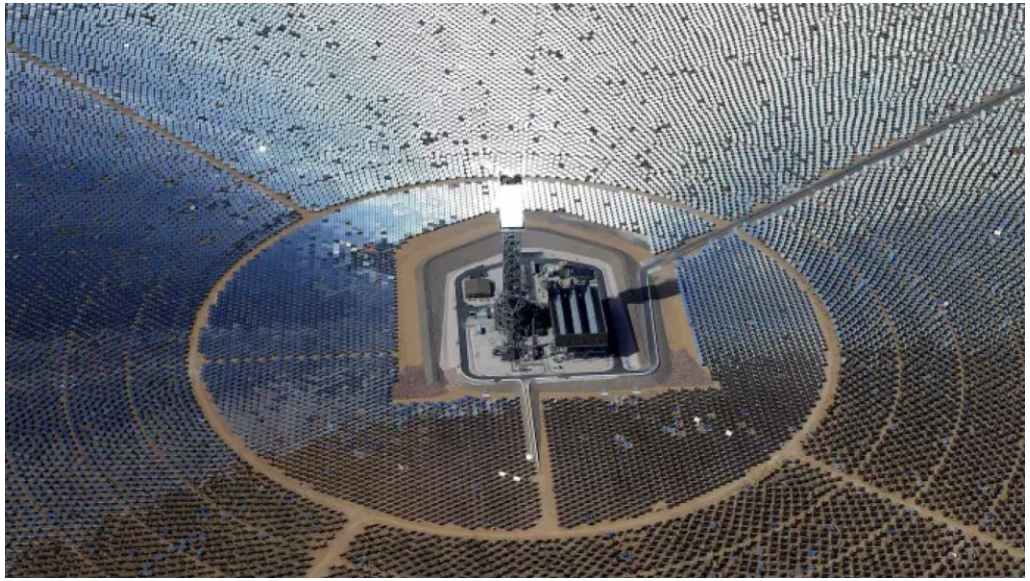
SEMINARIO

# BIOECONOMÍA Y ENERGÍAS RENOVABLES EN EL CRECIMIENTO VERDE



Luiz T. A. Maurer, The World Bank Group

Cali, September 26, 2017

# AGENDA

- Scope of this presentation
- What is happening in the world in the NCRE space?
- Are NCRE cost-effective?
- Key regulations to spur NCRE
- A case-study on distributed generation
- Opportunities for Colombia

# Scope of this presentation

# Scope of today's discussion on Renewables

- Non Conventional Renewables (NCRE)
  - Primarily Solar and Wind - and PV within solar category
  - Both utility scale and "behind the meter"
  - Both grid-connected and off-grid – but primarily the former
  - Just a subset of the NCRE space – which also includes biomass, mini-hydro

- NCRE is a subset of the broad renewables category, which also includes large hydro (no semantic discussion on being renewables or not)
- Neither are those NCRE the solution for the climate challenges – Energy Efficiency alone should be responsible for 45% of the expected GHG reduction

- The intent here is to focus on NCRE technologies that have been evolving rapidly and have grown at unprecedented pace – and therefore have the potential to transform the power industry

# Those technologies are also perfectly aligned with cleaner energies and climate objectives (WRI)

| ALIGNED | CONDITIONAL | MISALIGNED | CONTROVERSIAL |
|---|---|---|---|
| **Fully aligned with 2°C consistently in all scenarios analyzed** | **2°C aligned only under certain conditions in all scenarios analyzed** | **Consistently misaligned with 2°C in all scenarios analyzed** | **2°C aligned in some scenarios, but not in others (including because of significant social and environmental risks/tradeoffs)** |
| ■ Renewable energy | ■ Gas-fired power plants | ■ New coal-fired power plants with unabated emissions over their lifetime (no CCS) | ■ Biofuels |
| ■ Energy storage | ■ Electricity transmission and distribution (T&D) infrastructure[a] | ■ New coal production (no CCS)[b] | ■ Large hydropower |
| ■ Solar PV | ■ District heating | ■ Heavy fuel oil/light fuel oil power plants[c] | ■ Bioenergy carbon capture and storage |
| ■ Concentrated solar power (CSP) | ■ Minigrids | ■ Diesel-fired power[c] | ■ Nuclear |
| ■ Wind | ■ Energy mix | | ■ Carbon capture and storage (CCS) |
| ■ Small hydropower | ■ Hybrid | | ■ Oil and gas production |
| ■ Geothermal | ■ Fuel-switching | | |
| ■ Biomass | ■ Municipal solid waste to energy | | |
| ■ Biogas | | | |

# Most NCRE technologies are responsible for ongoing disruptions in the power sector

| UTILITY SECTOR DISRUPTIVE CHALLENGES | | | | |
|---|---|---|---|---|
| **TECHNOLOGIES** | **CLIMATE CHANGE PRESSURES** | | **STRUCTURAL MARKET CHANGES** | **DEMAND SIDE PARTICIPATION** | **URBANIZATION** |
| 1) Solar<br>2) Wind<br>3) DG/DR<br>4) Storage<br>5) Electric Vehicles<br>6) Smart Energy/Systems<br>7) Natural Gas Fracking | * Mitigation - or greening the grid | * Adaptation -- or making the system more resilient to climate events | * Distributed Generation Revenue Erosion<br>* Electric Cars Charging Stations<br>* Air Conditioning and Cooling Loads | * Demand Side Management<br>* Demand Response<br>* Load Control<br>* Time of Use Rates<br>* Crisis Management | * Urbanization Trends<br>* Increasing Reliability of Supply<br>* District Energy and Smart Cities |

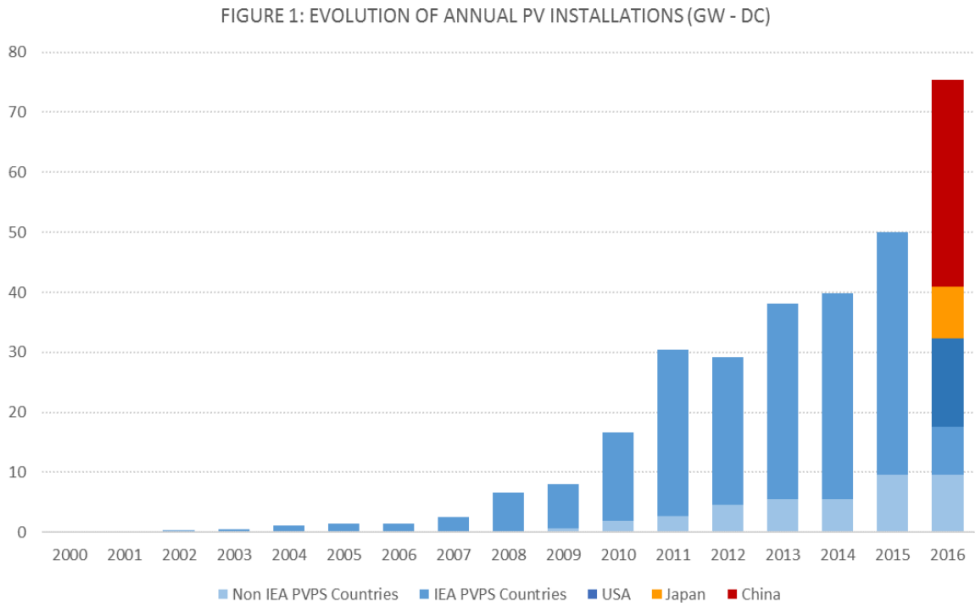
# What is happening in the world in the NCRE space?

# The beginning of wind and solar

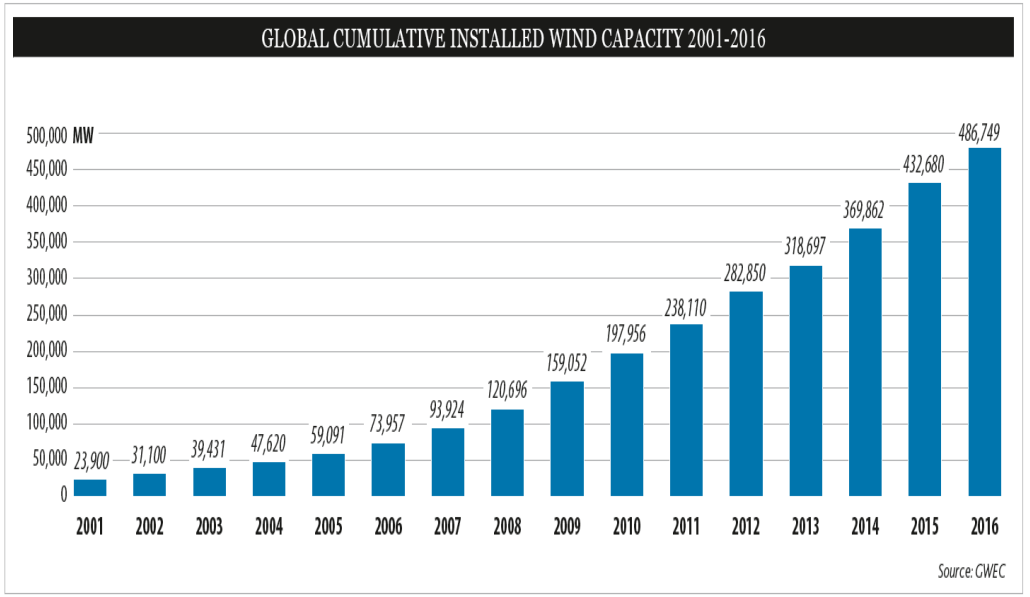
- Lab scale, niche application
- Adoption by tree-huggers
- Extremely expensive – US$ 239 for a 13 Watt PV panel (1981)
- California wind farm with 200 kW generators was a tourist attraction – today 3,500 – 4,000 kW are the norm
- Until 2010-2011 – large scale on-shore wind was already commercial, but still some skepticism that PV could one day be economically sustainable
- Those two technologies are today “in the money” and compete with traditional sources of energy
- But issues remain today on how intermittency should be managed and priced

# Impressive growth in NCRE capacity

**Cumulative Solar = 303 GW**

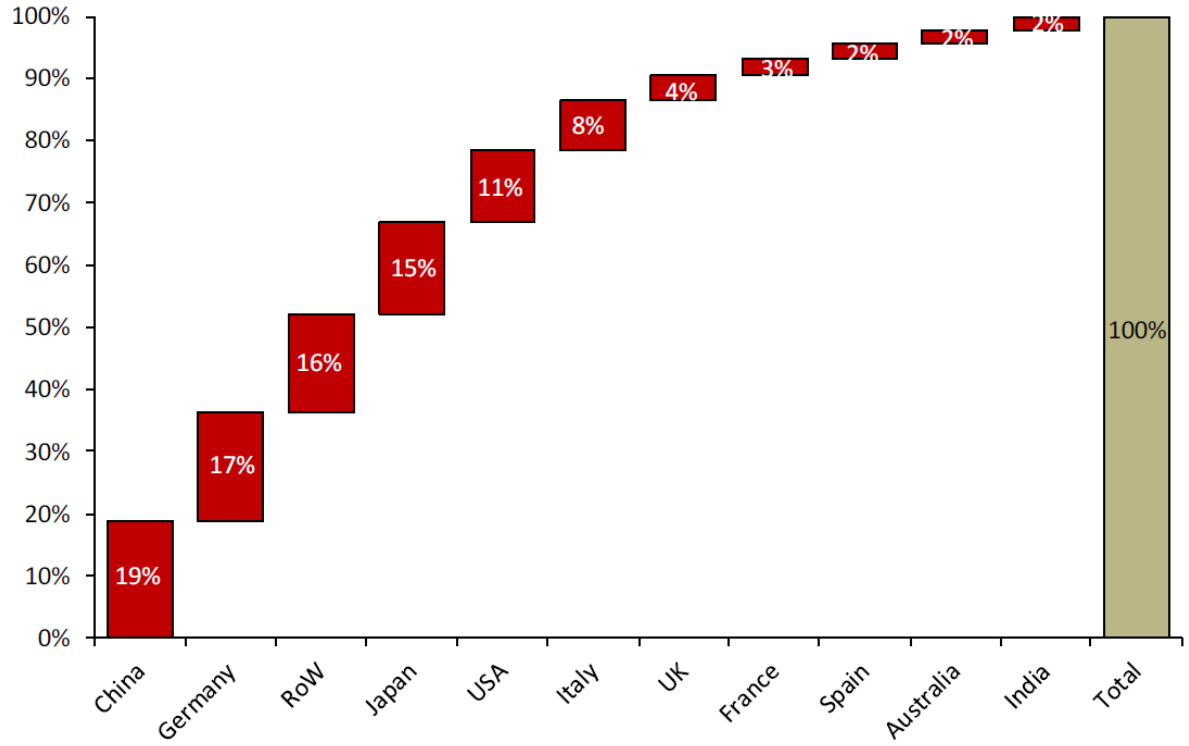



**Cumulative Wind = 487 GW**



# World wide leaders in NCRE

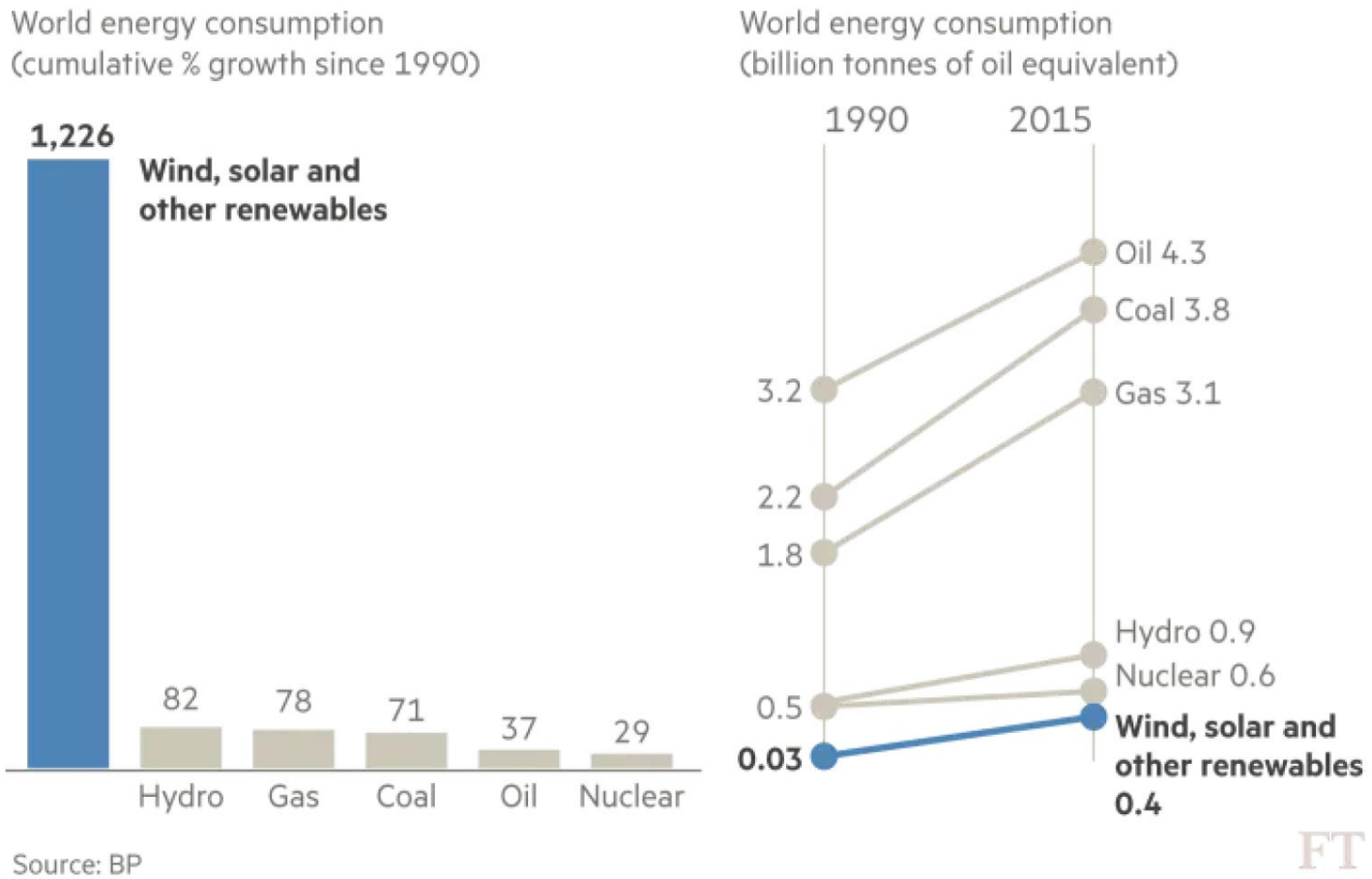
# Leaders in Solar Installations




Note: ROW: Rest of the World

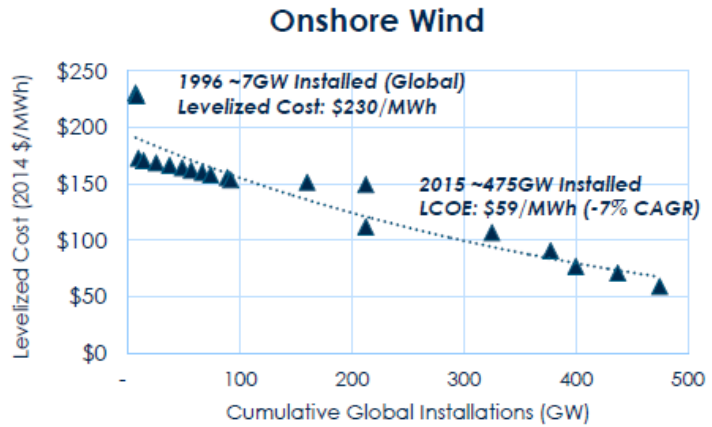
Source: Solar Power Europe Global Market Outlook for Photovoltaics until 2020, Solar Power Europe Market Report 2016; CREARA Analysis

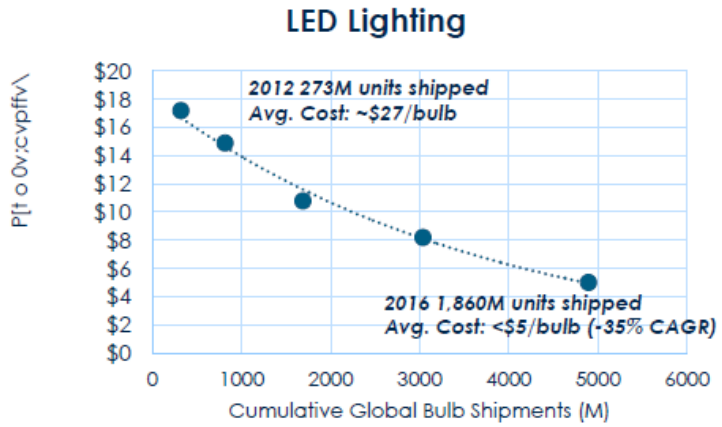
# Wind and solar have surged compared to other energy sources – but fossil fuels still dwarf renewables

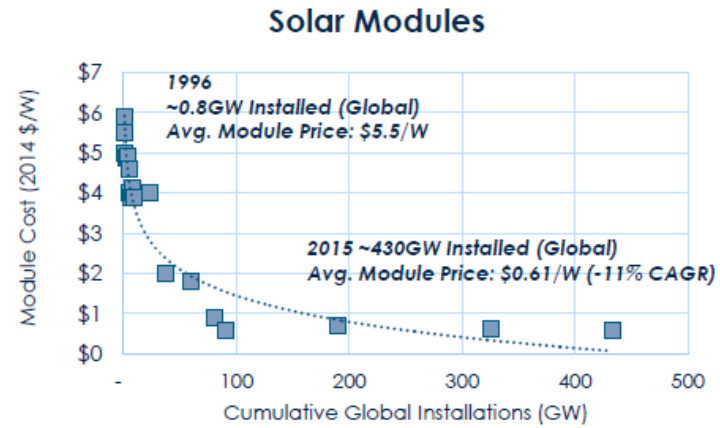


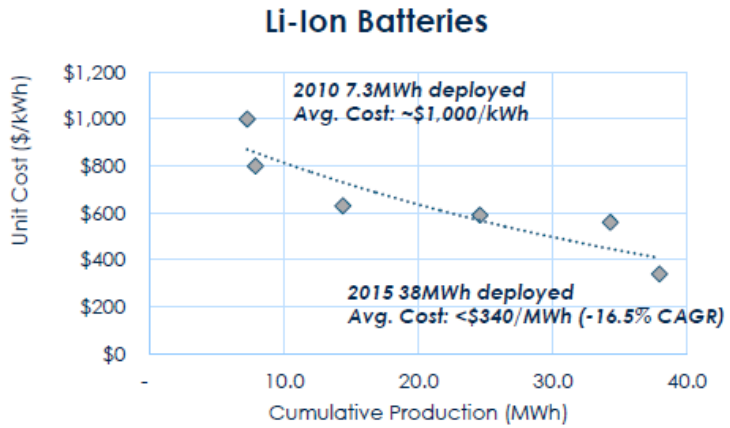
# Are NCRE cost-effective?

# There is an observed cost decline for clean energy technologies – driven largely by scale



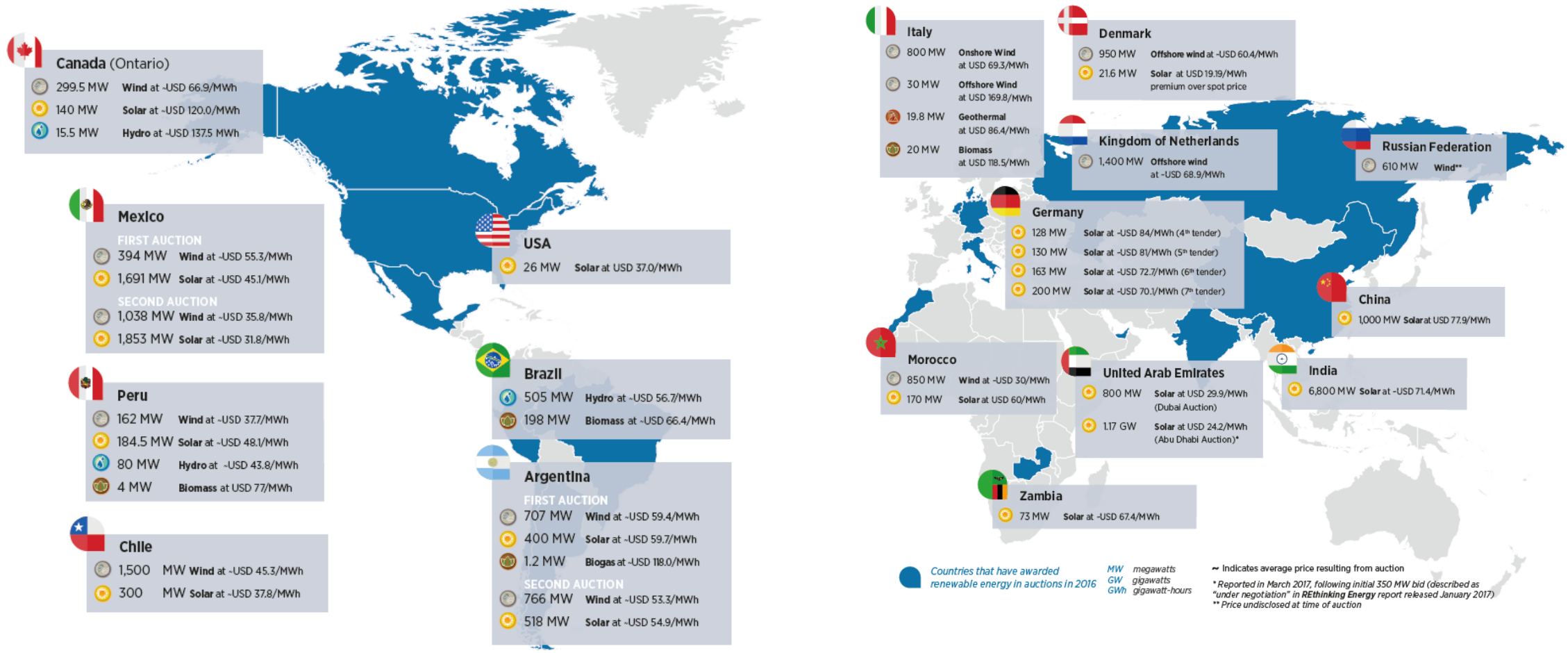



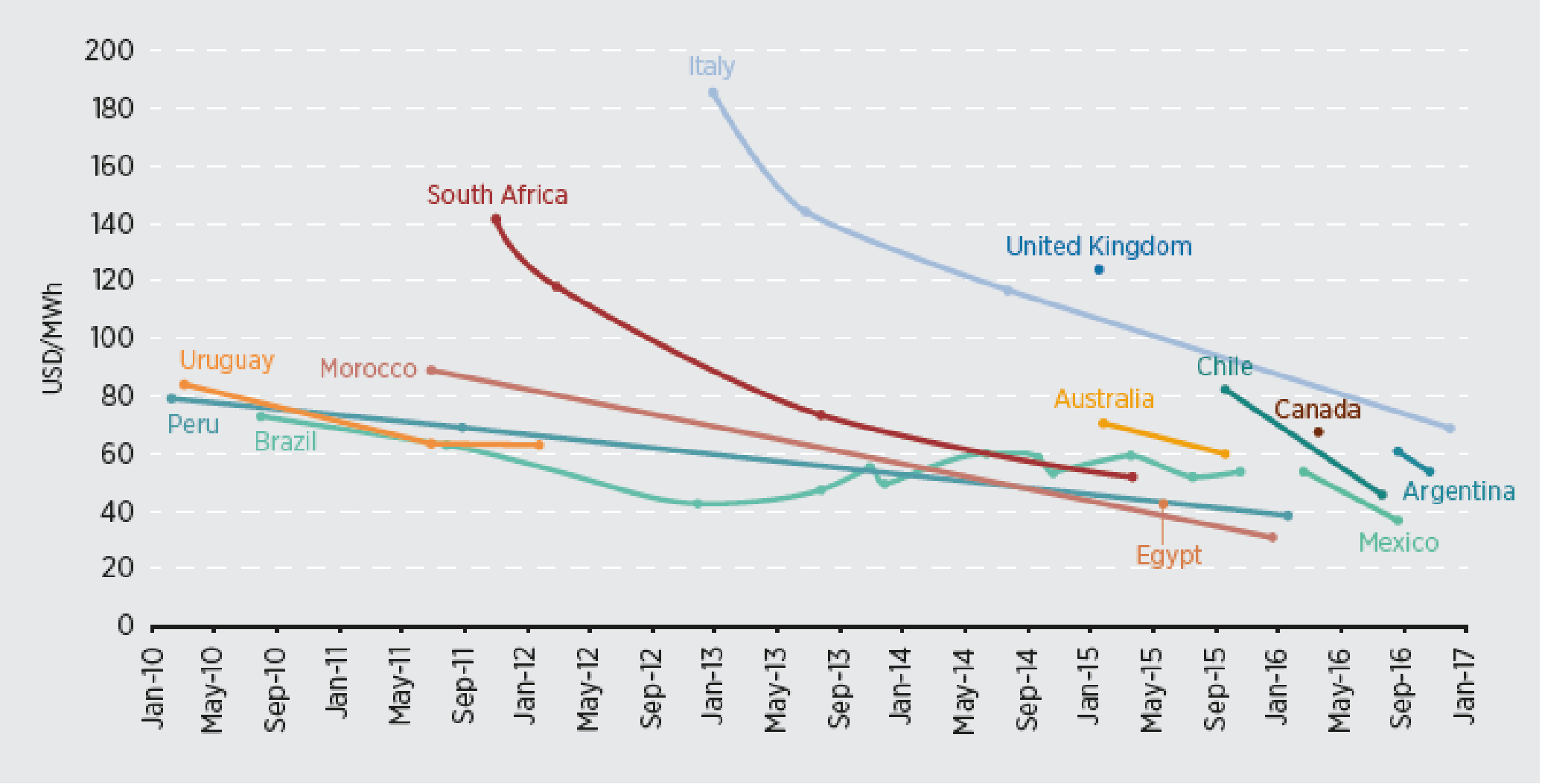

1. Assume 70% debt ratio; cost of debt (bps to LIBOR) 1.5; cost of equity 8%
Source: EIA, Bloomberg New Energy Finance, IHS Cera, Enovation Partners

# Technology in tandem with competition (auctions) provide the perfect recipe for price decline



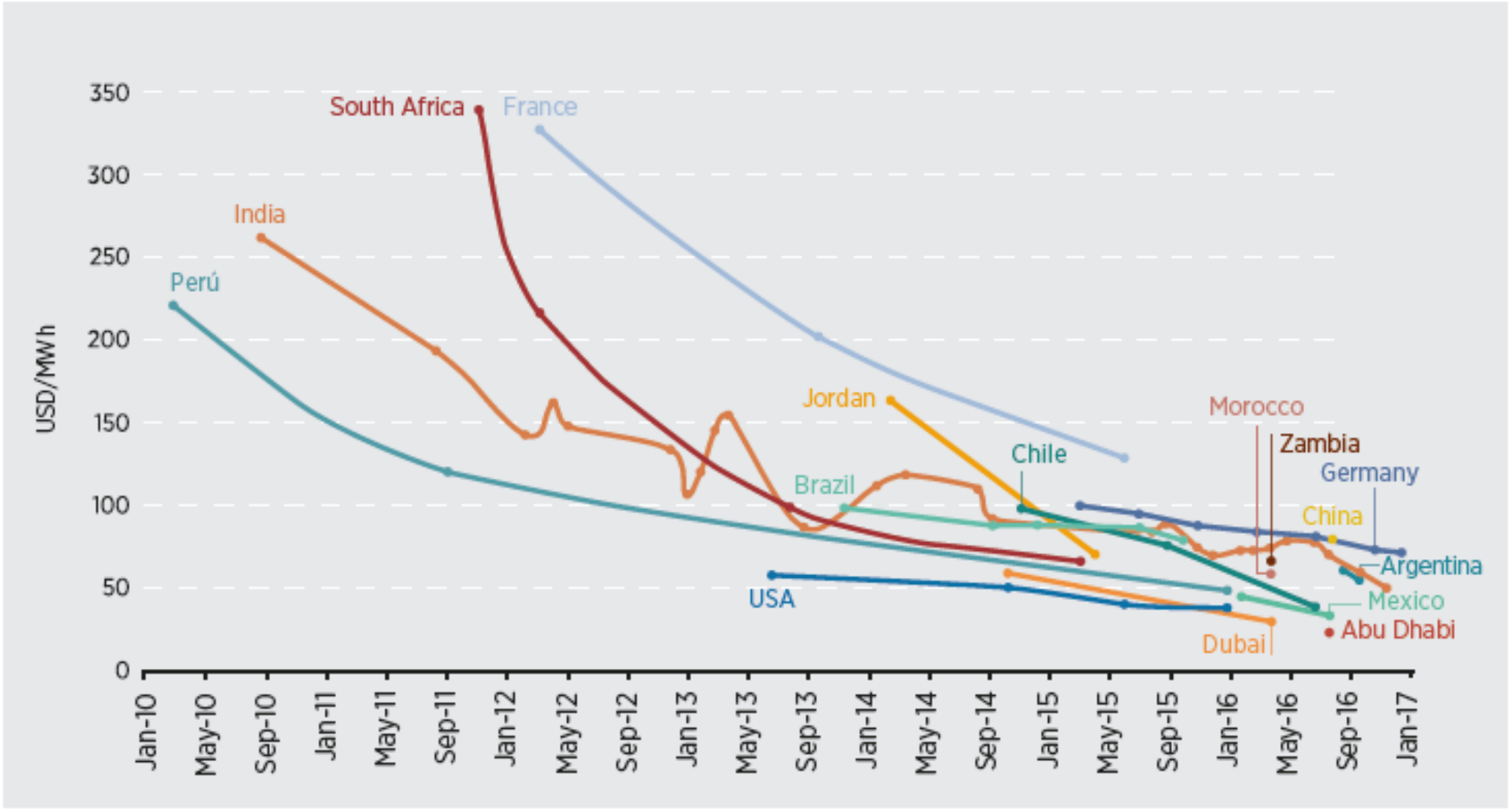
# Prices decline over time – e.g. renewable Energy Auctions for Wind

(Irena)



# Prices decline over time – e.g. renewable Energy Auctions for Solar

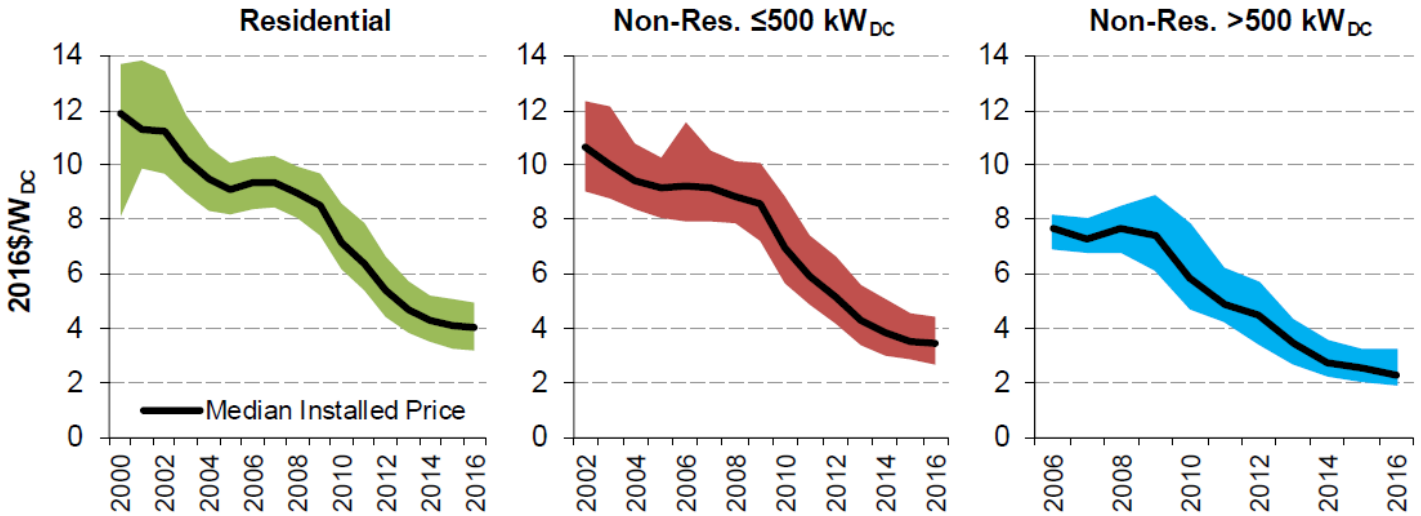
(Irena)

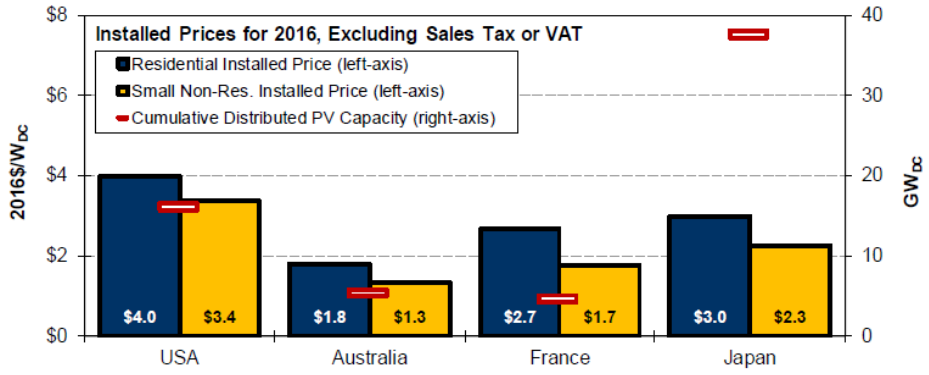


# Low prices are achievable - Estimates of PV market prices (USc/kWh) based on the WBG simplified model

| | Dubai 2016 | Zambia 2016 | S. Africa 2015 | India 2015 | Brazil 2015 |
|---|---|---|---|---|---|
| Total inv. costs | 0.75 | 1.1 | 1.25 | 0.8 | 1.23 |
| Costs of capital | 5.2% | 5.9% | 8.0% | 12.6% | 8.2% |
| Capacity factor | 25% | 22.6% | 22.5% | 21% | 22.6% |
| PPA term (years) | 25 | 25 | 20 | 25 | 20 |
| PV market price | 2.99 | 6.02 | 6.45 | 7.02 | 8.5 |

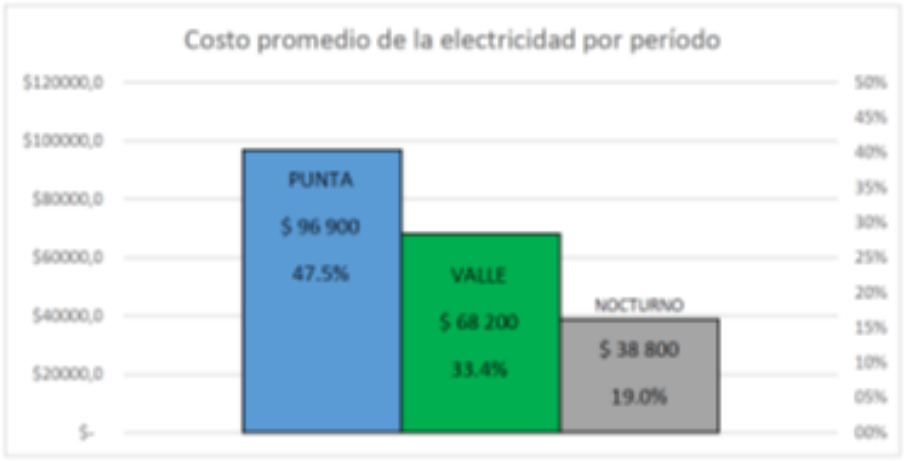
# What about Distributed Generation? Or behind-the-meter PV installations? They follow a similar pattern




*Notes: Data for Australia, France, and Japan are based on each country's respective IEA Photovoltaic Power Systems Programme's (PVPS) 2016 National Survey Report (Johnston and Egan 2017, L'Epine 2017, and Yamada and Ikki 2017).*

# Is the combination of PV and batteries behind the meter already feasible? Yes, in some cases

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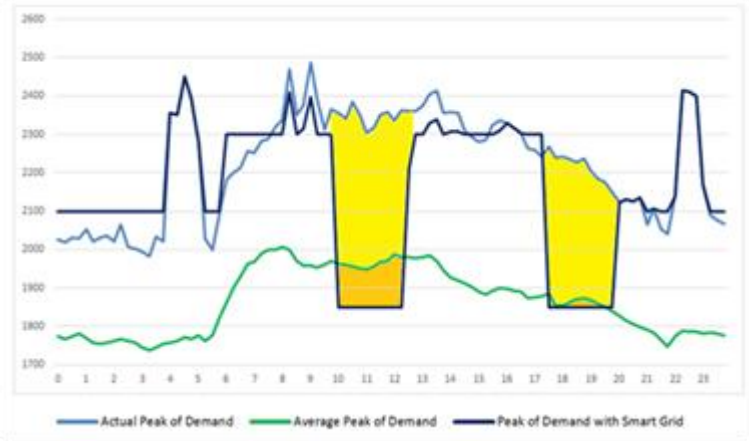
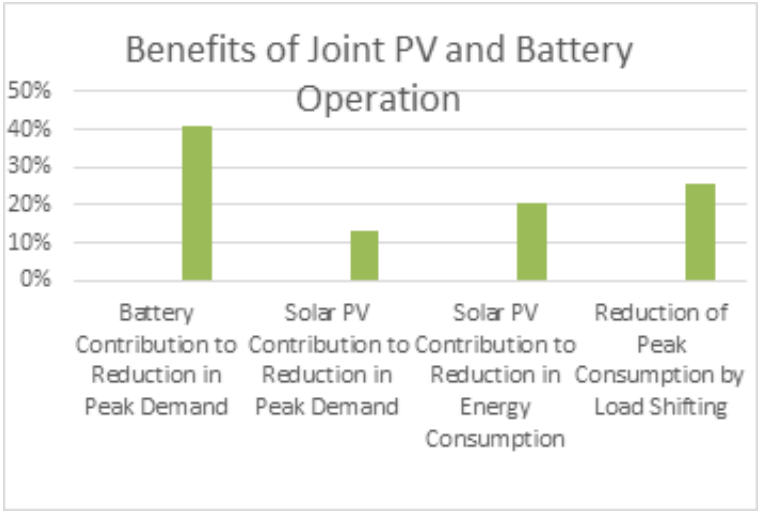


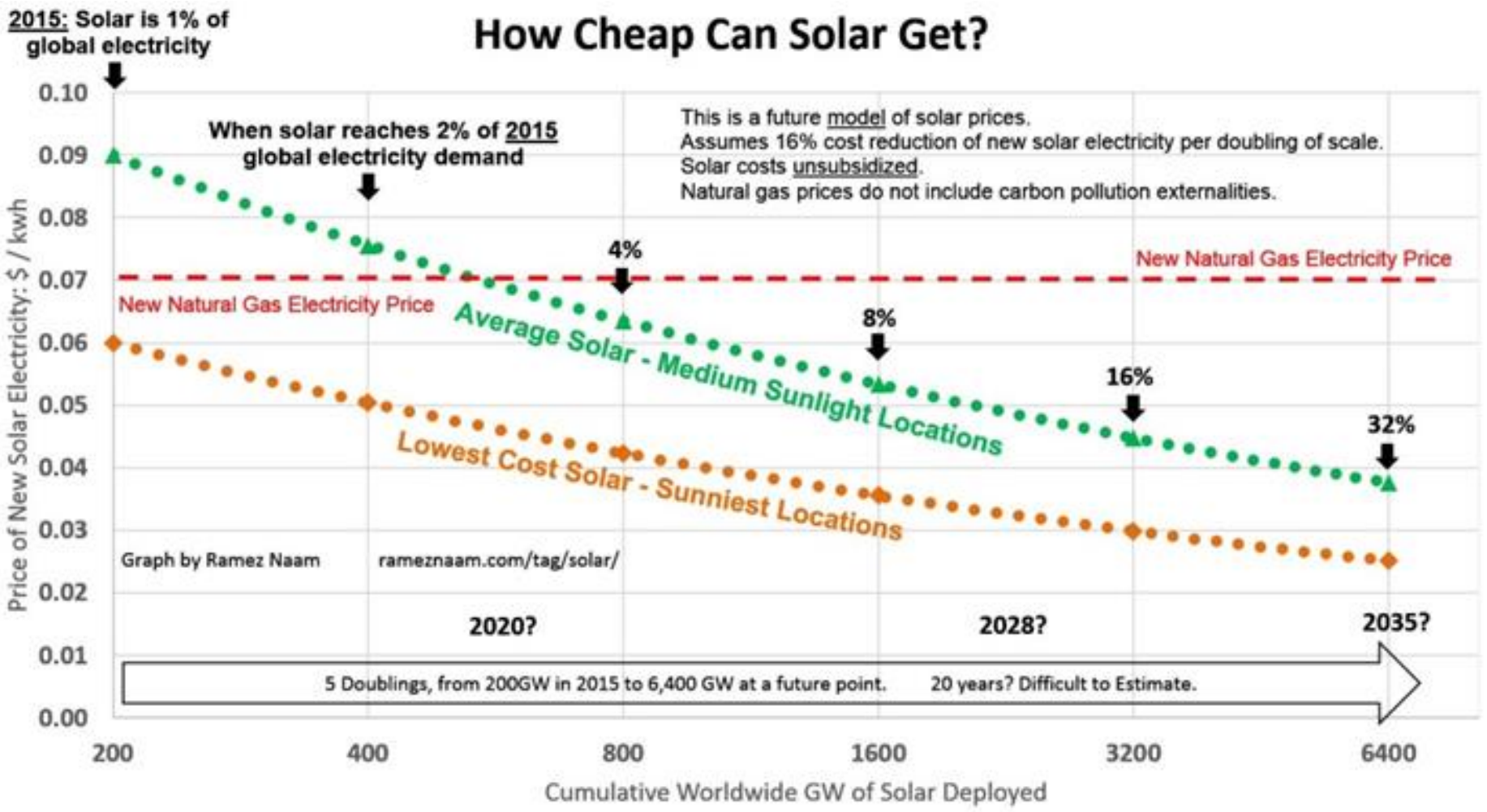

| FOR 300 kW SYSTEM | | FOR 1000 kW SYSTEM | |
|---|---|---|---|
| PV (300 kW) | 420,000 | PV (1000 kW) | 1,500,000 |
| Battery (1.3 MWh) | 675,000 | Battery (6.5 MWh) | 3,770,000 |
| Integration | 390,000 | Integration | 1,500,000 |
| Car Port | 120,000 | Car Port | 399,600 |
| TOTAL INVESTMENT | 1,605,000 | TOTAL INVESTMENT | 7,169,600 |
| Savings US$/year | 213,489 | Savings US$/year | 935,000 |
| Tariff Increase Assumption | 0% | | |

| IF RATIO is 2.2 and 4.4 | |
|---|---|
| Tariff Increase | 0% |
| Revenue (t=1) | 213,489 |
| IRR | 11.60% |
| NPV | 173,128 |
| | |
| Tariff Increase | 2% |
| Revenue (t=1) | 213,489 |
| IRR | 13.90% |
| NPV | 470,109 |
| | |
| Tariff Increase | 4% |
| Revenue (t=1) | 213,489 |
| IRR | 16.00% |
| NPV | 850,248 |

# More price declines are expected

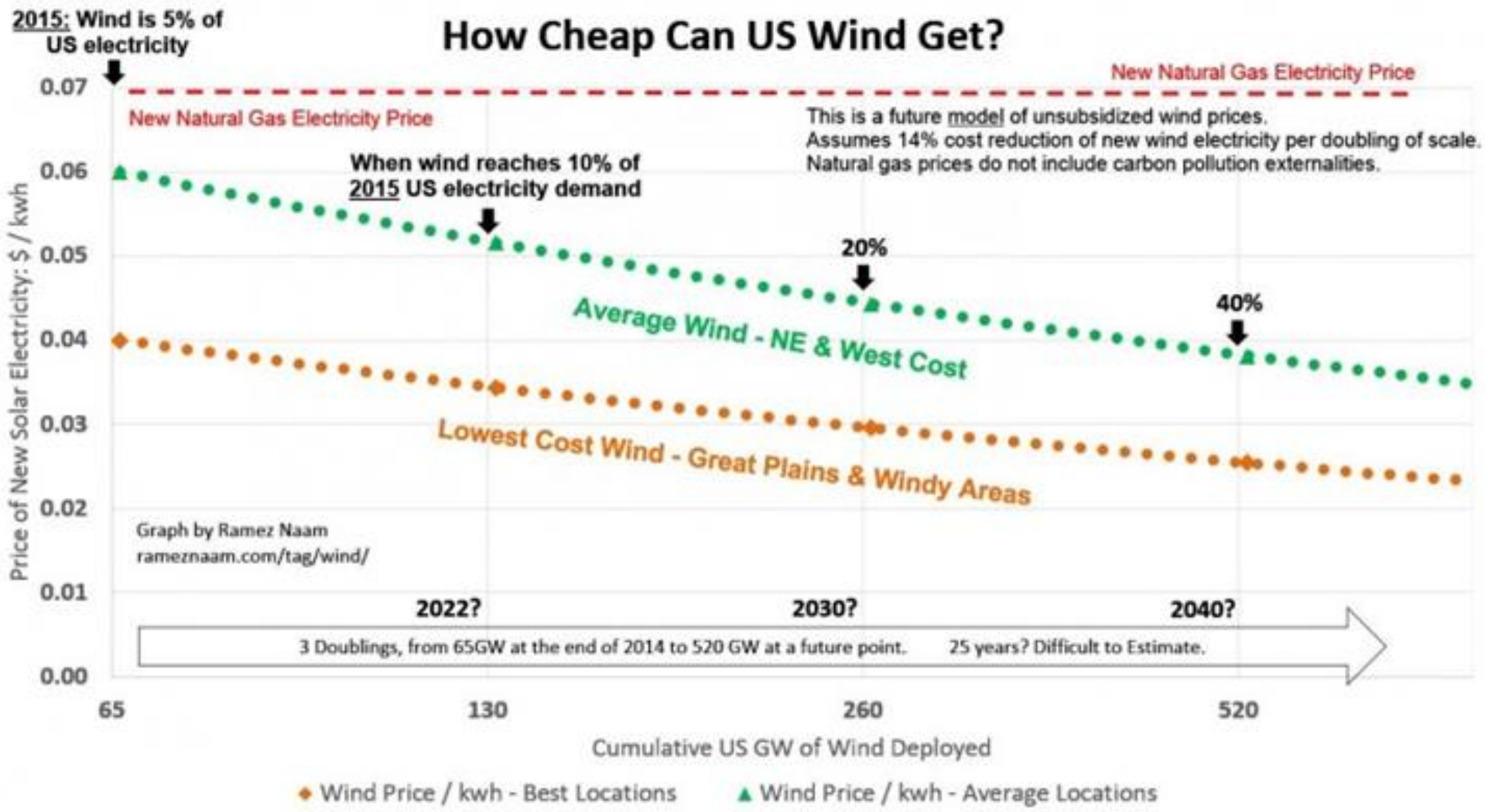
- **Costs:**
- Low cost solar can be achieved in most countries today if deals are structured properly; for WBG Utility Scaling Solar $1000/kW or less is possible today in many countries; $ 800/kW can be achieved in India
- These installed costs lead to generation costs of USc 6-8/kWh
- Prices are low enough to compete with conventional sources of electricity in many areas (e.g. coal in India)
- **Other factors pushing costs down today:**
- Nature of bidders – utilities and pension funds expect lower returns on equity than private developers
- “Plug and play” approach – i.e. access to land and transmission connection in place, along with standardized credit worthy PPA – e.g. India solar parks USc 1/kWh can be shaved off the final price
- Market share grabbing – projects with very low IRR
- Economies of scale on bulk modules orders for very large players

# Solar prices at par with natural gas in 2020? (Naam 2015)

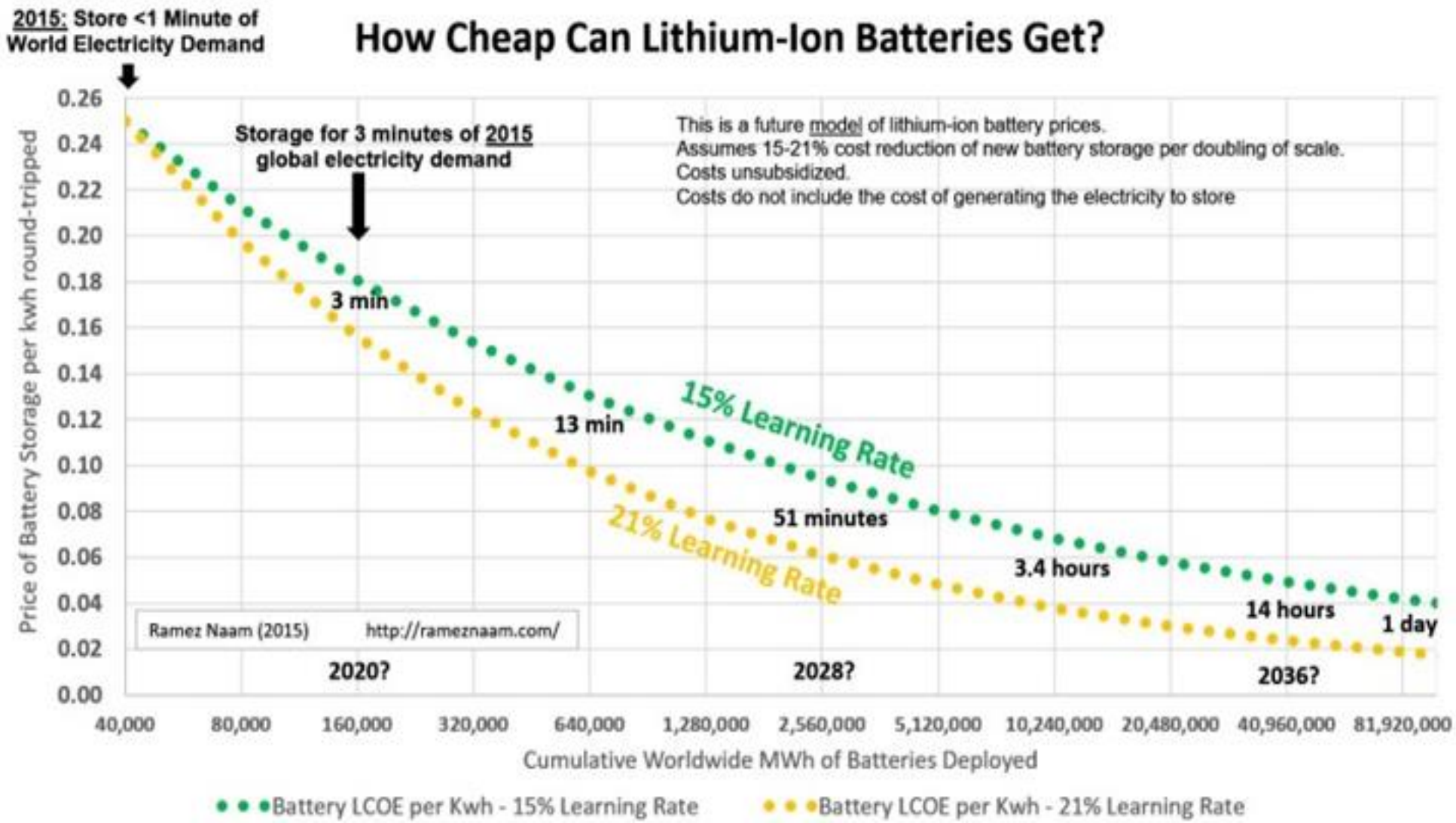


# While wind already cheaper than natural gas

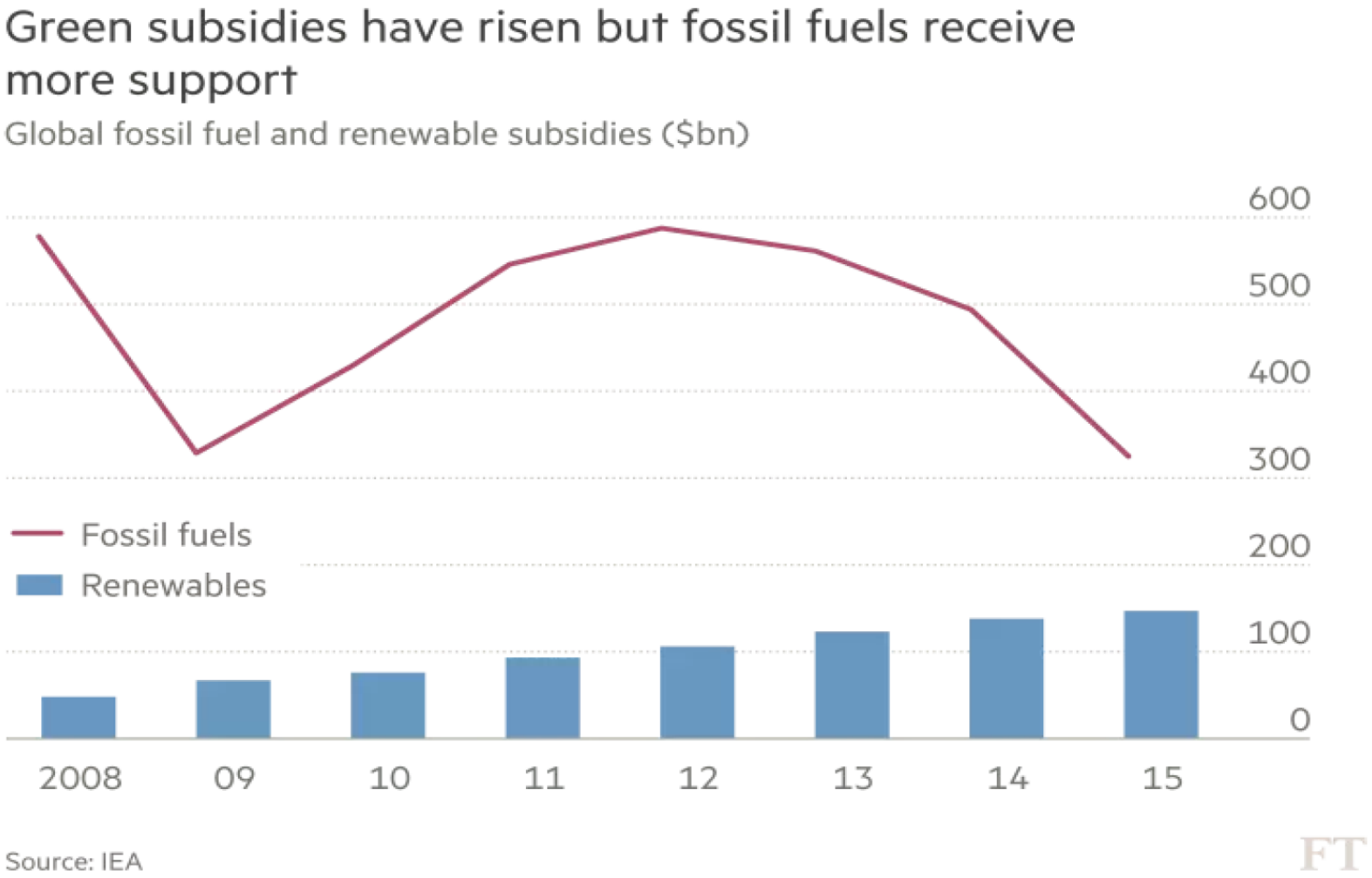
(Naam 2015)



# Cost of Lithium-Ion Batteries close to Usc 16/kWh by 2020? – Side Effect – 40% of new electric cars sales by 2040 !! And more electricity is needed



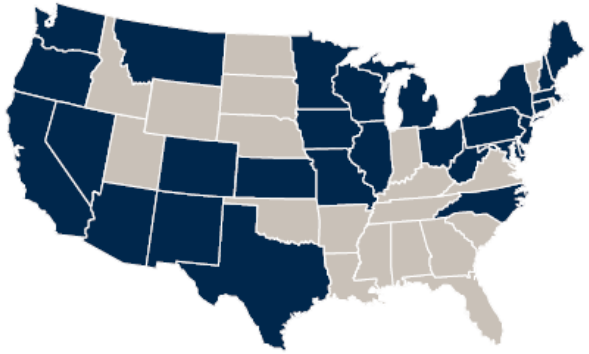
# Subsidies will no longer be needed for NCRE to compete – but they will have to confront huge amounts of subsidies received by the fossil fuel industry



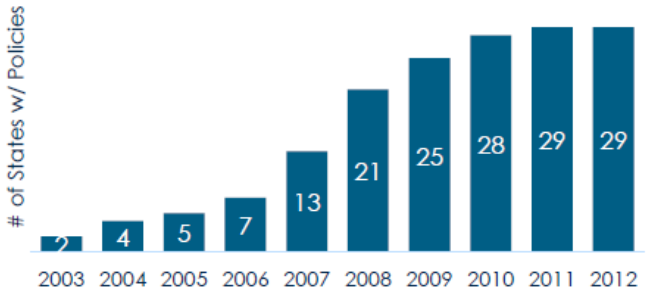
# Key regulations to spur NCRE

# Most developed countries have multiple regulations in place to foster clean energy and energy efficiency – is this all necessary?

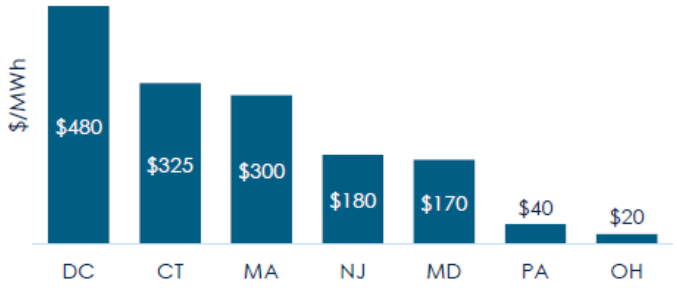
**States with Renewable Portfolio Standards (RPS)**



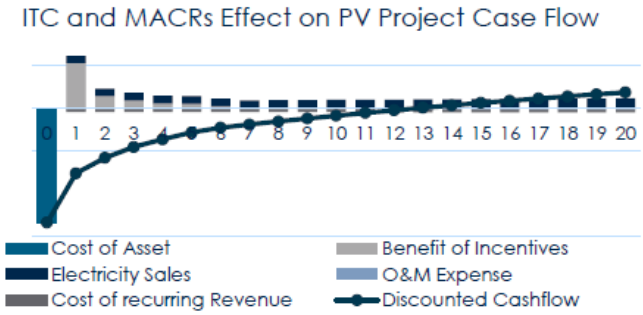
**State Energy Efficiency Rebate Programs**




**Solar Renewable Energy Credits (SRECs)**




**Tax Credits and Incentives**



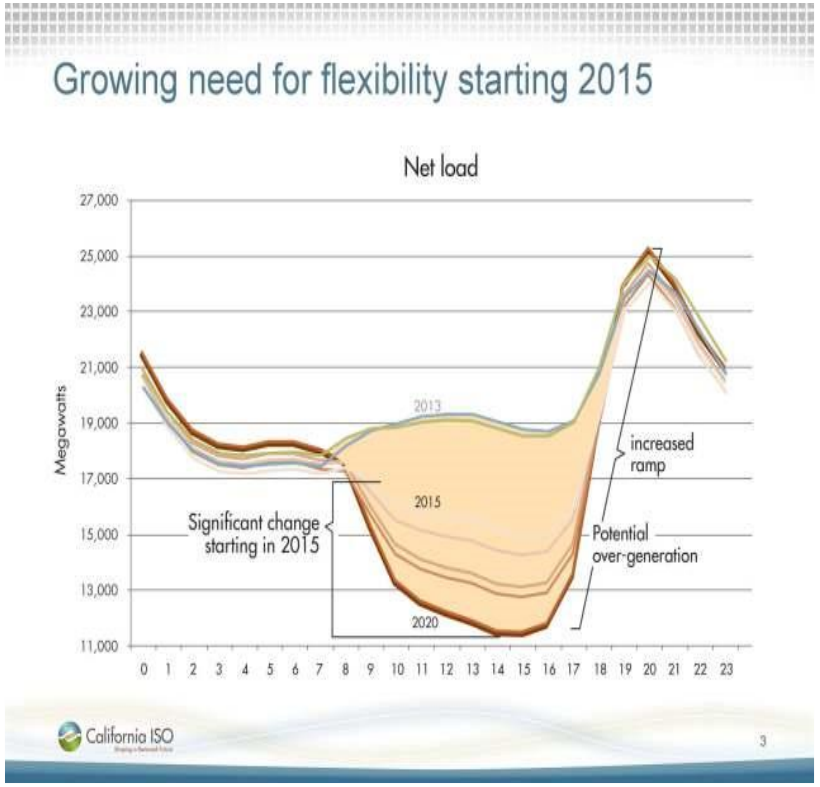

Source: : SREC Trade, DSIRE, Enovation Partners

# Based on international experience, two regulations are key to spur NCRE

- Utility Scale - first, a competitive process (auction) to procure long-term electricity contracts (PPAs)
  - A well designed competitive mechanism to foster competition and push prices down
  - PPA is a condition for bankability and to attract new generators – "the democratization of generation"
  - Policy issues have to determine how much to procure from each source, when, technology specific or agnostic
- Distributed Generation – net metering (or variations thereof)
  - A pricing mechanisms which allows DG to buy from the utility when needed and sell when there is excess production (this happens seamlessly)
  - In the pure net metering prices for the shortfall are identical to excess energy
  - Doubt have been raised about the fairness of the pure net metering scheme
  - Issue can be resolved via a fixed charge and/or time of use rate
  - In some cases, the utility also offers a 5 year PPA at pre-defined price

# What about utilities managing variable generation (and soon in the future variable loads?)

- The combination of PV rooftops, Electric Vehicles, and new AC loads will require utilities to review the way they operate and interface with loads and distributed generation. Revenue wise, PV rooftops will indeed cause a loss of revenues and possibly profits for the utility. One does not expect the “death spiral” phenomenon – possibly overplayed today – to materialize, as policy makers will put the proper regulations in place to compensate the utility for the grid and back-up services provided. Discussions on the best regulatory ways to achieve this goal are in state of flux. However, those will not compensate the utility for the forgone revenues. On the other hand, the utility has a huge potential to increase its revenues coming from electrification of transport and air conditioning loads.
- Those additional markets may be a blessing or a curse for the utility. It will all depend how those markets will draw energy from the system – which will in turn drive asset utilization for the utility. If those loads draw energy from the system during peak hours, the utility will have to significantly increase its asset base to serve peak loads. DG production from PV systems, EVs and ACs may interact with each other in a virtuous or vicious way. An emblematic example of this potential for interaction is the so called “duck load curve.” In 2020, when 33% of California's electricity is supposed to come from renewable sources, the net load curve will look like a duck, as depicted in the following graph.



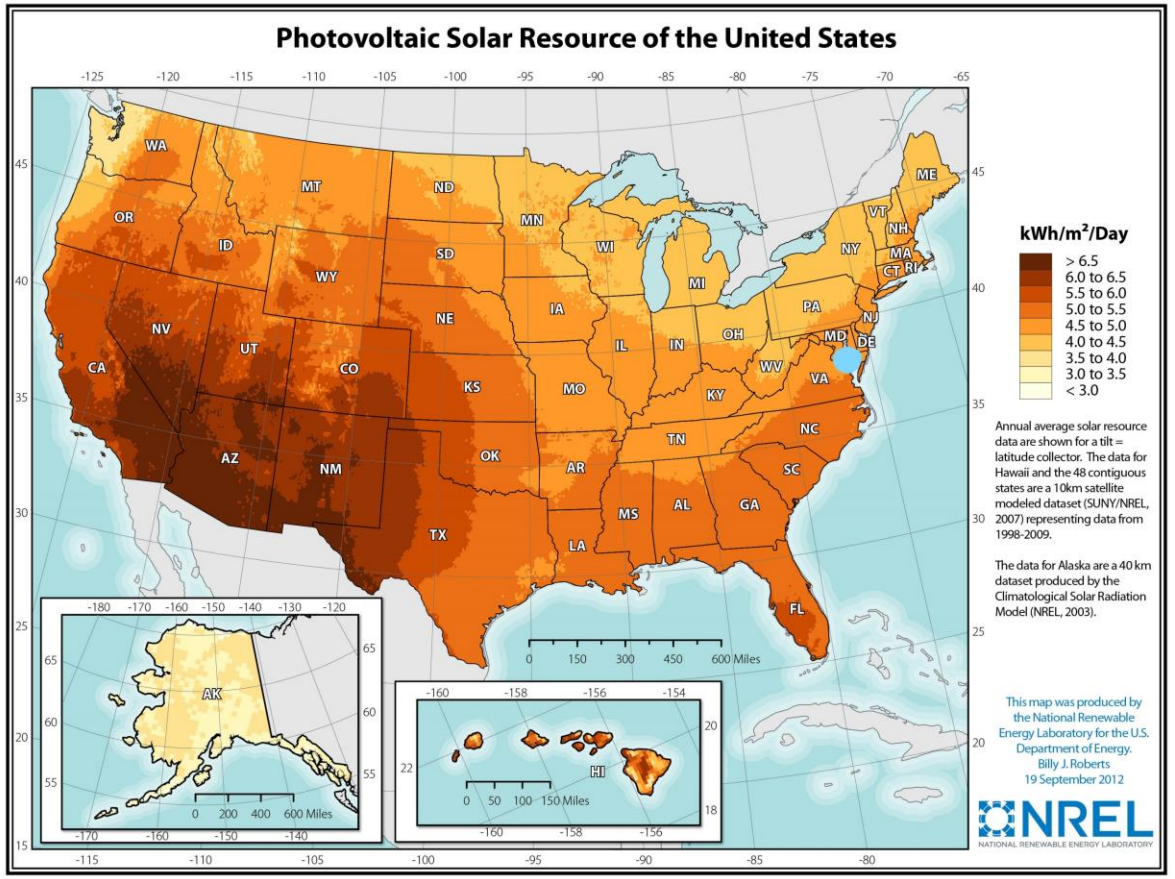
# Costs to manage and mitigate volatility

- Varies depending on the system chacteristics
- If there is hydro capacity – it is the cheapest battery offered by nature
- If not – fast ramp up thermal generation, batteries when very fast response (ancillary services) are required
- In Australia – studies revealed that costs of a renewable-only supply side is close to Usc 7.5/kWh
- Chile has tendered three 130 MW solar thermal towers, each with 13 hours of full load energy storage, at very competitive prices. The facility will deliver 390 megawatts of continuous output, resulting in over 2,800 gigawatt-hours generated annually.
- It will operate at a capacity factor and availability percentage equal to that of a fossil fired power plant, while providing a highly competitive price of power – and with zero emissions
- Not all countries have the same solar endowments, but the results are a major breakthrough

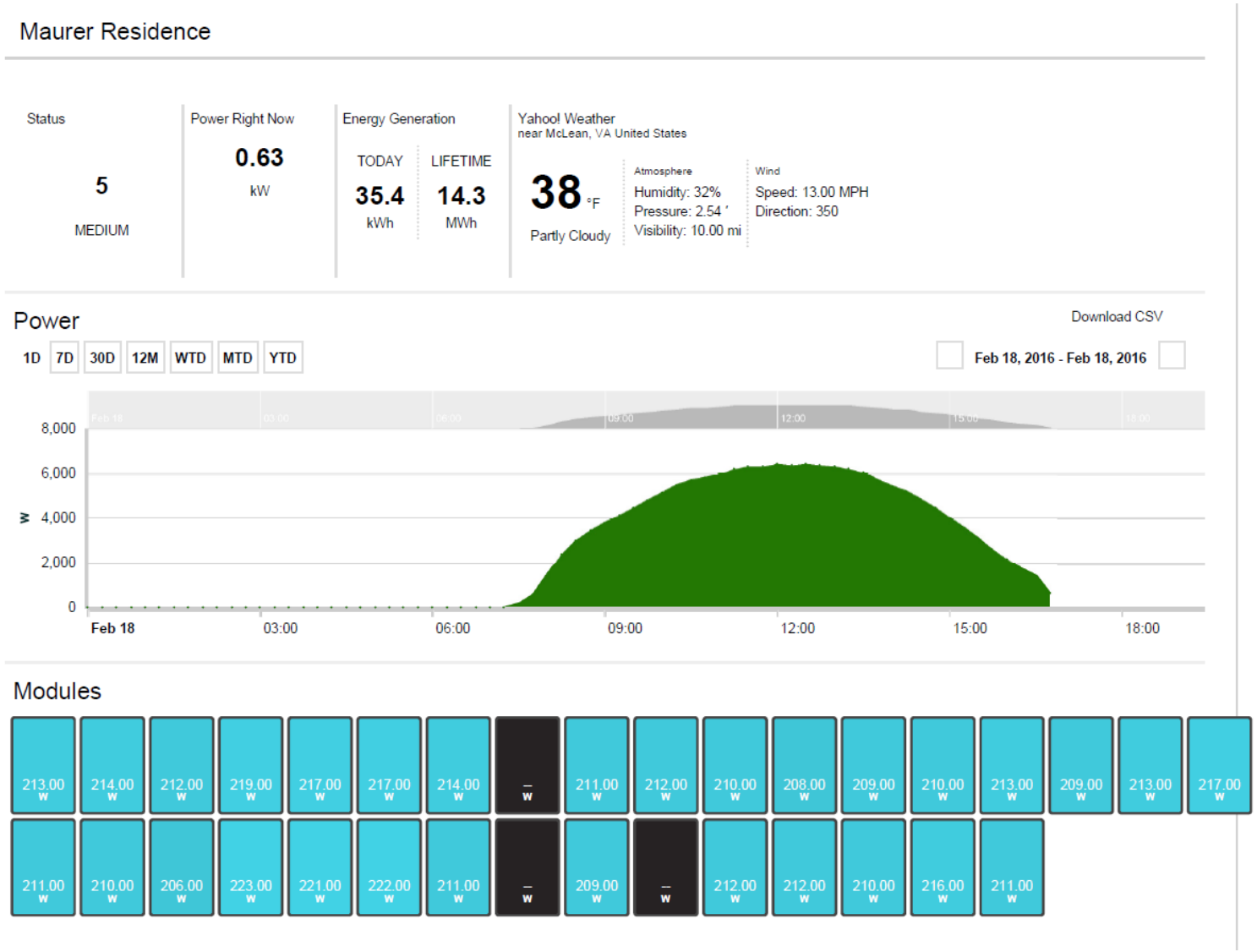
# An illustrative case-study

A “do-it-yourself” PV Rooftop Home Systems

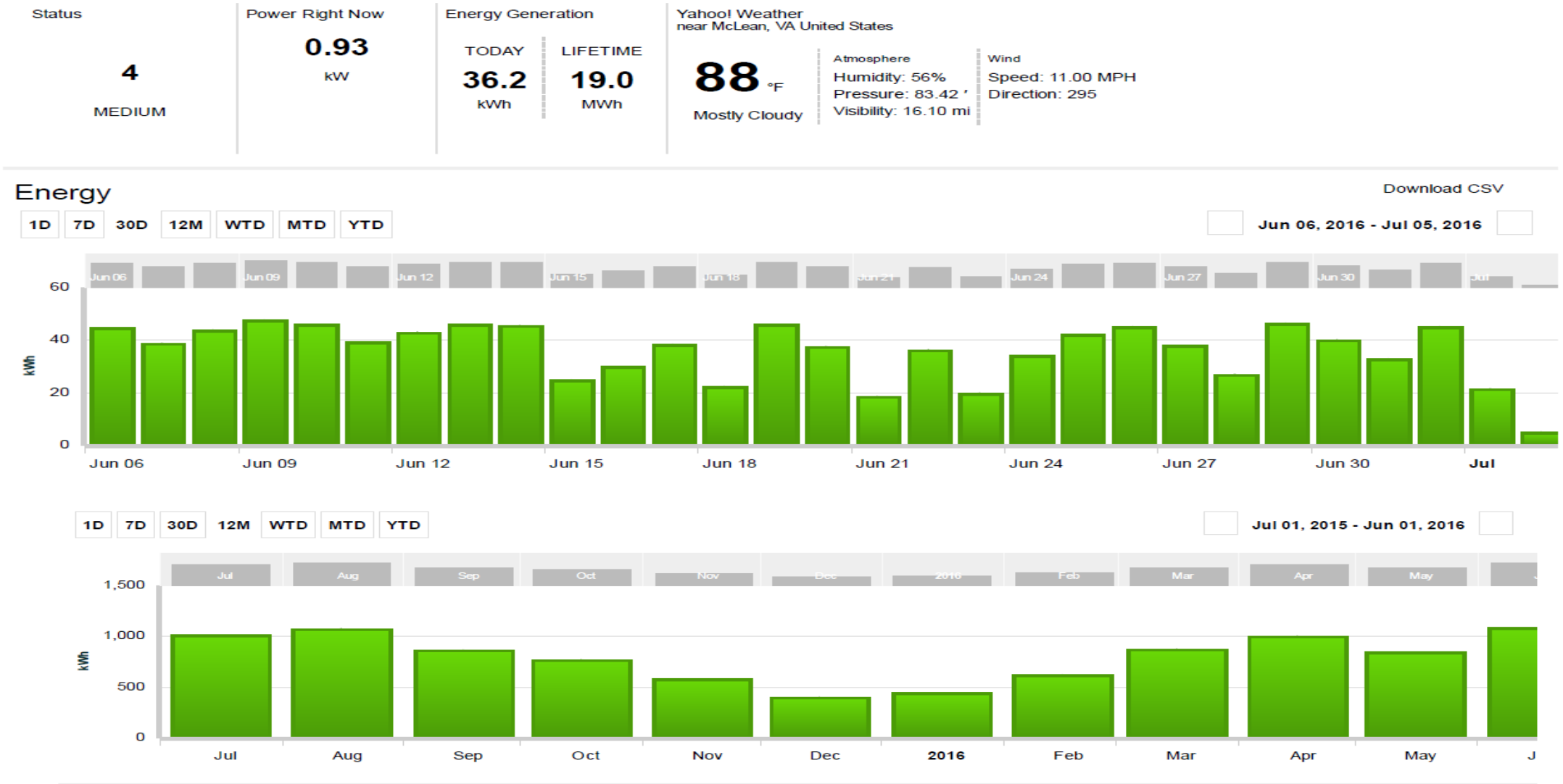
# Rendered image of a solar system in McLean, VA – 8.7 kW, cost of about US$ 2.4/Watt in 2013. Expected payback = 6 years, analogous to net-metering



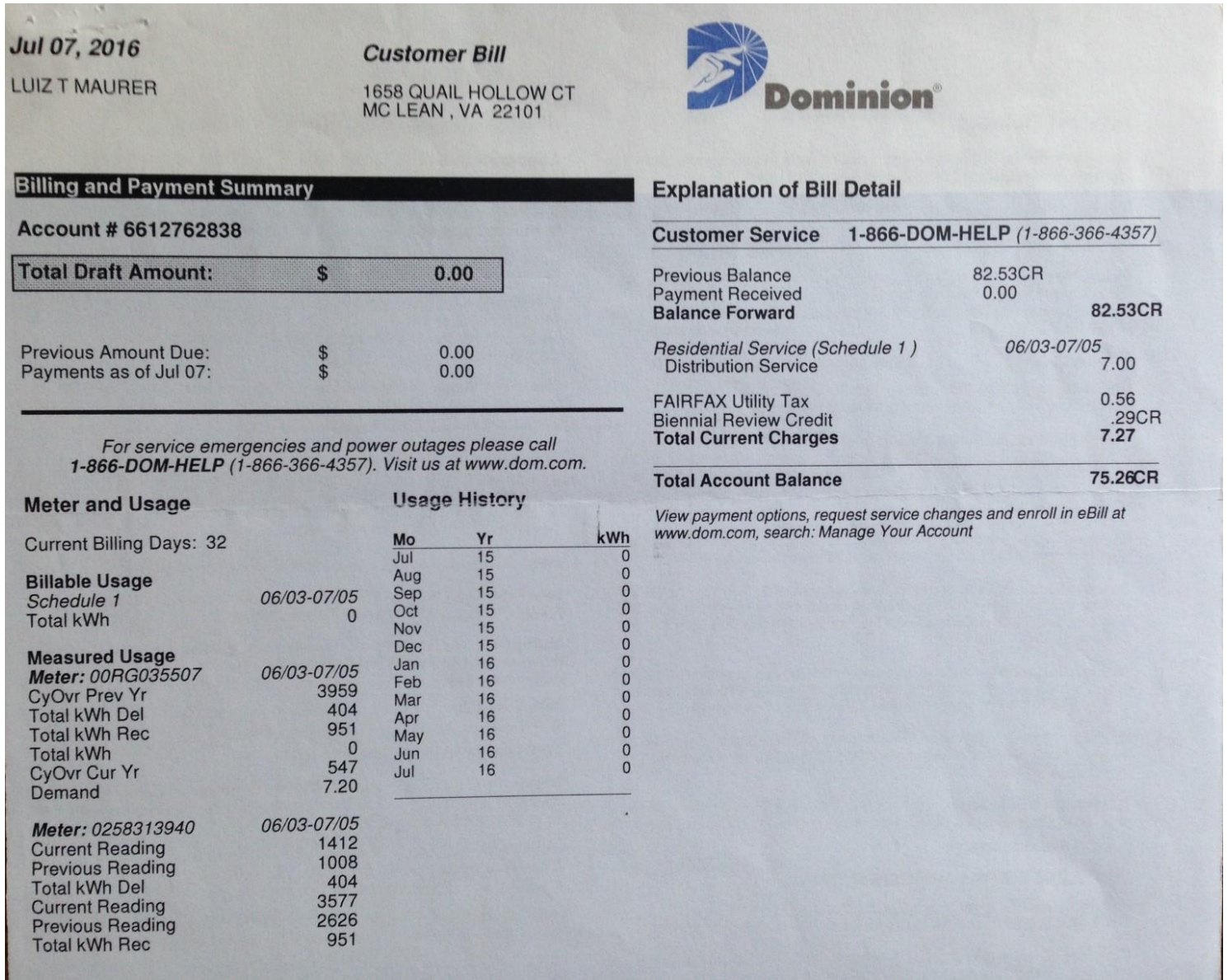
# Daily production profile of PV rooftop



# Daily and Monthly production quantities – more than 1100 kWh in the summer and about 400 kWh in the winter



# Electricity bill reflects energy delivered, received, annual and cumulative carry-overs (like a banking account in kWh)



**Jul 07, 2016**

LUIZ T MAURER

***Customer Bill***

1658 QUAIL HOLLOW CT
MC LEAN , VA 22101

Dominion®

**Billing and Payment Summary**

**Account # 6612762838**

| | | |
|---|---|---|
| **Total Draft Amount:** | **$** | **0.00** |

| | | |
|---|---|---|
| Previous Amount Due: | $ | 0.00 |
| Payments as of Jul 07: | $ | 0.00 |

*For service emergencies and power outages please call **1-866-DOM-HELP** (1-866-366-4357). Visit us at www.dom.com.*

**Meter and Usage**

Current Billing Days: 32

| | |
|---|---|
| **Billable Usage** | |
| *Schedule 1* | *06/03-07/05* |
| Total kWh | 0 |
| **Measured Usage** | |
| ***Meter:*** *00RG035507* | *06/03-07/05* |
| CyOvr Prev Yr | 3959 |
| Total kWh Del | 404 |
| Total kWh Rec | 951 |
| Total kWh | 0 |
| CyOvr Cur Yr | 547 |
| Demand | 7.20 |
| ***Meter:*** *0258313940* | *06/03-07/05* |
| Current Reading | 1412 |
| Previous Reading | 1008 |
| Total kWh Del | 404 |
| Current Reading | 3577 |
| Previous Reading | 2626 |
| Total kWh Rec | 951 |

**Usage History**

| Mo | Yr | kWh |
|---|---|---|
| Jul | 15 | 0 |
| Aug | 15 | 0 |
| Sep | 15 | 0 |
| Oct | 15 | 0 |
| Nov | 15 | 0 |
| Dec | 15 | 0 |
| Jan | 16 | 0 |
| Feb | 16 | 0 |
| Mar | 16 | 0 |
| Apr | 16 | 0 |
| May | 16 | 0 |
| Jun | 16 | 0 |
| Jul | 16 | 0 |

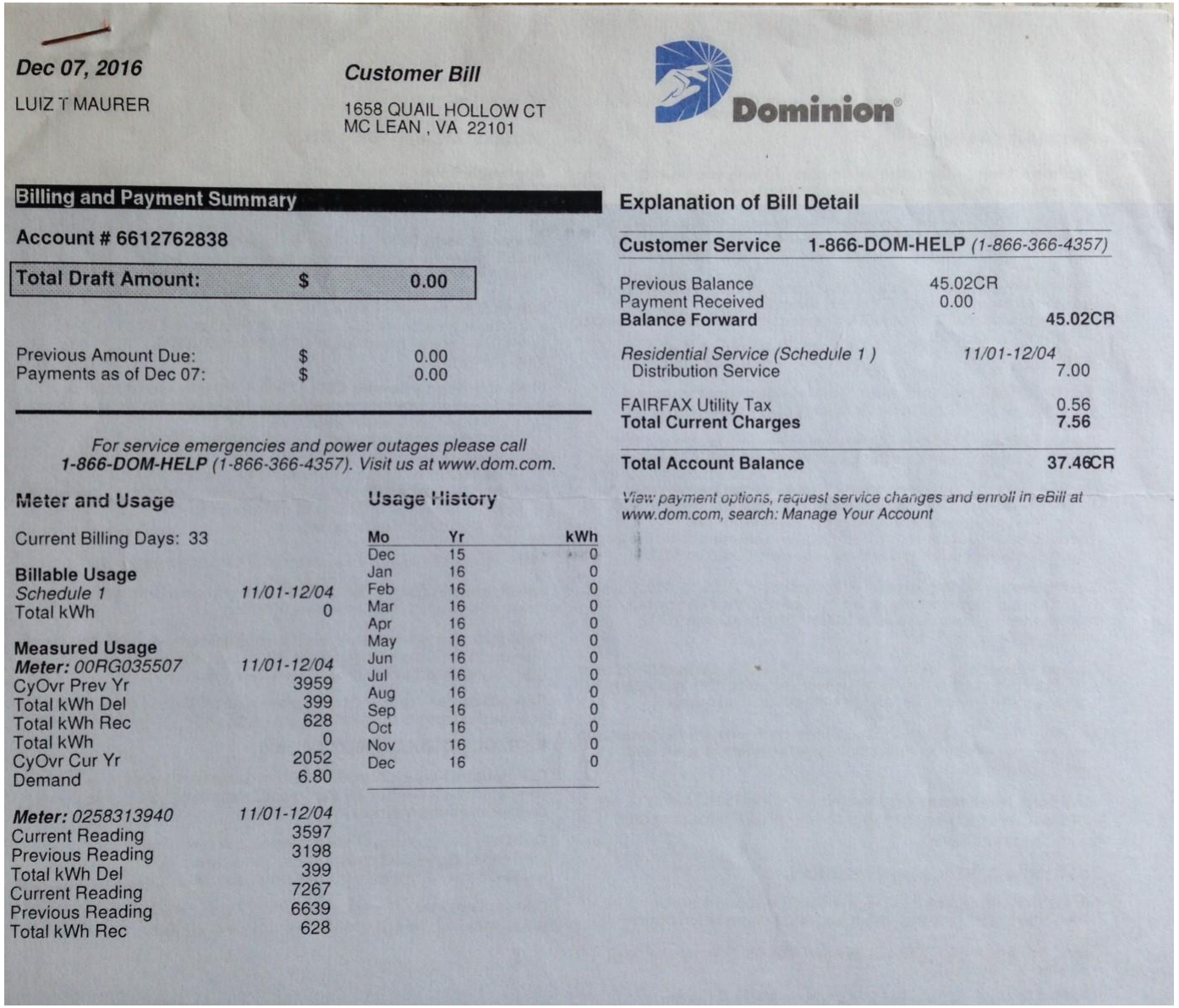
**Explanation of Bill Detail**

**Customer Service** **1-866-DOM-HELP** *(1-866-366-4357)*

| | | |
|---|---|---|
| Previous Balance | 82.53CR | |
| Payment Received | 0.00 | |
| **Balance Forward** | | **82.53CR** |
| *Residential Service (Schedule 1 )* | *06/03-07/05* | |
| Distribution Service | | 7.00 |
| FAIRFAX Utility Tax | | 0.56 |
| Biennial Review Credit | | .29CR |
| **Total Current Charges** | | **7.27** |
| **Total Account Balance** | | **75.26CR** |

*View payment options, request service changes and enroll in eBill at www.dom.com, search: Manage Your Account*

# Energy surplus in 2016 about 2 MWh – including the consumption of an electric car (4 miles/kWh)



**Dec 07, 2016**

LUIZ T MAURER

**Customer Bill**

1658 QUAIL HOLLOW CT
MC LEAN , VA 22101

Dominion®

**Billing and Payment Summary**

**Account # 6612762838**

| | | |
|---|---|---|
| **Total Draft Amount:** | **$** | **0.00** |
| Previous Amount Due: | $ | 0.00 |
| Payments as of Dec 07: | $ | 0.00 |

*For service emergencies and power outages please call **1-866-DOM-HELP** (1-866-366-4357). Visit us at www.dom.com.*

**Meter and Usage**

Current Billing Days: 33

| | |
|---|---|
| **Billable Usage** | |
| *Schedule 1* | *11/01-12/04* |
| Total kWh | 0 |
| **Measured Usage** | |
| ***Meter:** 00RG035507* | *11/01-12/04* |
| CyOvr Prev Yr | 3959 |
| Total kWh Del | 399 |
| Total kWh Rec | 628 |
| Total kWh | 0 |
| CyOvr Cur Yr | 2052 |
| Demand | 6.80 |
| ***Meter:** 0258313940* | *11/01-12/04* |
| Current Reading | 3597 |
| Previous Reading | 3198 |
| Total kWh Del | 399 |
| Current Reading | 7267 |
| Previous Reading | 6639 |
| Total kWh Rec | 628 |

**Usage History**

| Mo | Yr | kWh |
|---|---|---|
| Dec | 15 | 0 |
| Jan | 16 | 0 |
| Feb | 16 | 0 |
| Mar | 16 | 0 |
| Apr | 16 | 0 |
| May | 16 | 0 |
| Jun | 16 | 0 |
| Jul | 16 | 0 |
| Aug | 16 | 0 |
| Sep | 16 | 0 |
| Oct | 16 | 0 |
| Nov | 16 | 0 |
| Dec | 16 | 0 |

**Explanation of Bill Detail**

**Customer Service** **1-866-DOM-HELP** *(1-866-366-4357)*

| | | |
|---|---|---|
| Previous Balance | 45.02CR | |
| Payment Received | 0.00 | |
| **Balance Forward** | | **45.02CR** |
| *Residential Service (Schedule 1 )* | *11/01-12/04* | |
| Distribution Service | | 7.00 |
| FAIRFAX Utility Tax | | 0.56 |
| **Total Current Charges** | | **7.56** |
| **Total Account Balance** | | **37.46CR** |

*View payment options, request service changes and enroll in eBill at www.dom.com, search: Manage Your Account*

# Opportunities for Colombia

# Current situation of NCRE in Colombia

- Colombia is blessed with solar and wind resources
  - La Guajira – the second best wind resource in Latin America
  - Solar – abundant along the coast
- However, those resources – co-generation included, are still undeveloped
- Most countries in LAC not only pioneered but also have consolidated the auction process and achieved impressive price results and MW built
- Some of them have also achieved fast deployment of DG- e.g. Mexico
- Paradoxically, Colombia as one of the most efficient and modern power systems, but is lagging behind its LAC peers in NCRE

# Colombia is planning to catch up fast

- Analyzing issues and options to establish a competitive mechanism (auction) for energy contracts (separate from the cargo por confiabilidad)
- In principle, technology agnostic, but backed by long term PPAs
- This will create conditions for bankable projects and new entrants
- CREG has proposed four options in a public hearing (under discussion)
- Colombia is also examining regulations for self-generation (which will likely include all categories behind the meter, with options for each)
- There is a good alignment among DNP, MinMinas, CREG, XM, UMPE, and FDN as a financier
- This alignment helps address policy, regulatory and financial issues which are all necessary to put together a NCRE program of the desired scale
- The World Bank is collaborating with those government agencies in terms of technical assistance and in putting together a credit enhancement facility for FDN

# Source material on NCRE and Auctions