and Revenues

◆ 6 MW Interconnected to the Grid

◆ Capital Cost

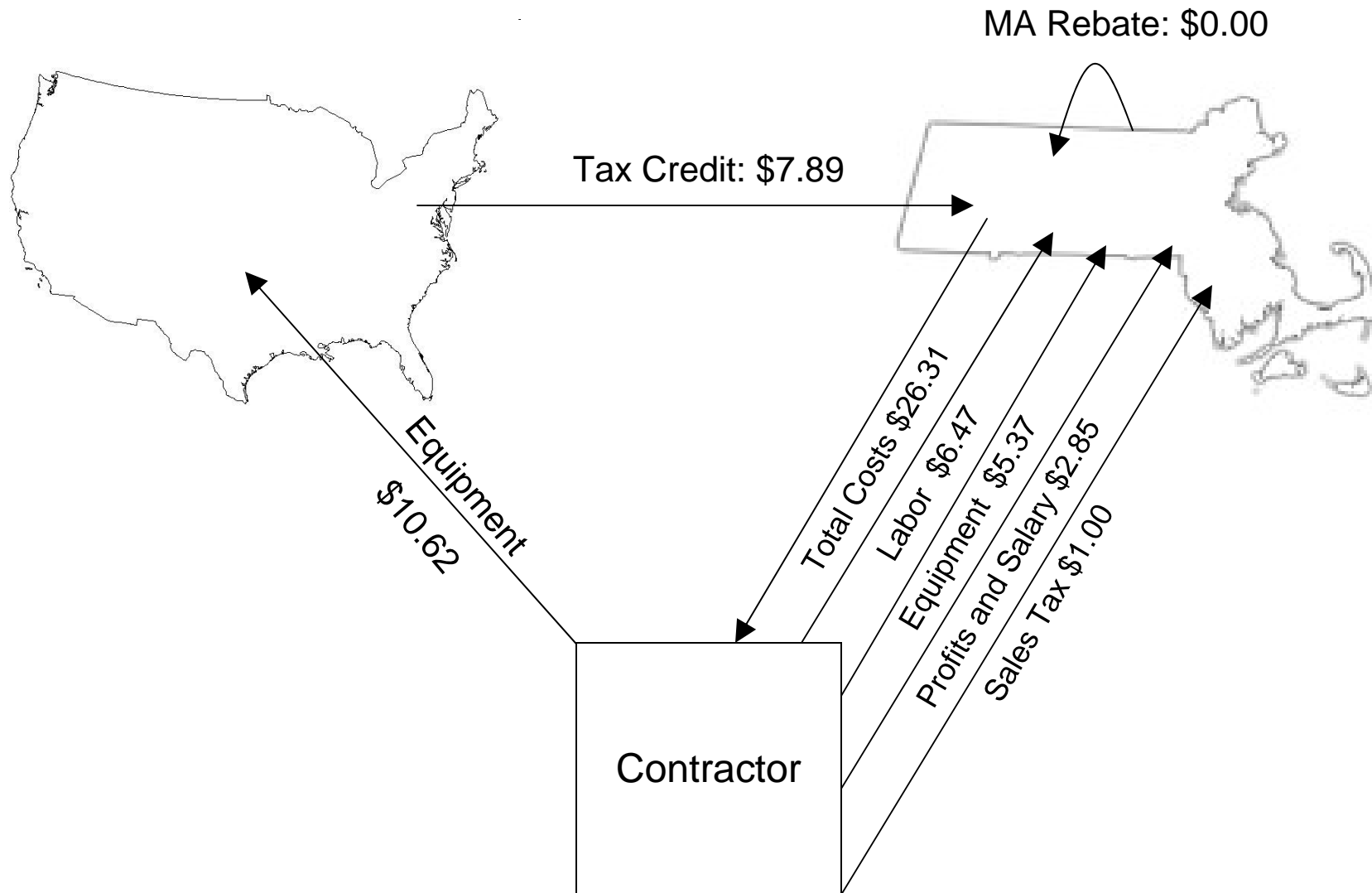
• Cost estimate	\$ 26.31 million
• Federal 30% solar tax credit	\$ 7.89 million
• MA solar rebate (max)	<u>\$ 0.00 million</u>
• Net cost	\$ 18.42 million

◆ Annual Revenues

• Energy gen @ 17% c.f.	8,935.2 MWh/yr
• Energy rev.s @ 3.27 ¢/kWh*	\$ 292,168 / yr
• SREC rev.s @ \$300/MWh	<u>\$2,680,560 / yr</u>
• Total (first year)	\$2,972,728 / yr

* Assumes wholesale value of solar generation

MA Utility-Scale Solar – Capital Cost Flows



Note: \$ millions

MA Solar Development – Conclusions

◆ Wholesale Power Market Impacts

- Complicated combination of commitment and dispatch changes
- About 60% of energy savings in MA
- Wind expected to grow but require load-following and reserves
- Solar relatively small with complex load impacts

Best estimated by chronological dispatch simulation models

◆ Socio-Economic Impacts

- Can't ignore jobs, local spending, property taxes, etc.
- Difficult to “follow the money” in-state v out-of-state

Best estimated by economic input-output models

Appendix

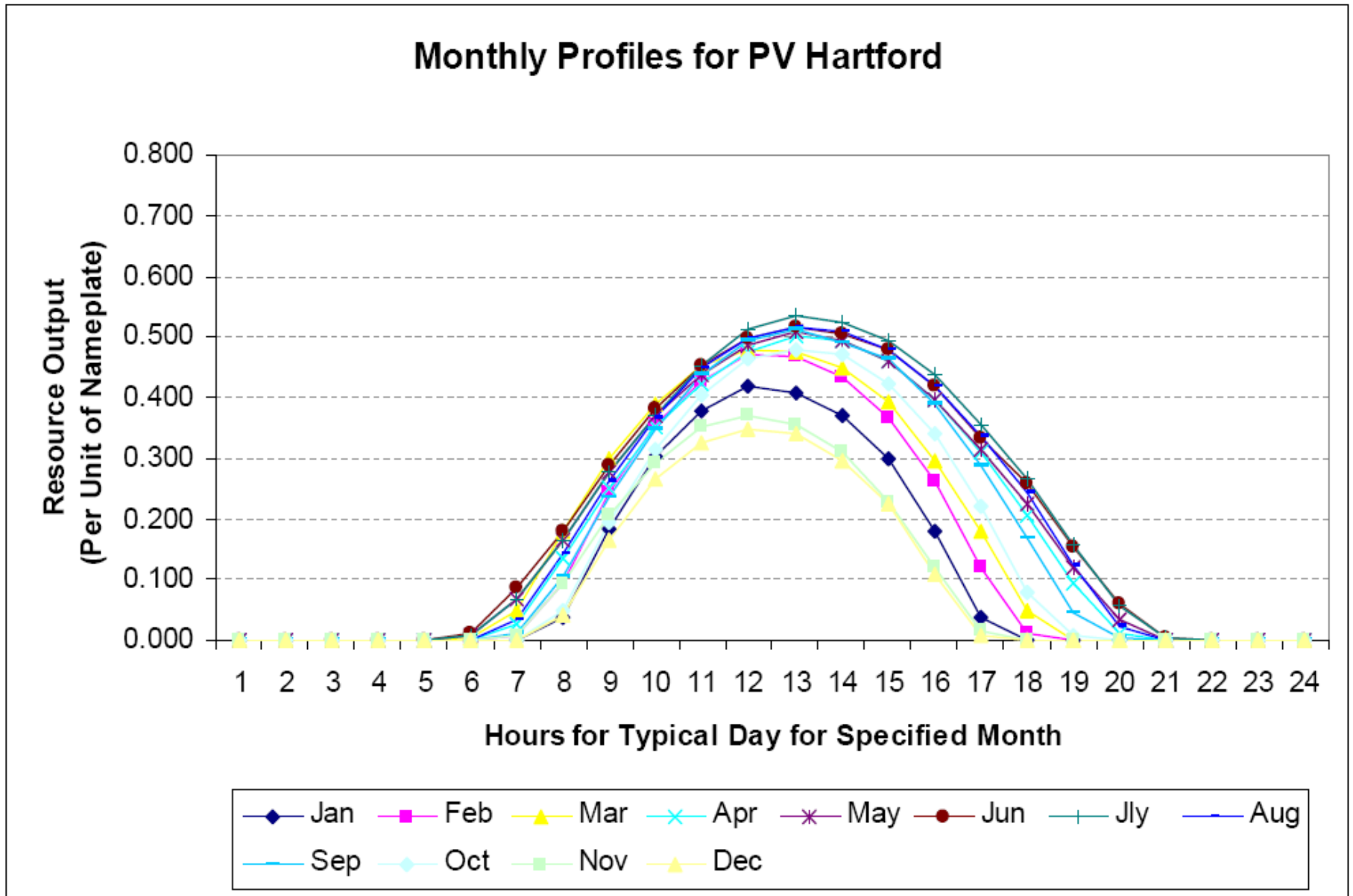
- ◆ Solar PV Generation Profiles

- Hartford
- Boston

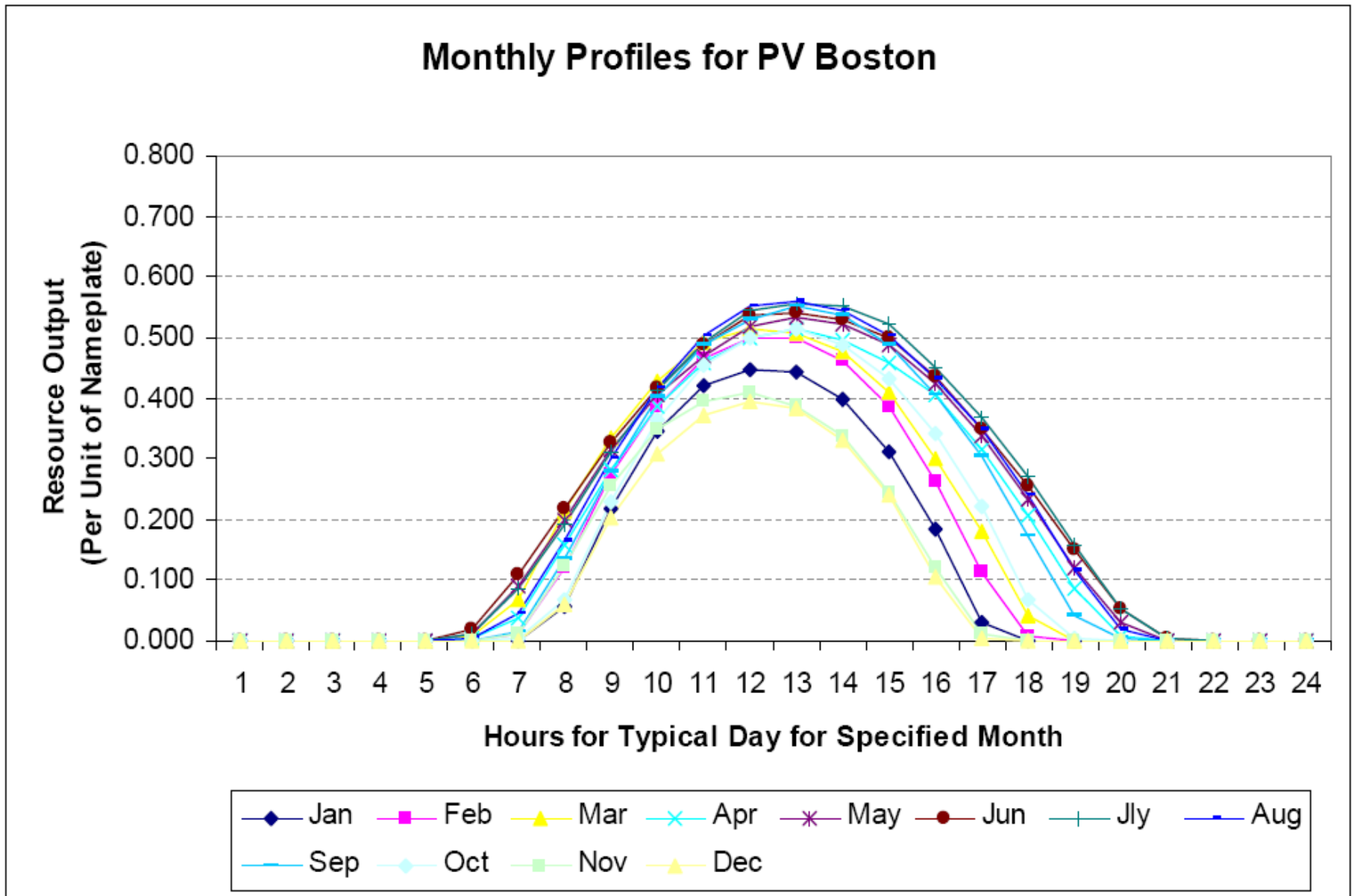
- ◆ Solar PV Capacity Factors

- Hartford
- Boston

Solar PV Generation Profile - Hartford



Solar PV Generation Profile - Boston



Solar PV Capacity Factors

Monthly Capacity Factors - Photovoltaic Sites

