



Solar Energy: Technology, Management & Regulations

Presented at UPES Dehradun on 6th Oct 2017

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Objectives

- ▶ Introduction on climate Change, renewable energy, EV & Energy Storage
- ▶ Solar Energy technical & financial basics for MBA students
- ▶ Policy, Regulations & Acts
- ▶ Current Trends & Future Scenario
- ▶ Career & Entrepreneurship

Methodology

- ▶ PPT/ PDF on subject
- ▶ Video reference
- ▶ Q&A session
- ▶ Industry Practice
- ▶ Discussion
- ▶ Feedback

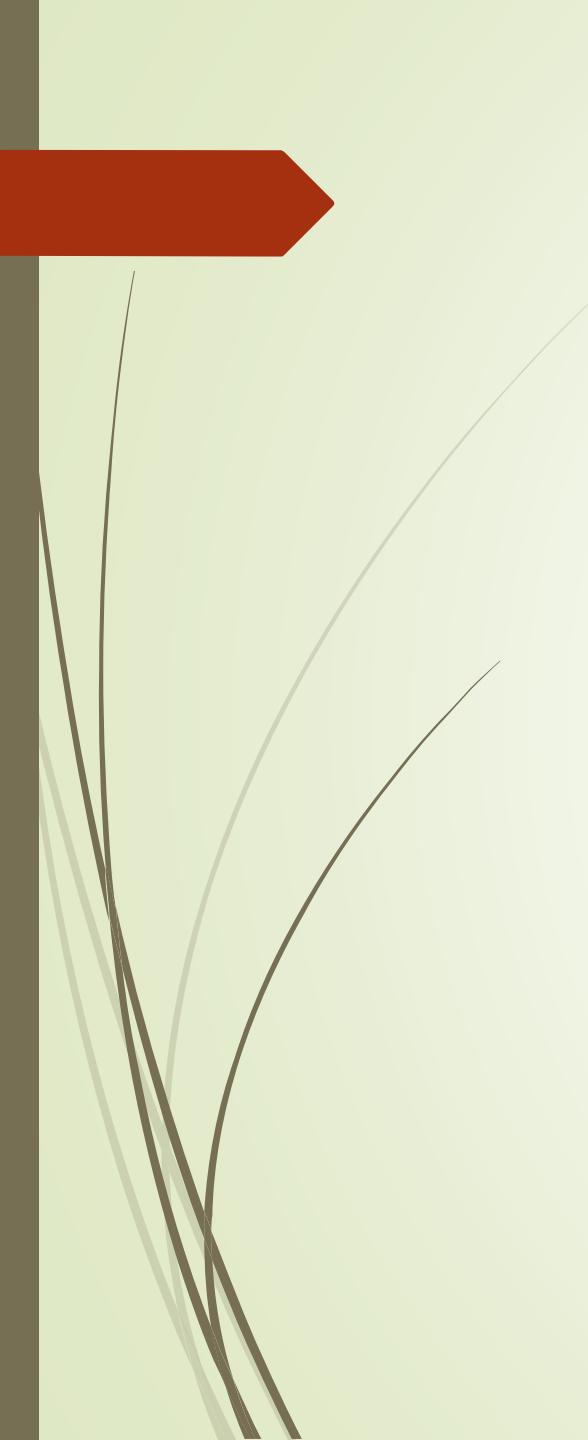
Day 1

- ▶ Energy Scenario
- ▶ Climate Change & Impact
- ▶ Solar Energy & Types
- ▶ Technology & Working
- ▶ Electricity Charges
- ▶ Module Manufacturing
- ▶ Recent News
 - ▶ Rewa Solar Plant
 - ▶ Anit-Dumping
 - ▶ Section 201
 - ▶ Net-Metering
 - ▶ SECI 1000 MW

Day 2

- ▶ Roof-top Solar Basic Concepts
- ▶ Roof-top Solar Evaluation
- ▶ Solar Financing (CAPEX & BOOT)
- ▶ Financial Calculations in excel
- ▶ Making a techno-commercial Offer
- ▶ Energy Storage, Electric Vehicle, Smart Grid & Monitoring
- ▶ FAQ's
- ▶ Starting a career
- ▶ Companies in solar





► Ministry Of Power Annual Report

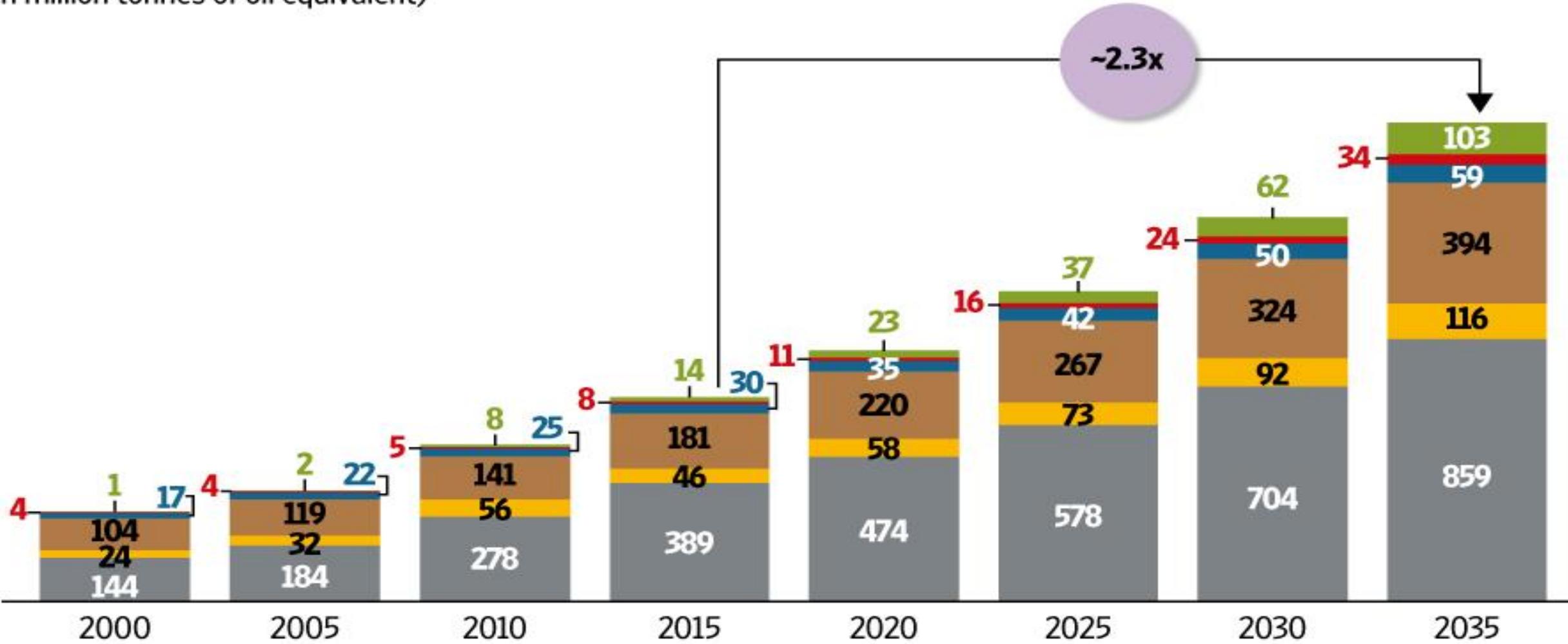
- ▶ With about **308 GW of installed capacity** (as of November 2016), the Indian power system is among the largest in the world, but per capita consumption of electricity is less than one fourth of the world average. Energy consumption in India has witnessed a **CAGR of about 7%** during the last decade.
- ▶ BP Energy Outlook 2035 expects India to achieve the **fastest energy consumption growth** among all major economies, despite rapid increases in non-fossil fuel production.
- ▶ The total energy consumption is expected to **grow by 128% by 2035**. Demand for gas is expected to expand by 155%, followed by coal (121%) and oil (118%), while **demand for renewables**, nuclear and hydro are estimated to rise by **656%**, 334%, and 99%, respectively (see chart).
- ▶ Coal **accounts for approx. 58%** of the energy consumption in the country.
- ▶ It is expected that India will be the largest consumer of coal, equivalent to over 435 million tonnes of oil by 2035. According to current estimates with respect to oil and gas, India is **home to only 0.3% of the world's sedimentary basins**. Further, we account for a mere **0.3% of the global oil and 0.8% of the global gas reserves**.
- ▶ We are, however, blessed with abundant natural resources in the form of sun and wind. The total wind potential in the country is estimated to be over 30 times the current installed capacity of 27 gigawatts (GW), while our solar potential is expected to grow by about 90 times the current installed capacity of 8GW.
- ▶ Already, the government has an aggressive target of **60GW of wind** capacity and **100GW of solar capacity by 2022**.

RISING NEED

Primary energy demand is expected to increase by 2.3 times over the next 20 years.

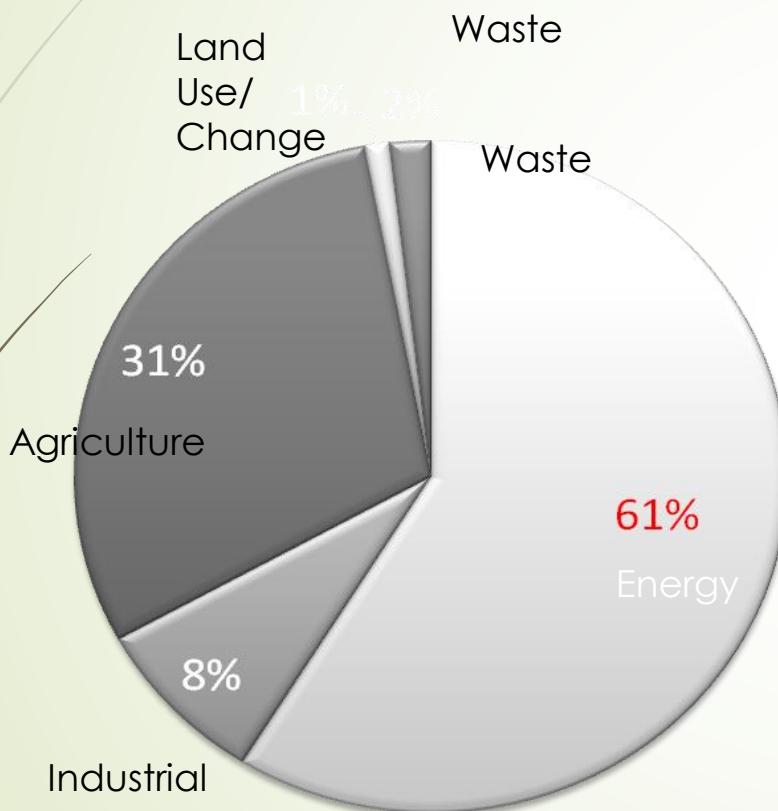
Renewables Nuclear Hydro Oil Gas Coal

(in million tonnes of oil equivalent)

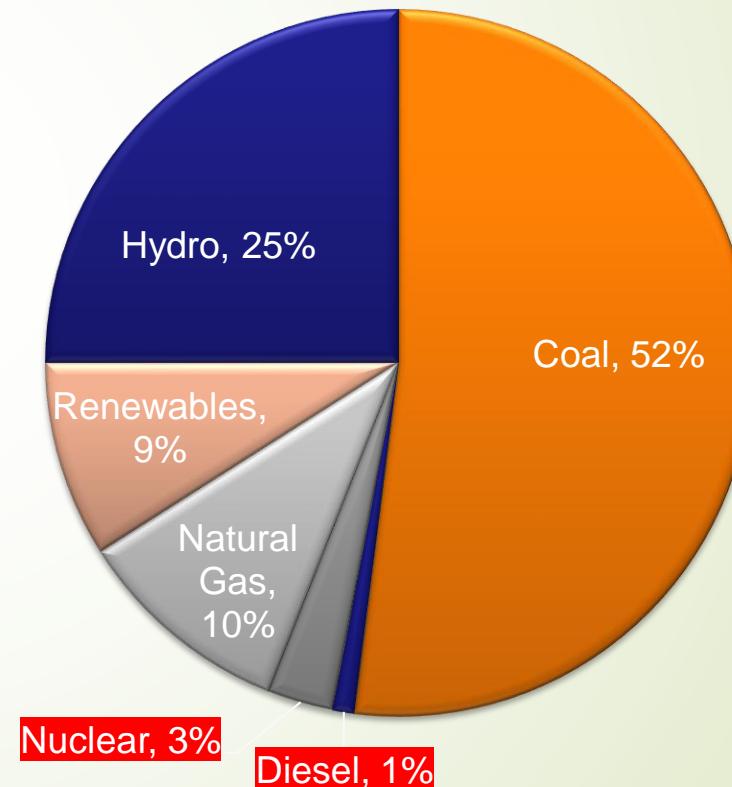


Where Indian emissions come from

GHG Indian Emissions Measured in CO₂ Equivalent



Indian Source of Power Generation



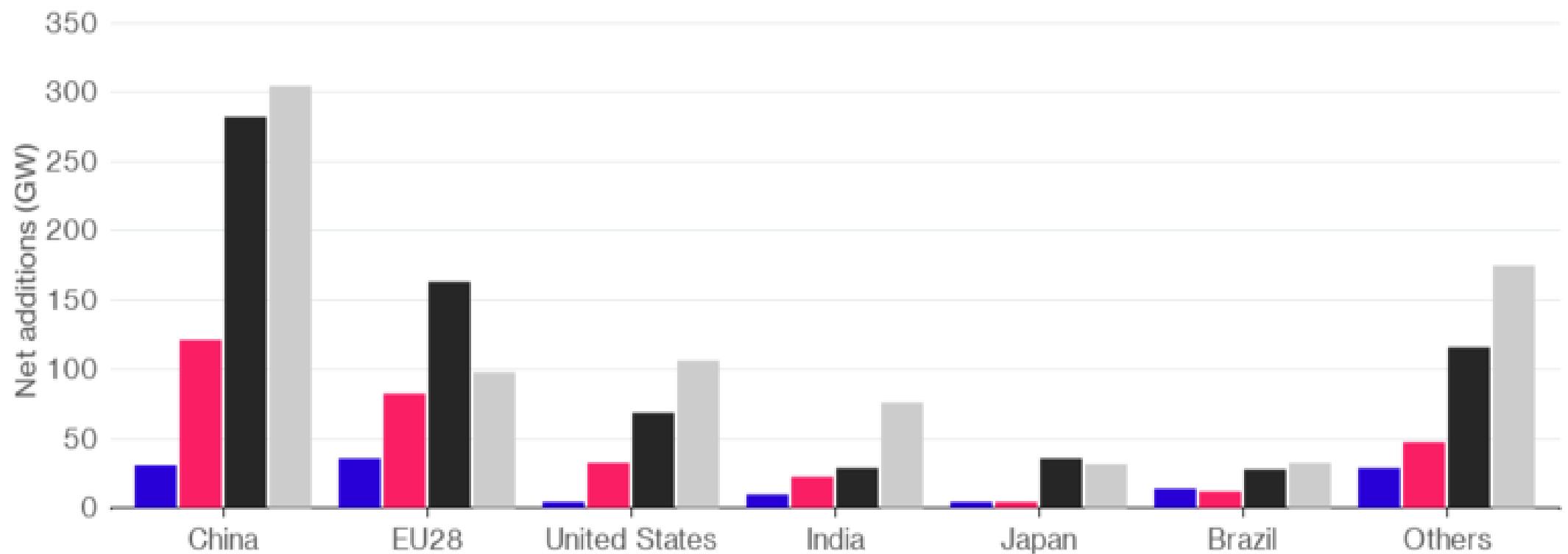
Source: CEA and MNRE (2008), Amit Garg (2006)

Note: Garg estimates based on 1994 data

The Clean Energy Boom, By Country

Global renewable electricity net additions to power capacity

■ 1997-2003 ■ 2003-2009 ■ 2009-2015 ■ 2015-2021



Source: International Energy Agency

Bloomberg

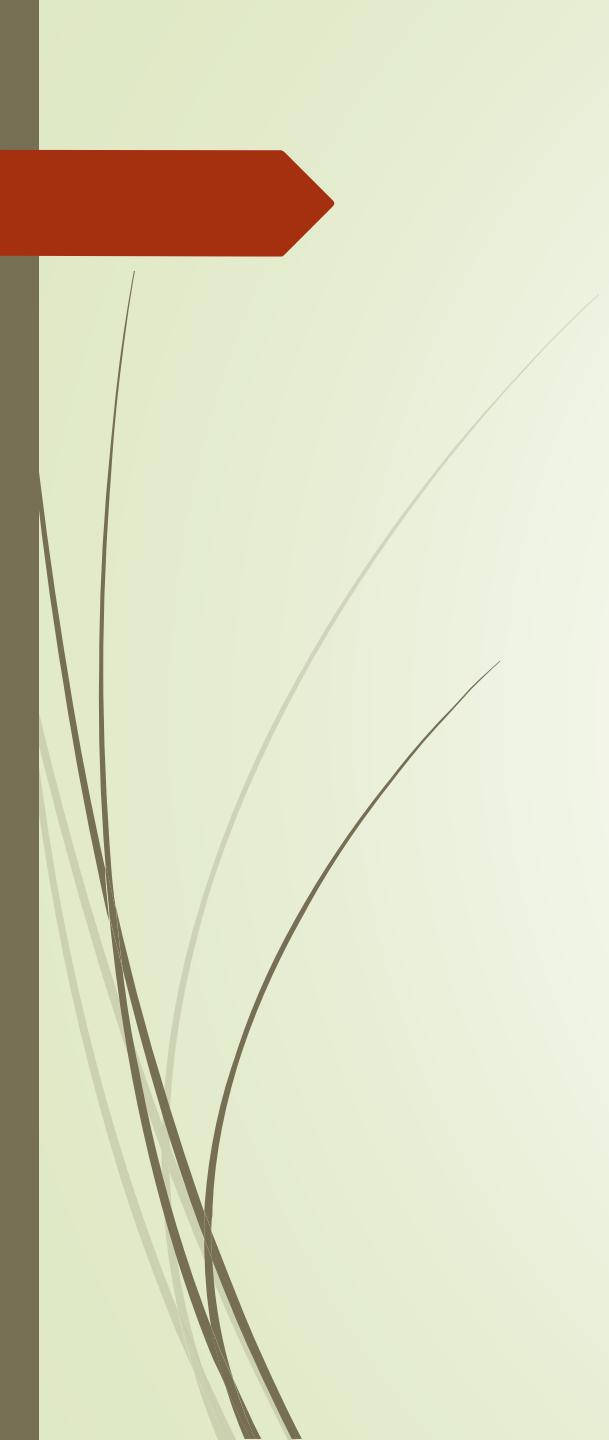






© Heidi Cullen



- 
- NASA Website
 - Video 1 & 2

HOW E LECTRICITY GETS TO YOUR HOME

1 ELECTRICITY IS GENERATED AT A POWER PLANT



3 ELECTRICITY TRAVELS ACROSS THE PROVINCE ON TRANSMISSION LINES



2 VOLTAGE IS INCREASED AT THE TRANSFORMER STATION



5 ELECTRICITY IS CARRIED TO YOUR NEIGHBOURHOOD TRANSFORMERS ON DISTRIBUTION LINES



4 THE NEIGHBOURHOOD TRANSFORMER STATION DECREASES VOLTAGE



6 THE TRANSFORMER ON THE POLE DECREASES VOLTAGE BEFORE ENTERING YOUR HOUSE



Traditional vs. Alternative Energy Sources

- oil
- natural gas
- coal
- hydroelectricity
- nuclear electricity



- solar
- wind
- biomass energy
(wood, peat, manure)
- tidal power
- geothermal



What happens when we waste electricity?



When you leave a bulb on for 1 hour, you are responsible for burning approximately **600-800 gms of coal** at the power plant.





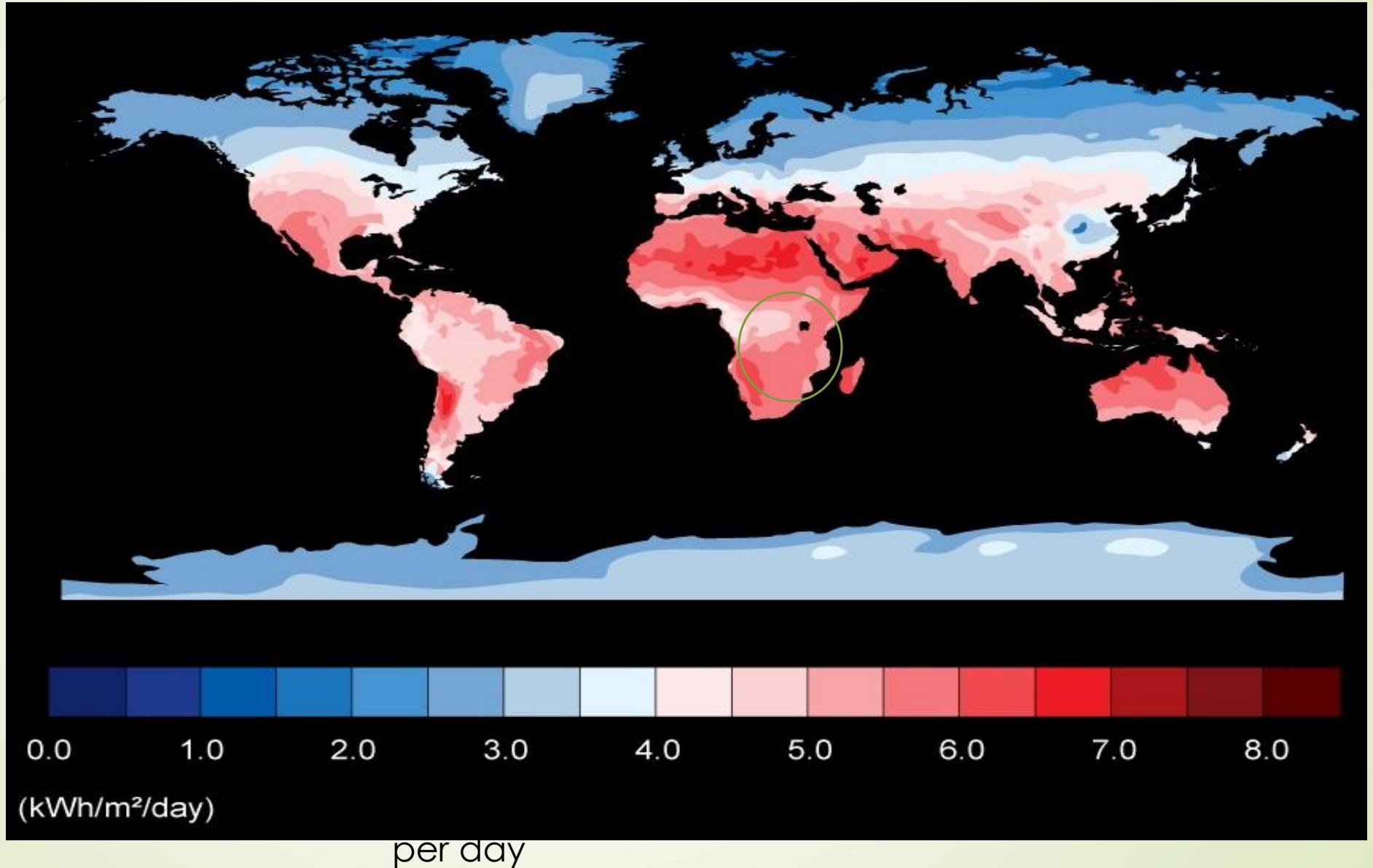
If a 14-year-old boy
can build a working
windmill to power
his village in
Malawi, we can
solve the climate
crisis





© 2008 Getty Images/AFP/Andreas Solaro

India's Solar Energy Potential



Green Energy Progress

How Do Projections Compare With Reality?

The solar energy market will grow 1 GW per year by 2010

The reality is
that goal was exceeded by

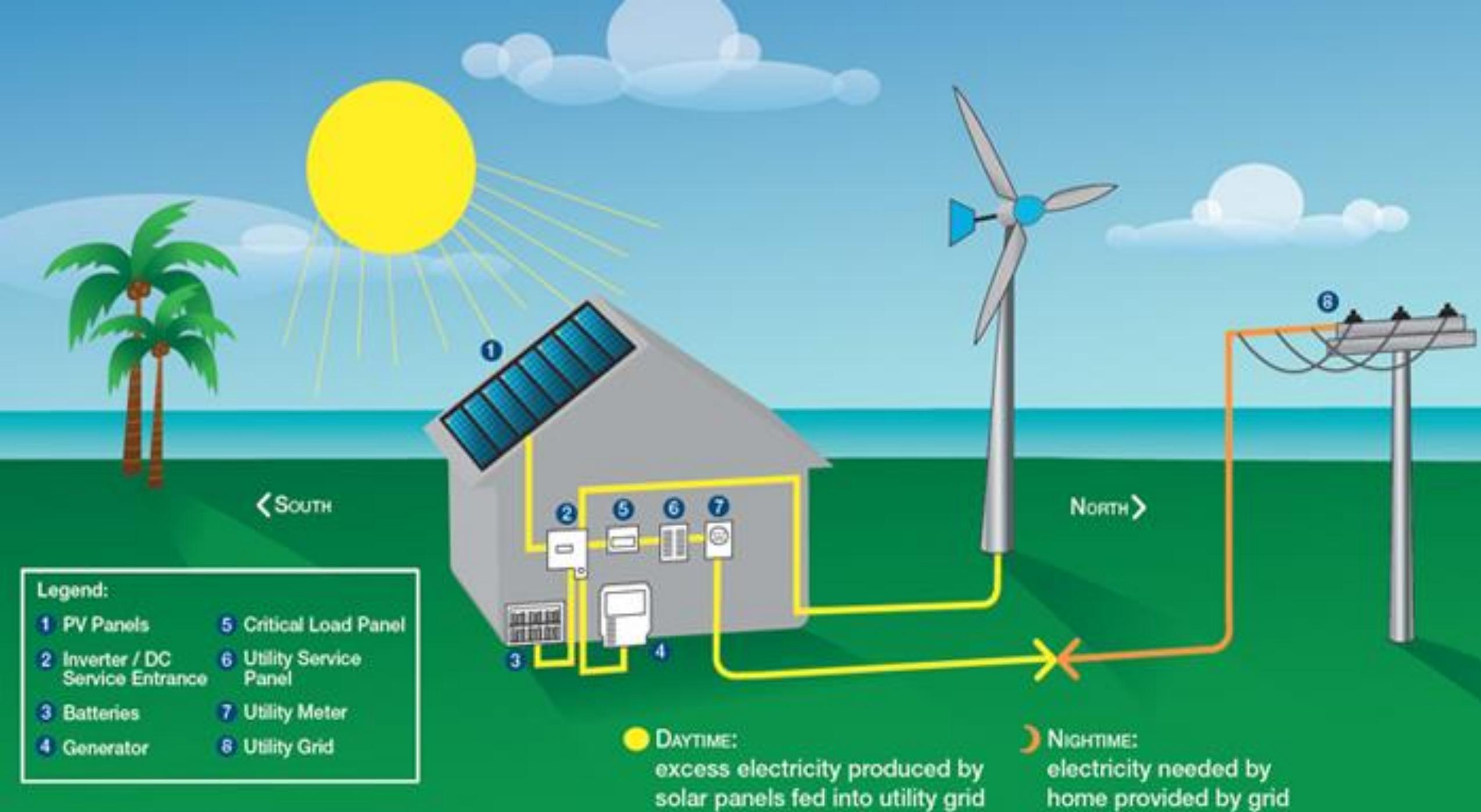
In 2016 it was exceeded by

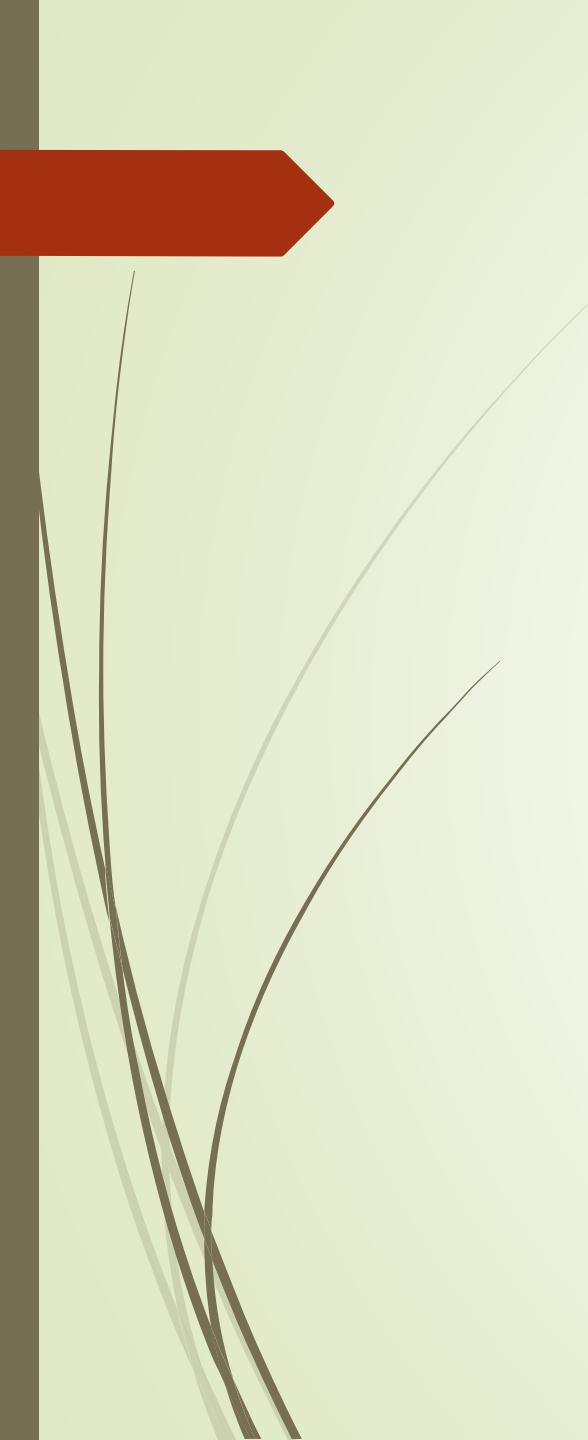
This year it will be exceeded by
as much as

17 x

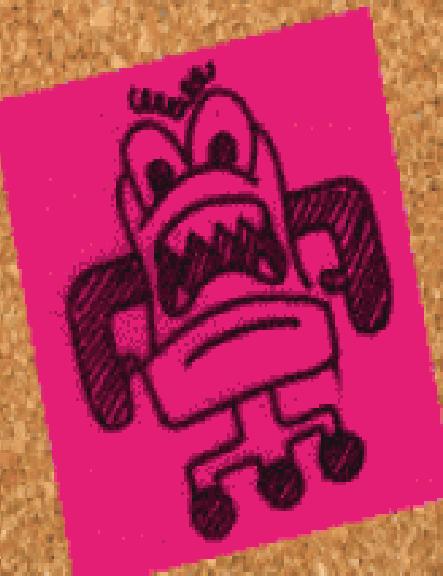
48 x

62 x



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- ▶ Solar Energy Types & Applications – NREL
 - ▶ Solar Thermal
 - ▶ Video 3 How Solar PV works
 - ▶ Video 4 Installation by Mr Pandey

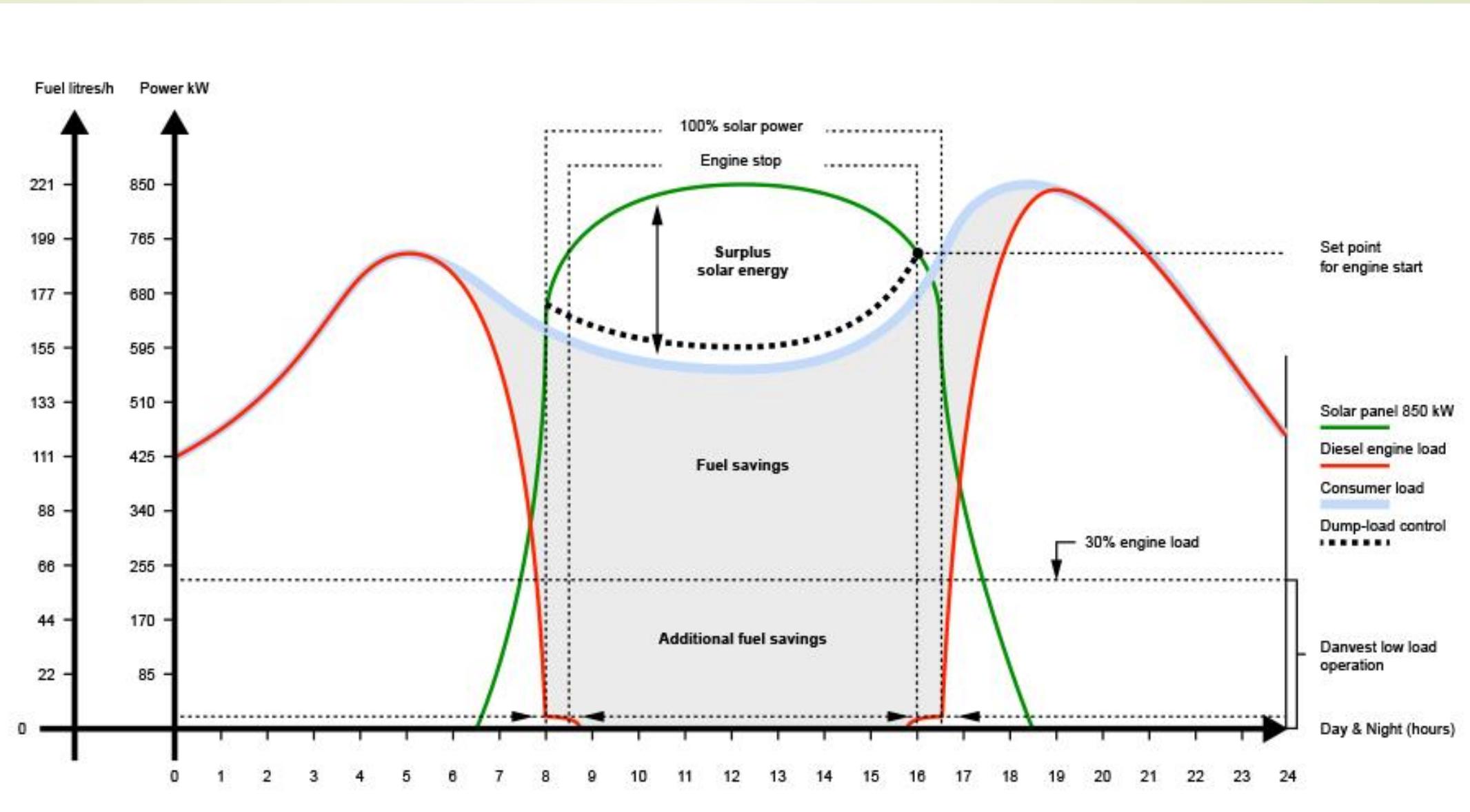
Take a
BREAK



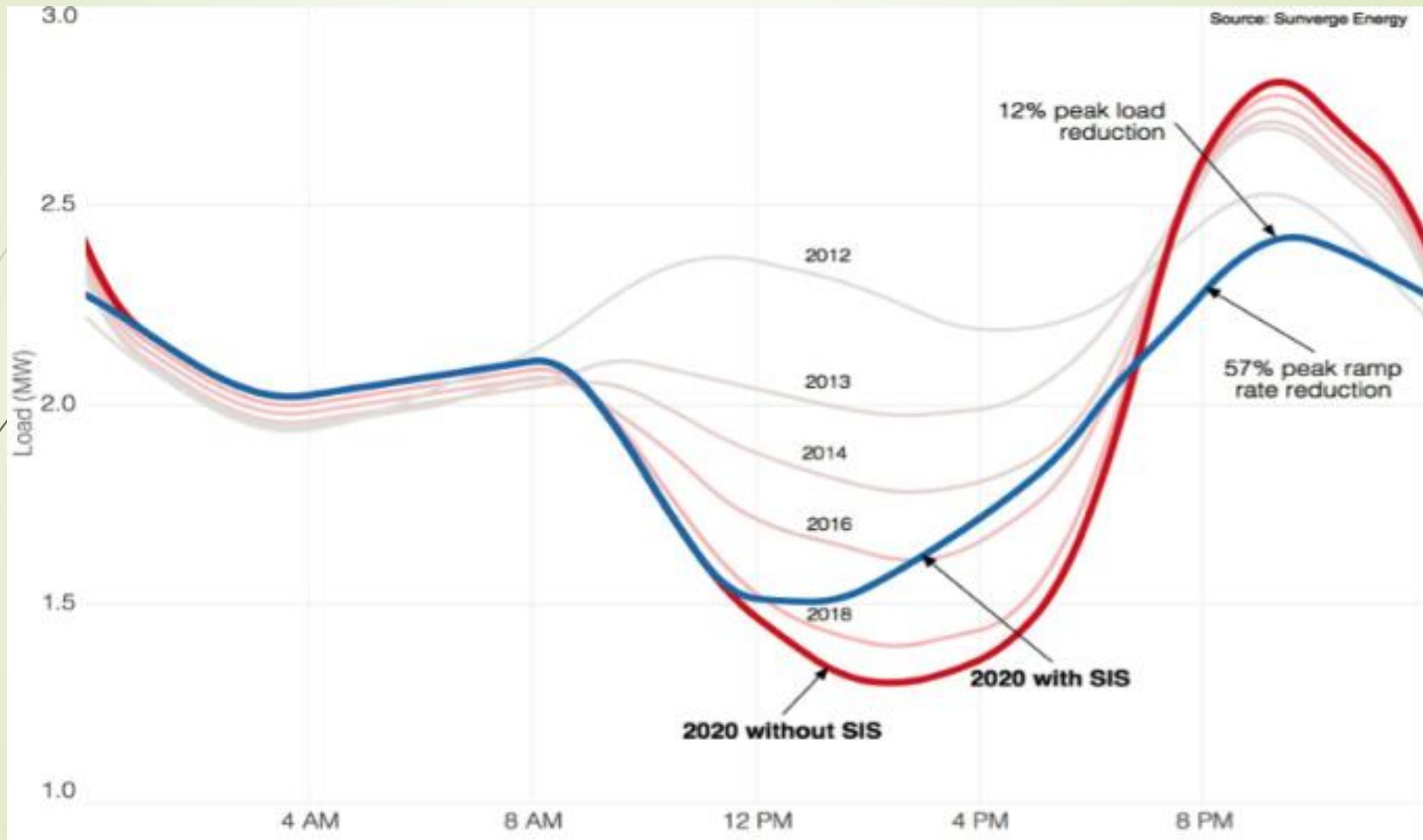


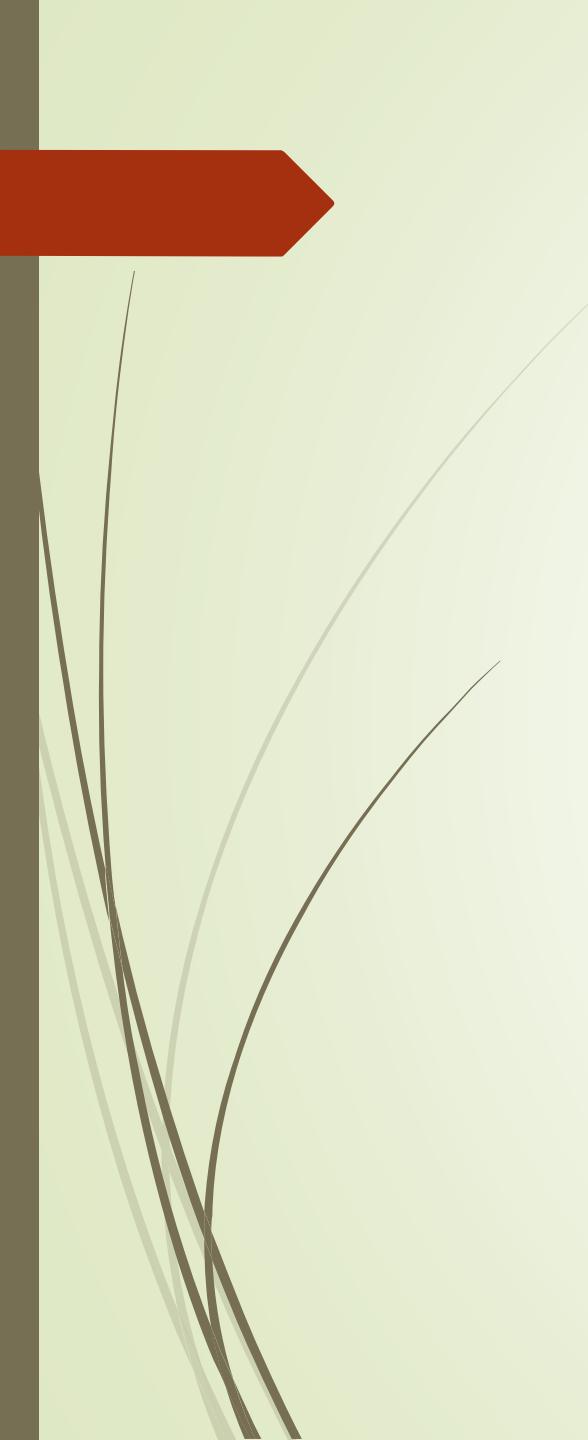
Electricity Charges

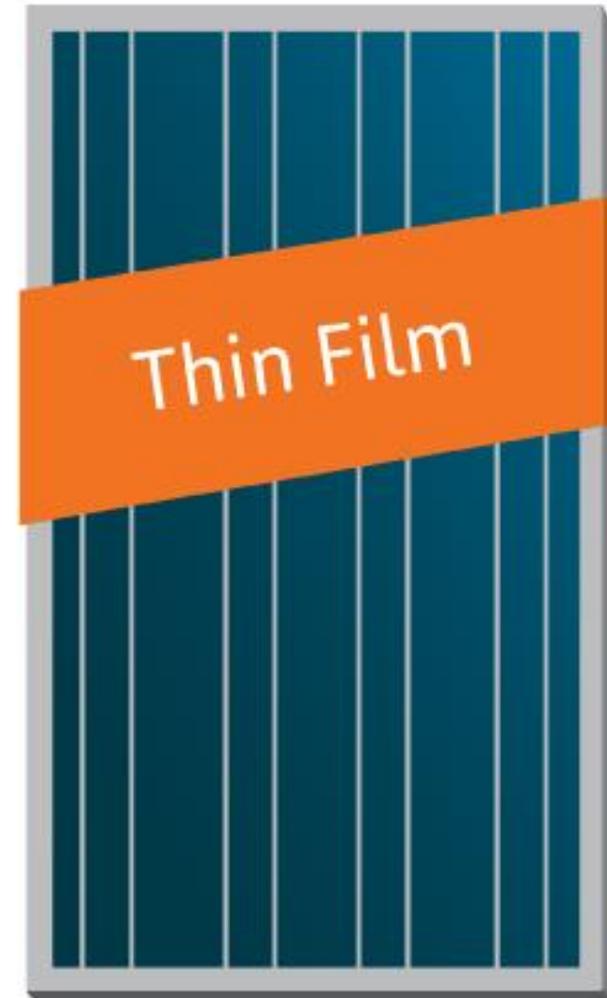
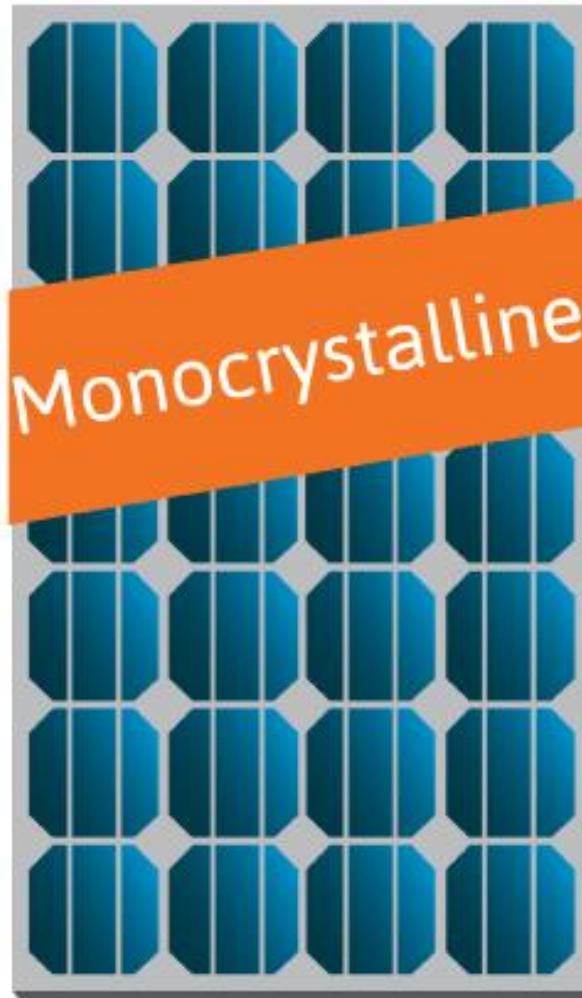
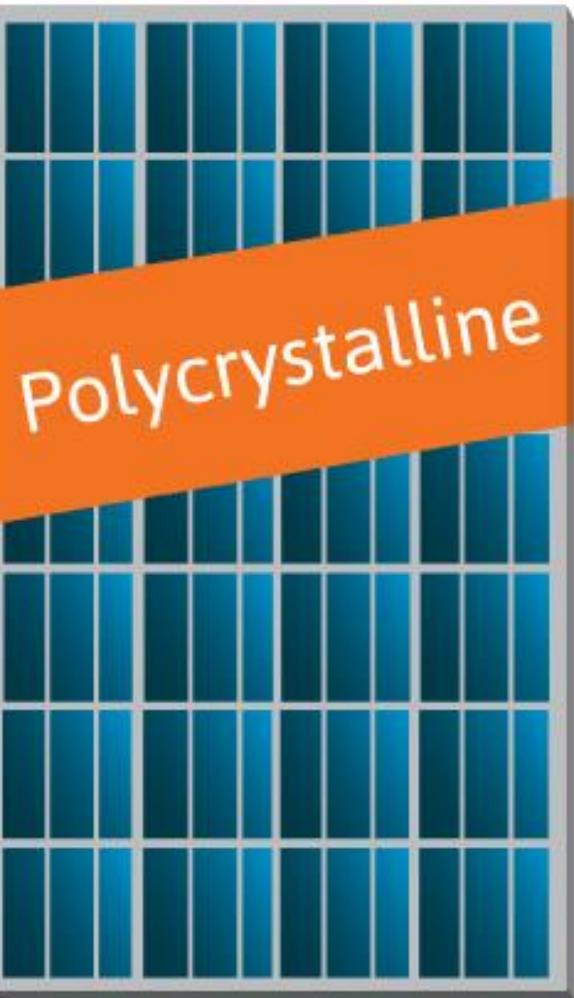
Duck Curve & Solar Generation Curve



Solar Integrated Storage



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- ▶ Video Module Manufacturing- BOSCH
 - ▶ Video- Rewa Solar Plant
 - ▶ India Module Manufacturing Status PDF





Anit-Dumping Duties

- ▶ India has initiated a new investigation to probe dumping of solar cells and modules from China, Taiwan and Malaysia. The petition for this investigation was submitted by Indian Solar Manufacturers Association (ISMA) on behalf of Indosolar, Websol and Jupiter Solar. The investigation covers both crystalline and thin-film technologies and will affect all imports making up more than 85% of total cell and module sales in India.
- ▶ Proving dumping for solar imports should be relatively easy as Chinese suppliers have been selling modules in India at prices lower than in China;
- ▶ The investigation provides a great test case for design of Indian policy making as there is no evidence from other countries of protectionist duties benefitting the prospects of domestic manufacturers;
- ▶ But with solar capacity addition growing at 100% CAGR in last 3 years and cost of solar power crashing to INR 2.44/kWh, we feel that the government may be more sympathetic to the demands of domestic manufacturers this time;
- ▶ Dumping is defined as exporting a product at a price that is lower than the domestic price for the same product. For solar imports, proving dumping may not be difficult as it is common knowledge that Chinese suppliers have been selling modules in India at prices lower than in China.
- ▶ The latest petition follows an earlier probe in 2012-14 on dumping of solar cells and modules, which had recommended anti-dumping duties of USD 0.11-0.81/Wp on cells and modules imported from China, US, Malaysia and Taiwan. However, the Indian government decided not to act on this recommendation following intervention by the then newly appointed Minister for Power, Piyush Goyal as the duties were seen detrimental to the growth prospects of solar industry in India. Instead, domestic manufacturers were promised assured demand through a Domestic Content Requirement (DCR) regime. Loss in the case against DCR at WTO has brought events full circle back to anti-dumping duties.

- The dumping investigation will be carried out by Directorate General of Anti-Dumping and Allied Duties (DGAD), who will consider a 15-month period from Apr-16 to Jun-17 to probe dumping and three-year financial data of the petitioning companies to analyse injury to domestic manufacturers. All other affected parties have a period of 40 days to share their response to the domestic industry's application. While the investigation can take 12 to 18 months, a provisional duty can be announced as early as on 22 September, 60 days after commencement of the investigation. This coincidentally is the same date when the USA is expected to [decide on a safeguard duty petition from Suniva](#).
- ISMA has submitted a separate parallel petition to Directorate General of Safeguards to consider imposition of safeguard duty on solar cells and modules. Safeguard duty is defined as temporary measure in defense of the domestic industry which is injured or has potential threat of injury due to sudden surge in imports. Unlike anti-dumping duty, a safeguard duty is country agnostic, is imposed on all imports and can be implemented much faster. In a recent precedent, India imposed [safeguard duty of 10 per cent on import of specified steel products](#).
- As we have always maintained, we see little upside to imposition of anti-dumping or safeguard duties on solar cells and modules. There is no evidence from other countries of such duties resulting in any long-lasting benefits for domestic manufacturers. At the same time, any duties raise the risk of side-tracking India's solar capacity addition target affecting more than 10,000 MW of project pipeline.
- Unlike last time around, however, we believe that there is more sympathy within government for imposition of anti-dumping and/or safeguard duties. In our previous commentary, we had highlighted that with cost of solar power crashing to INR 2.44/kWh, [there is a risk that the government may be tempted into a knee-jerk decision to protect domestic manufacturers](#) at the cost of causing disruption in the solar market.

DCR

- ▶ The World Trade Organization's Appellate Body has declared domestic content requirement (DCRs) in India's Jawaharlal Nehru National Solar Mission (JNNSM) as **illegal**. Last year in Aug 2015, the WTO disputes panel also ruled that India's subsidies for solar power contravene WTO trade rules and India must remove the subsidies or face trade sanction.
- ▶ United States filed the WTO complaint in 2013. The US alleged that India's subsidies for the JNNSM discriminates against foreign suppliers of solar component. The primary point of conflict is with regards to government entering into long term electricity purchase contract with eligible solar power developers (SPDs), assuring them guaranteed prices for 25 years. This government procured electricity is then sold to distribution companies who, in turn, sell it to consumers. However only those SPDs who source certain types of solar cells and modules domestically are eligible
- ▶ In Phase 1 of NSM, the DCRs only covered solar cells and modules. From the US standpoint, this was bearable as US companies export few solar cells and solar modules to India.
- ▶ But in phase II to NSM, India extended the DCRs to thin film technologies that have traditionally dominated the Indian market
- ▶ A similar ruling was passed in 2013 when Canada had launched a similar effort to encourage the growth of solar power. Japan and EU objected to the local content requirement that Canada had mandated
- ▶ Ironically, the US itself provides subsidies for renewable. Over the past 5 years, federal subsidies for renewable energy have averaged 39bn\$ a year.
- ▶ Domestic Content Requirement are part of many state and federal projects in the US. India had called attention to DCRs attached to renewable energy programmes in Michigan, Texas and California.
- ▶ Additionally, US also protects its own solar sector – it has imposed tariffs against Chinese solar product

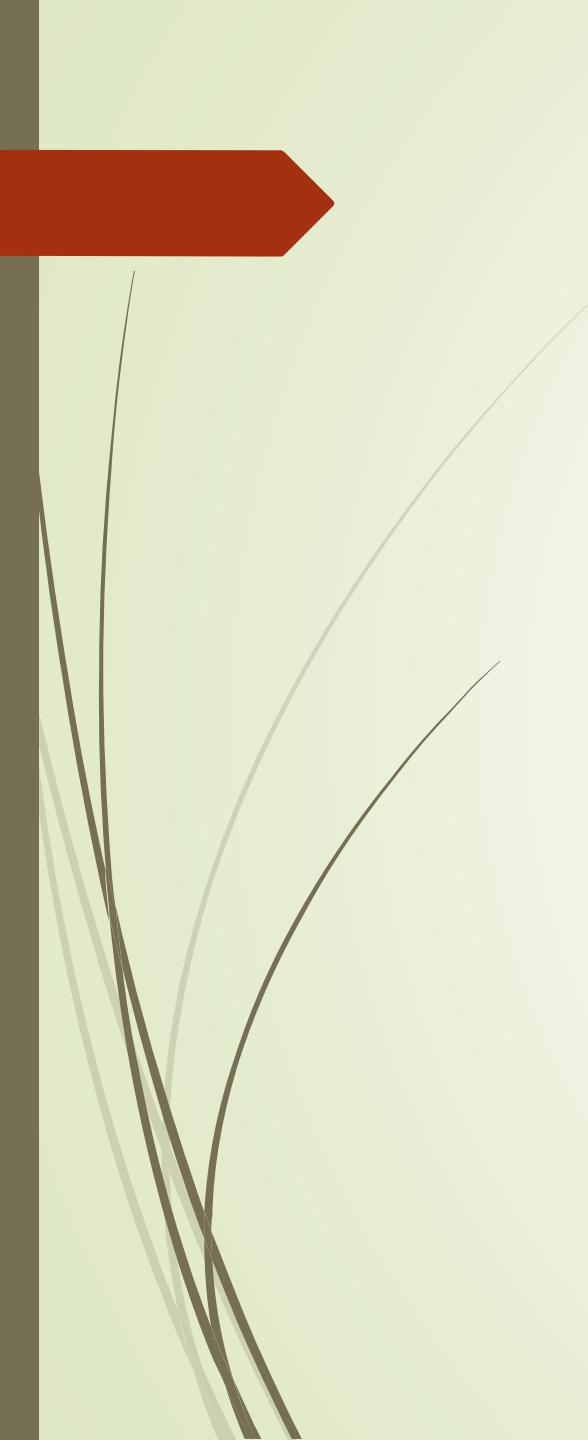
Impact of the verdict on India:

- ▶ India has said that it will ratify the Paris Climate Deal on 2nd Under the treaty, India has committed to 30% of its energy requirements being met through renewables by 2030. By 2022, India plans to have 100GW of installed solar capacity. The domestic manufacturers are yet to establish their competitiveness vis a vis the imported solar panels and modules. The specification of DCR was built in to provide support to this nascent industry so that India would be able to fulfill the targets for renewable it had set out to achieve. This now seems problematic. However Ministry of New and Renewable Energy has indicated that it is willing to replace the DCR measures with subsidies to safeguard solar manufacturing
- ▶ India had claimed that the DCR should not be countered as it is a government procurement programme which fall under Article III.8 of GATT that renders rules against discrimination inapplicable to government procurement. This was the argument given by India's Chief Economic Advisor Arvind Subramaniam
- ▶ The WTO ruling signals once again that neoliberalism favours trade over environment protection. The measure of India was to promote green energy. India has also taken the lead in establishing International Solar Alliance which focuses on exploiting the potential of solar power for fulfilling energy needs

Section 201: USA

- ▶ Section 201 of the 1974 Trade Act is the United States' "global safeguard" law. It allows for temporary relief in situations where surging imports are causing "serious injury" to a U.S. industry. An industry representative may petition the U.S. International Trade Commission (ITC or Commission) to conduct an investigation into whether imports are causing such injury and recommend remedies.
- ▶ The petition was properly filed by Suniva on May 17, 2017. The first phase of the case involves the ITC's determination on "injury," which the ITC must render by September 22, 2017. If injury is found, a "remedy" phase is initiated, during which the ITC must deliver a transmittal report to the president by November 13, 2017 containing any relief recommendations. The president then has until January 12, 2018 to decide whether to accept the ITC's recommendation and impose that relief, impose alternative relief, or not impose any relief.
 - ▶ As filed, the petition asks for four forms of relief for imported CSPV cells:
 - ▶ A tariff and minimum import price on imports that evolves over four years as follows:
 - ▶ \$0.40/watt per CSPV cell, with a minimum import price of \$0.78/watt per module (year 1)
 - ▶ \$0.37/watt per CSPV cell, with a minimum import price of \$0.72/watt per module (year 2)
 - ▶ \$0.34/watt per CSPV cell, with a minimum import price of \$0.69/watt per module (year 3)
 - ▶ \$0.33/watt per CSPV cell, with a minimum import price of \$0.68/watt per module (year 4)
 - ▶ A share of money distributed to domestic producers from the duty deposits currently being held by the US government as a result of the AD/CVD proceedings on CSPV cells and modules from China and Taiwan.



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- ▶ Video - SAPA
 - ▶ Video - Railway Station- Dexler Energy
 - ▶ Video – Dharnai
 - ▶ Video CSP
 - ▶ Solar Desalinating

Top States for Ground Mounted Projects

| State | Rank | Installed Capacity (As on 31 st Dec,2016) | Highlights | Key Drivers |
|------------|------|--|--|--|
| Tamil Nadu | 1 | 1591 | <ul style="list-style-type: none">• FiT at Rs.7.01 in 2015• 1200 MW bid in 2015, received interest for a capacity of 3200 MW• Recent 500 MW tender, received just 300 MW of bids | <ul style="list-style-type: none">• High solar tariffs• Adani Power's 648 MW |
| Rajasthan | 2 | 1318 | <ul style="list-style-type: none">• Tariff rates as low as Rs.4.34 for the NTPC bid in 2016• Major chunk of SECI's 750 MW allotted to Rajasthan | <ul style="list-style-type: none">• Abundant barren land with high solar insolation levels |
| Gujarat | 3 | 1159 | <ul style="list-style-type: none">• FiT until March, 2015• Tariff rates were very high initially, at about Rs.15 in 2009 | <ul style="list-style-type: none">• Excellent solar FiT rates until March, 2015• High credit rating of utility along with ease of business transactions |

Top States for Ground Mounted Projects

| State | Rank | Installed Capacity (As on 31 st Dec,2016) | Highlights | Key Drivers |
|----------------|------|---|---|---|
| Andhra Pradesh | 4 | 980 | <ul style="list-style-type: none"> AP 500 MW bid in 2014 saw tariff rates at Rs.5.25 – 5.98 ,with 3% escalation NTPC - 250 MW commissioned in 2016 – Sale to AP Discoms at Rs. 6.16 | <ul style="list-style-type: none"> Installed capacity was mainly tariff driven Wheeling Charges exemption for Third Party Sale & Captive Cross Subsidy Charges exemption for Third Party sale – first 5 years |
| Telangana | 5 | 973 | <ul style="list-style-type: none"> Telangana- 500 MW bid in 2014 saw tariff rates at Rs. 6.46-6.9 Tariff rates for the 2016 bids - Rs.4.66-5.57 | <ul style="list-style-type: none"> Similar to Andhra, installed capacity mainly tariff driven Wheeling Charges exemption for Captive, Cross Subsidy Charges exempt for Third Party Sale |
| Madhya Pradesh | 6 | 840 | <ul style="list-style-type: none"> SECI's VGF Scheme contributed 210 MW in 2015 | <ul style="list-style-type: none"> SECI Projects at a tariff of Rs.5.5 in 2015 M.P 100 MW bid, 2014, tariff – Rs.6.475 - 6.97 |

Top States for Ground Mounted Projects

| State | Rank | Installed Capacity (As on 31 st Dec,2016) | Highlights | Key Drivers |
|---------------|------|--|---|---|
| Punjab | 7 | 545 | <ul style="list-style-type: none"> • 250 MW bid in 2015 saw tariffs at Rs.6.88 – 7.21 | <ul style="list-style-type: none"> • High tariffs |
| Maharashtra | 8 | 431 | <ul style="list-style-type: none"> • Utility tariff rates at Rs. 7.21-11.5 for industrial and Rs. 6.60-13.01 for commercial sector | <ul style="list-style-type: none"> • High degree of industrialization • Very high utility tariff rates for the C&I sector – solar a cheaper alternative |
| Karnataka | 9 | 328 | <ul style="list-style-type: none"> • 300 MW Farmer's Scheme – tariff rate – Rs.8.4 • State also introduced high FiT rates at Rs.9.56 for rooftop projects in 2015 | <ul style="list-style-type: none"> • Special schemes like Farmer's Scheme with high FiT rates • Wheeling, banking, cross subsidy charges – fully exempt for 10 years, for plants commissioned between 2013-2018 |
| Uttar Pradesh | 10 | 239 | <ul style="list-style-type: none"> • Tariff rates in 2016 at Rs.4.78 • Earlier bids in 2013 saw rates at 8.01-9.33 with 3% escalation | <ul style="list-style-type: none"> • Scope for alternative RE sources poor |

Top States for Rooftop Projects

| State | Rank | Installed Capacity (As on Sept,2016) | Highlights | Key Drivers |
|-------------|------|---|---|---|
| Tamil Nadu | 1 | 132 | <ul style="list-style-type: none"> Highest contribution came from industrial sector, 74% | <ul style="list-style-type: none"> High degree of industrialization Capacity allowed equal to that of sanctioned load |
| Maharashtra | 2 | 89 | <ul style="list-style-type: none"> Utility tariff rates at Rs.7.21-11.5 for industrial and Rs.6.60-13.01 for commercial sector | <ul style="list-style-type: none"> High degree of industrialization Very high utility tariff rates , both for C&I |
| Gujarat | 3 | 69 | <ul style="list-style-type: none"> FiT rates offered between Rs.9.28-8.03 from 2012 - 2015 | <ul style="list-style-type: none"> Offered high FiT rates until 2015 Ease of transactions in the state |

Top States for Rooftop Projects

| State | Rank | Installed Capacity (As on Sept,2016) | Highlights | Key Drivers |
|-----------|------|--------------------------------------|---|--|
| Haryana | 4 | 57 | <ul style="list-style-type: none"> Govt identifies cluster of public/private buildings (possible plant sizes up to 1 MW) and invites IPPs to rent the rooftop space to develop projects IPPs, chosen based on the lowest bid, to sell the power to HPPC (Haryana Power Purchase Centre) IPPs can also choose to sell power to the owners of the premises and sell the excess to HPPC | <ul style="list-style-type: none"> Ease of approvals ensured with single window clearance Rooftops made available for IPPs |
| Punjab | 5 | 55 | <ul style="list-style-type: none"> World's largest single rooftop power plant, 11.5 MW in Beas Dera Campus | <ul style="list-style-type: none"> 85% of installations from commercial sector Well defined Net Metering Policy |
| Karnataka | | | <ul style="list-style-type: none"> Net Metering for C&I to be | <ul style="list-style-type: none"> FiT rates set from 2015- March, 2016 at Rs. 0.51 |

Top States for Rooftop Projects

| State | Rank | Installed Capacity (As on Sept,2016) | Highlights | Key Drivers |
|----------------|------|--------------------------------------|---|--|
| Rajasthan | 7 | 46 | • Excess energy compensated at Rs.7.5 per unit without AD, Rs.6.63 per unit with AD | • Well defined Net Metering policy with excess energy compensated at high tariff rates |
| Delhi | 8 | 35 | • Utility tariff rates for C&I at Rs.8.8-9.5 | • High tariff rates for the C&I Sector • GBI at Rs.2 for the residential sector for a period of 3 years since March, 2016 |
| UP | 9 | 33 | | |
| Andhra Pradesh | 10 | 32 | • Utility tariff rates for commercial sector at Rs.7.03-9.15 | • High tariff rates for the Commercial sector • Choice between Net Metering and Gross Metering |

Drivers for Ground Mounted Projects –

| Drivers | Level of difference that can be made | Ease of execution to enable driver | Notes |
|-------------------------------------|--------------------------------------|------------------------------------|---|
| Attractive solar tariffs | V High | Low | Major reason for the huge installed capacities in TN and Gujarat |
| Financial health/Payment security | High | Depends on discom | State guarantee on timely payments and off-taker credibility quoted as the main attractiveness for the recent 750 MW Rewa Project |
| Off-take guarantee to developers | High | Medium | |
| Additional incentives to developers | Medium | High | Incentives like deemed conversion of agricultural land, deemed industry status, stamp duty exemptions for land acquired attract more developers, same reflected in the large project pipelines of A.P, Telangana, Karnataka |

Drivers for Ground Mounted Projects – Third-Party Sale/Off-Site Captive

| Drivers | Level of difference that can be made | Ease of execution to enable driver |
|---|--------------------------------------|------------------------------------|
| Degree of industrialization | High | Low |
| Relatively high grid tariff rates for C&I | High | Medium |
| Open access incentives – wheeling, CSS waivers | High | Medium |
| Evacuation and grid connectivity | High | Medium |
| Land acquisition and availability | Medium | Medium |
| Competitiveness against wind | Medium | Low |
| RPO compliance | Medium | Low |

Drivers for Rooftop Solar Projects

| Drivers | Level of difference that can be made | Ease of execution to enable driver |
|---|--------------------------------------|------------------------------------|
| Degree of industrialization | High | Low |
| Relatively high utility tariff rates for C&I | High | Low-Medium |
| Optimal Metering Mechanism – Net Metering, attractive FiTs | High | Medium- High |
| Ease of approvals | High | High |
| Capacity relative to Distribution Transformer | Medium | Medium |
| Percentage capacity relative to sanctioned load | Medium | Medium |
| Subsidies / Incentives | High | Low |

Way Forward

Changes That Can Have a Medium-High Impact And Relatively Easy To Implement

Ground Mounted Projects

- 1) Enable payment and off-take guarantees for developers for projects under sale to utility model
- 2) Easier land and evacuation infrastructure access through solar parks

Rooftop Projects

- 1) Optimal Net Metering policies
- 2) Ensure ease of approvals by enabling single window clearances and adherence to timelines
- 3) Increase awareness among the residential sector through online and offline media

Major Bottlenecks Faced By States

| Bottleneck s | Segment Affected | States Worst Affected | Suggestions to Overcome the Challenge | Notes |
|--------------------------------------|-------------------------------------|-----------------------------|--|---|
| Poor credit worthiness of the Discom | Ground-Mounted Projects | Tamil Nadu, Rajasthan, U.P | Compliance with UDAY Scheme | All three states part of the UDAY Scheme – expected to cause financial turn around |
| Grid Curtailment | Ground-Mounted Projects | Tamil Nadu, Rajasthan | Optimal framework for grid and RE management | Gujarat has a well defined process for eliminating curtailment risk –day ahead forecast and scheduling, well-defined hierarchy for flow of orders , ramping of transmission and evacuation infrastructure |
| Land Acquisition and Availability | Ground-Mounted Projects | Telangana, Maharashtra, U.P | Proactive implementation of the terms laid out in solar policies on land acquisitions | A total of 125 projects were stalled in 2014 in Maharashtra due to land acquisition issues |
| Delays in approvals | Ground-Mounted and Rooftop Projects | U.P, Punjab | Enforce deemed conversion status for land, ease other clearances and approvals | Introduction of single window clearances, especially for the rooftop sector can accelerate growth |
| Lack of | Ground- | Punjab . Karnataka | Tie-up with agencies with sound | Punjab Farmer's Scheme had to be |