



The Parker Ranch installation in Hawaii

Installed Solar System Prices

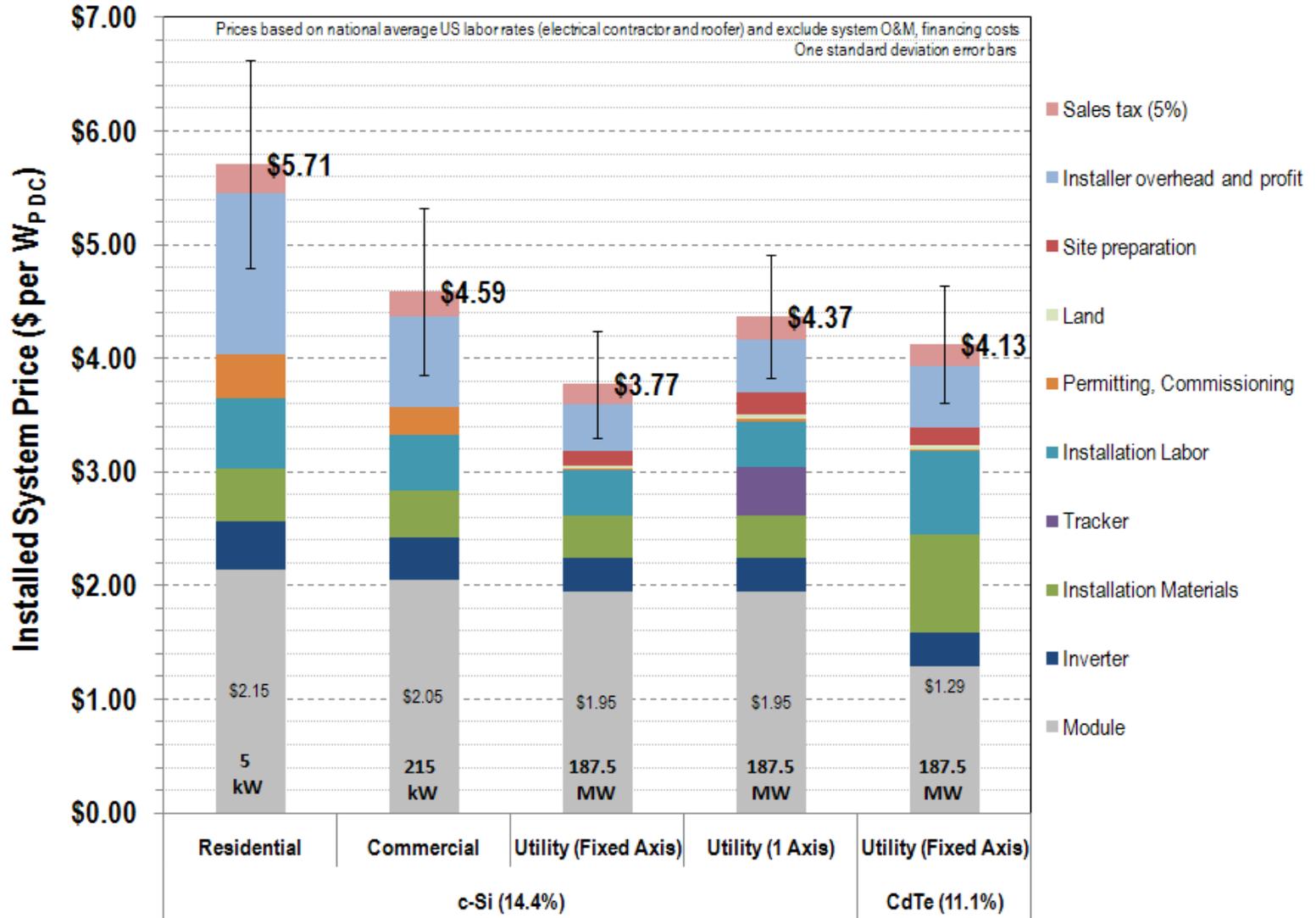
Solar Energy Technology Program

February 22, 2011

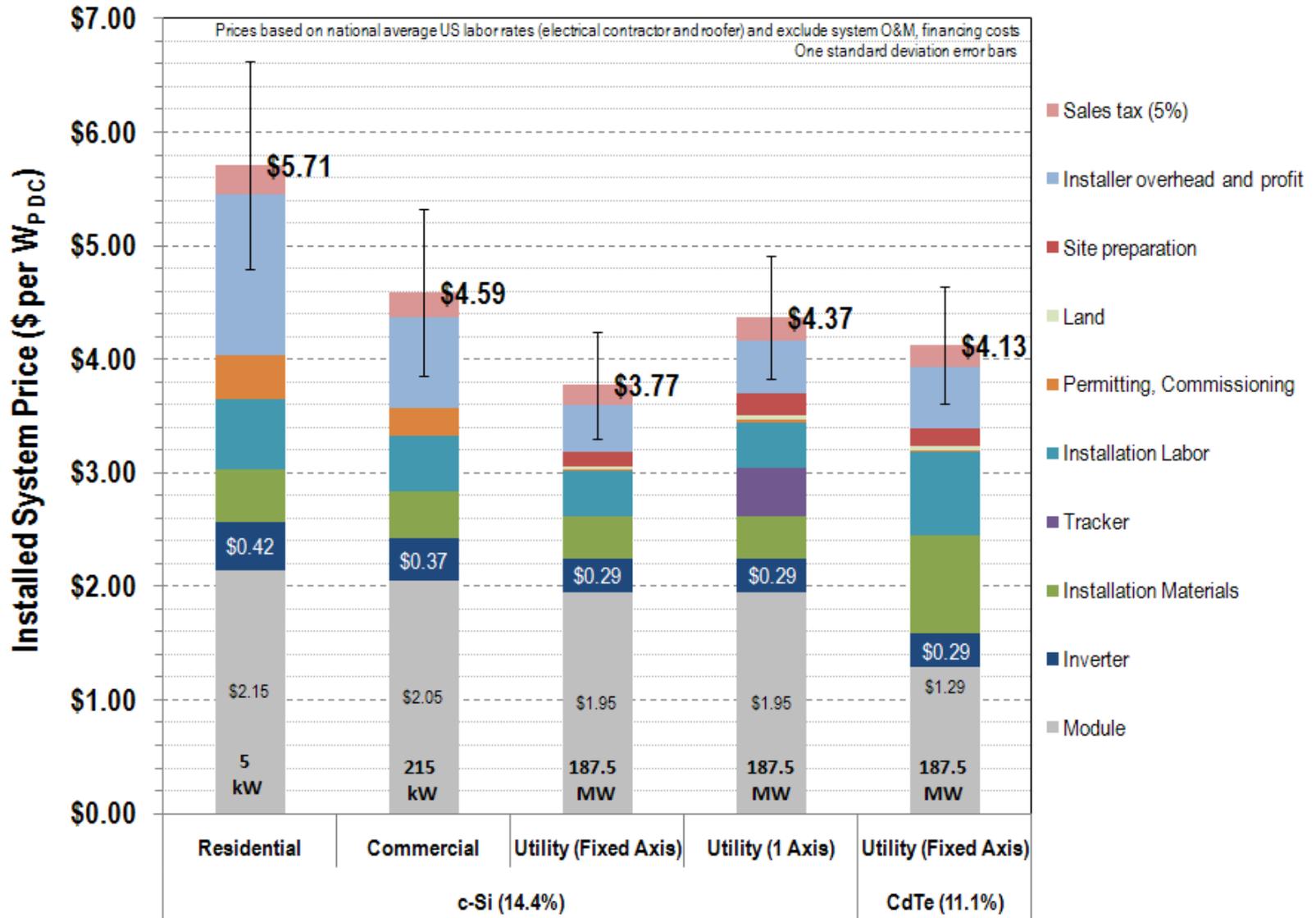
Kevin Lynn

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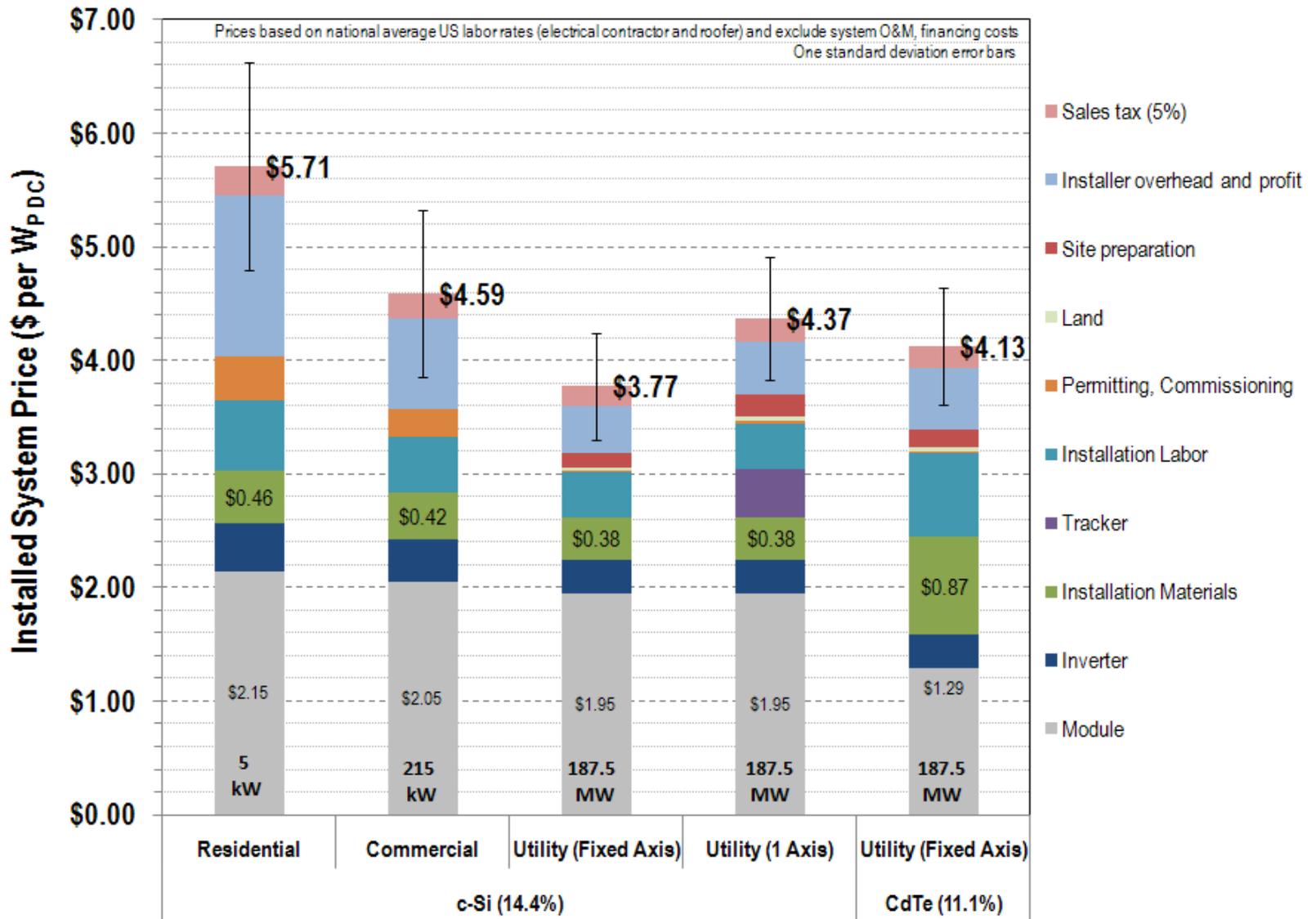
NREL System Price Model: Q4 2010 Results



NREL System Price Model: Q4 2010 Results



NREL System Price Model: Q4 2010 Results





•Installation Materials

- Modules
- Racking, through roof mounts
- DC wiring, combiner boxes, disconnect, conduit and connectors
- Inverter
- AC wiring, meter, monitoring, disconnect, conduit and connectors

•Installer Markup:

- Inventory and contingency costs



•Labor content, rates:

- Labor type (electrical, hardware)
- Installation time per component
- Overhead
- Installer profit

•Indirect capital costs:

- Local and utility permitting
- Commissioning
- Sales tax

NREL PV System Price Model: Utility Scale



• Installation Materials:

- Modules
- Racking, ground mounts (tracker)
- DC wiring, combiner boxes, disconnect, conduit and connectors
- Inverter
- AC wiring, meter, monitoring, disconnect, conduit and connectors

• Land, Site Preparation

- Land purchase, or lease
- Leveling, plant removal, sediment control, roads, fencing, surface treatment

• Installer markup

- Inventory and contingency costs

• Labor content, rates:

- Labor type (electrical, hardware)
- Installation time per component
- Overhead
- Installer profit

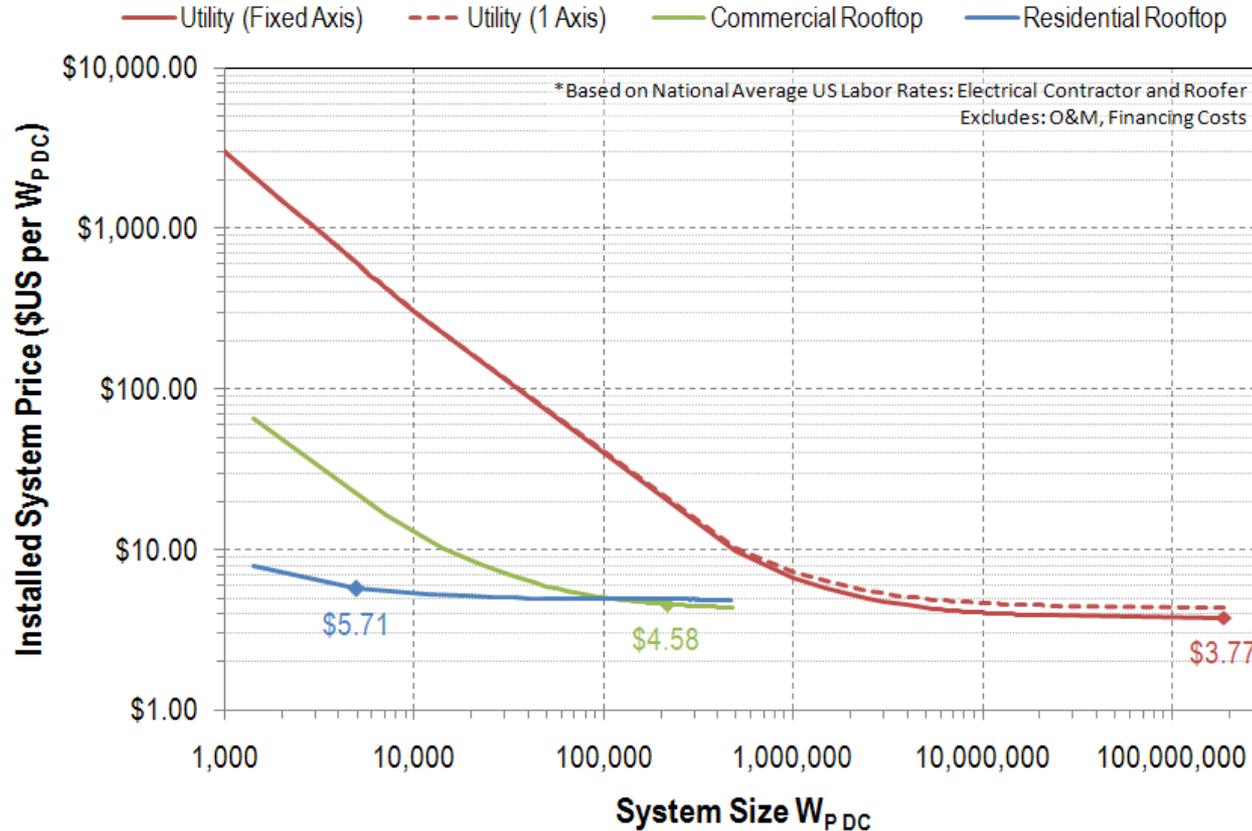
• Indirect capital costs:

- Environmental permitting
- Grid interconnect (materials, labor)
- Sales tax

Results May Vary: e.g. Economies of Scale

Solar PV System Prices: Sensitivity to Project Size

Source: NREL internal cost models



- Based on project specifics, difficult to make comparisons ...even within a single market sector.

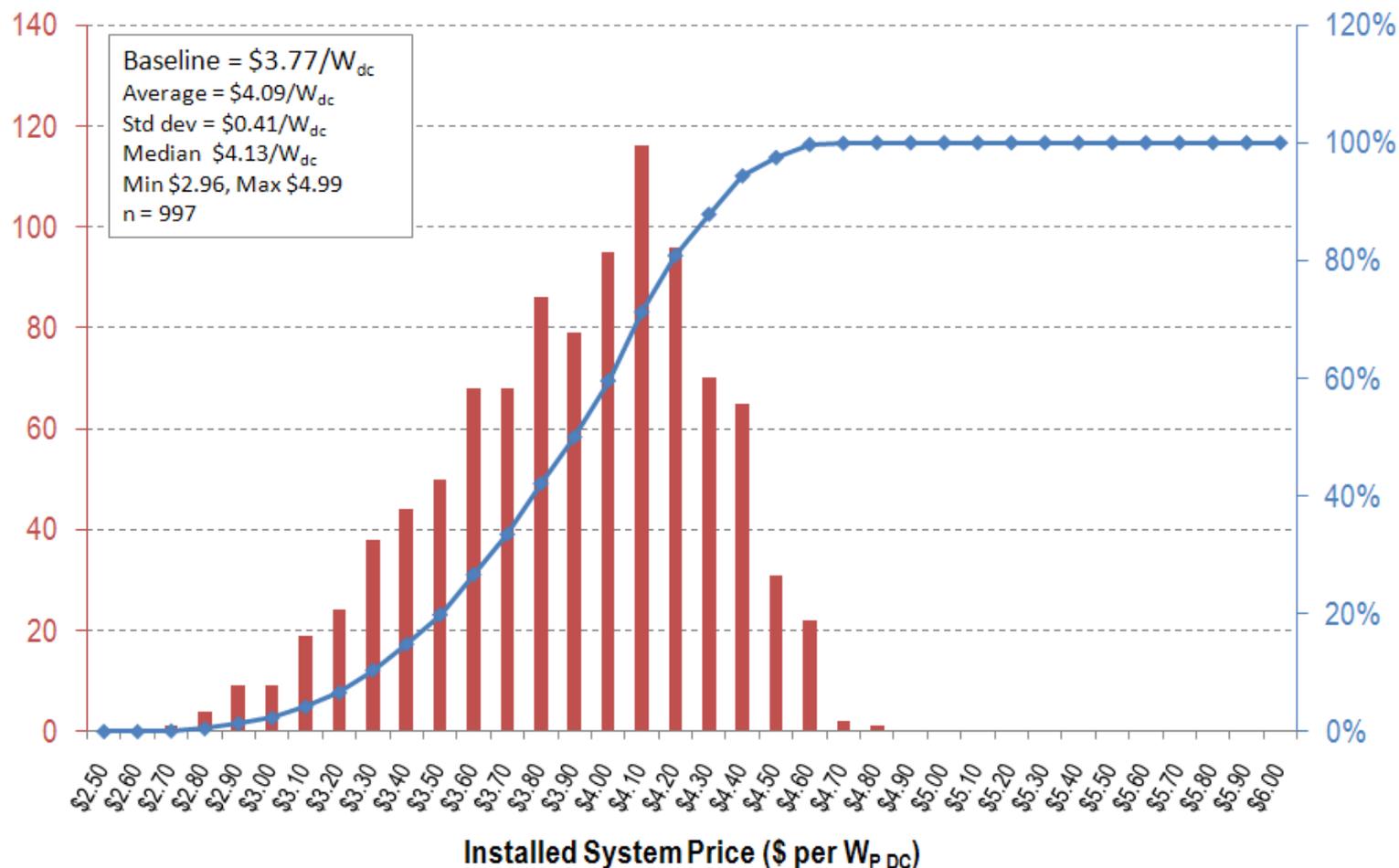
Utility Scale PV: Uncertainty Analysis (1)

- Regional cost differences
 - Labor rates
 - Installer productivity
 - Permitting and delays
 - Land costs
- Technology selection
 - Module efficiency
 - Configuration
- Economies of scale
 - Project size (indirect costs)
 - Installer purchasing power

| | Sensitivity variables: | Minimum | Maximum | Baseline |
|----|------------------------|-------------|-------------|-------------|
| 1 | Module Price | \$1.13 | \$3.80 | \$1.95 |
| 2 | Inverter Price | \$0.23 | \$0.38 | \$0.29 |
| 3 | Module Efficiency | 12.90% | 15.50% | 14.40% |
| 4 | Electrical Labor Rate | \$16.66 | \$81.34 | \$49.00 |
| 5 | Hardware Labor Rate | \$11.25 | \$54.95 | \$33.10 |
| 6 | Materials Markup | 2% | 25% | 10% |
| 7 | Installer Overhead | 10% | 32% | 16% |
| 8 | Installer Profit | 9% | 30% | 10% |
| 9 | Permitting | \$400,000 | \$1,000,000 | \$1,000,000 |
| 10 | Grid Interconnect | \$1,500,000 | \$3,000,000 | \$1,600,000 |
| 11 | Land Acquisition | \$500 | \$105,000 | \$6,000 |
| 12 | Land Prep. | \$14,000 | \$35,000 | \$25,000 |
| 13 | System Size | 1,000,000 | 290,000,000 | 20,000,000 |
| 14 | Worker Productivity | 0.75 | 1.25 | 1.00 |
| 15 | Land use | 0.90 | 1.83 | 1.00 |

Utility Scale PV: Uncertainty Analysis (2)

2010 Fixed Axis Utility Scale PV System Price: NREL internal model, Sensitivity to (15) Key Variables



| | Non-Module Hardware Costs | Inverter Costs ¹ |
|------------------|------------------------------|--------------------------------|
| Residential | \$0.60 31% | \$0.42 20% |
| Commercial | \$0.50 29% | \$0.37 16% |
| Utility (fixed) | \$0.41 25% | \$0.29 14% |
| Utility (1 axis) | \$0.88 32% | \$0.29 13% |

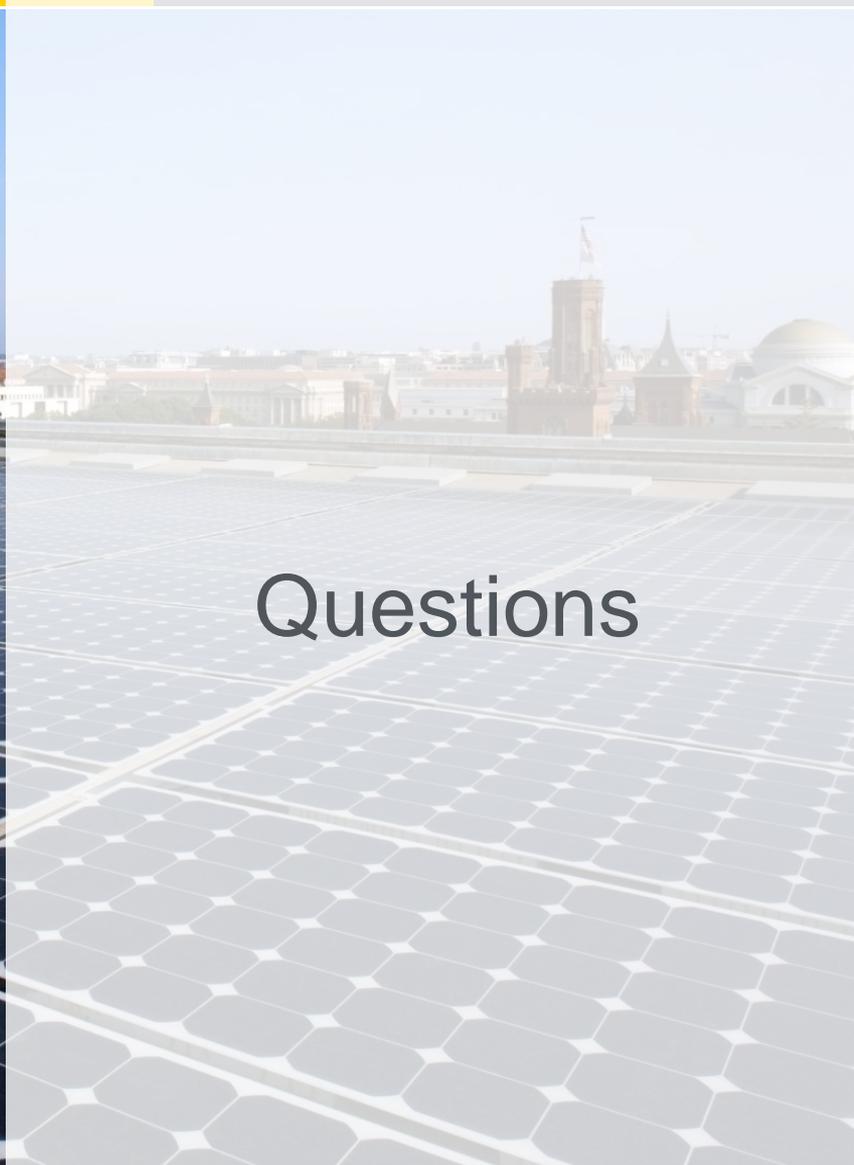
Includes installer markup on materials (inventory and contingency costs).

Inverter prices include transformer.

- Non-module hardware costs: 25-30% of system prices
- Labor costs: 13-20% of system prices
- Indirect costs: 5-7% of system prices
- Residential PV installer overhead (54%) more than 3x national average for electrical contractors
 - Reflects higher cost of doing business (regulatory, productivity, etc.)

- Alan Goodrich
 - Michael Woodhouse
 - Ted James
 - Robert Margolis
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 - Kristen Ardani
 - John Bartlett
-
- *Many industrial collaborators for their willingness to share data and to provide invaluable external review.*
 - *Many colleagues at NREL who contributed through both formal and informal discussions.*

Thank You



| | Residential Rooftop | Commercial Rooftop | Ground Mount Utility* |
|--|------------------------|-----------------------|--------------------------|
| System size (kWp dc) | 5.0 | 216 | 187,500 |
| | | | *Fixed axis |
| <u>Bill of Materials</u> | \$/Wp dc | \$/Wp dc | \$/Wp dc |
| Module | \$2.15 | \$2.05 | \$1.95 |
| Mounting (racking) hardware | \$0.30 | \$0.30 | \$0.20 |
| Storage | \$0.00 | \$0.00 | \$0.00 |
| Inverter | \$0.42 | \$0.37 | \$0.29 |
| Combiner boxes | \$0.00 | \$0.00 | \$0.01 |
| Meter | \$0.02 | \$0.04 | \$0.00 |
| System Monitor | \$0.09 | \$0.03 | \$0.00 |
| DC, AC-Disconnects | \$0.01 | \$0.01 | \$0.00 |
| Combiner boxes | \$0.02 | \$0.02 | \$0.00 |
| Fuses and Holders | \$0.01 | \$0.01 | \$0.00 |
| DC, AC-Wiring (conduit) | \$0.02 | \$0.02 | \$0.16 |
| | <hr/> | <hr/> | <hr/> |
| | \$3.03 | \$2.83 | \$2.62 |
| Markup on materials ¹ | \$0.89 | \$0.55 | \$0.27 |
| | <hr/> | <hr/> | <hr/> |
| | \$3.91 | \$3.38 | \$2.88 |
| ¹ <u>Markup on materials assumptions:</u> | 30% | 20% | 10% |

| | Residential Rooftop | Commercial Rooftop | Ground Mount Utility* |
|---|------------------------|-----------------------|--------------------------|
| System size (kWp dc) | 5.0 | 216 | 187,500 |
| Labor Costs | | | |
| Electrical hours | 24.9 | 656.3 | 1,030,529.6 |
| Hardware hours | 39.8 | 1,651.2 | 328,116.6 |
| | 64.7 | 2,307.5 | 1,358,646.2 |
| Electrical | \$0.30 | \$0.18 | \$0.33 |
| Hardware | \$0.33 | \$0.31 | \$0.07 |
| Overhead ² | \$0.34 | \$0.16 | \$0.06 |
| Profit ² | \$0.19 | \$0.10 | \$0.09 |
| | \$1.16 | \$0.75 | \$0.55 |
| ² <u>Labor overhead and profit margin assumptions:</u> | | | |
| <i>Worker's Compensation Insurance</i> | 6.4% | 6.4% | 6.4% |
| <i>Federal and State Unemployment Insurance</i> | 6.2% | 6.2% | 6.2% |
| <i>Social Security Taxes (FICA)</i> | 7.7% | 7.7% | 7.7% |
| <i>Builder's Risk Insurance</i> | 0.4% | 0.4% | 0.4% |
| <i>Public Liability</i> | 2.0% | 2.0% | 2.0% |
| <i>Operating Overhead</i> | 54.0% | 32.0% | 16.0% |
| <i>Profit</i> | 30.0% | 20.0% | 10.0% |

| | Residential Rooftop | Commercial Rooftop | Ground Mount Utility* |
|--|------------------------|-----------------------|--------------------------|
| System size (kWp dc) | 5.0 | 216 | 187,500 |
| <u>Owner and Indirect Project Costs</u> | | | |
| Environmental, Utility Permitting | \$0.08 | \$0.23 | \$0.01 |
| Commissioning/Grid interconnect | \$0.30 | \$0.01 | \$0.01 |
| Land Purchase | \$0.00 | \$0.00 | \$0.03 |
| Site Preparation | \$0.00 | \$0.00 | \$0.13 |
| Sales Tax ³ | \$0.26 | \$0.21 | \$0.18 |
| | <hr/> | <hr/> | <hr/> |
| | \$0.64 | \$0.45 | \$0.34 |
| <u>Total System Price:</u> | \$5.71 | \$4.58 | \$3.77 |

³ Sales tax assumption: 5%