Renewable Energy Solutions For India - Action Plan

PREPARED FOR
THE PRIME MINISTER OF INDIA
NEW DELHI, INDIA

The Sun: Goldmine of green energy

Prepared by:

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Purpose of this Presentation

For economic as well as environmental reasons India need to shift to Renewable non-polluting Energy.

The aim of this presentation:

- ✓ Provide **Renewable Energy** (RE) solutions **ACTION PLAN** (for 5 and 10 Years) to meet India's Energy Needs
- ✓ **Develop Favorable policies For RE development**

5 YEARS PLAN:

- ➢ **Develop Solar Energy > 100,000 MW by 2020***
- ➢ **Develop Wind Energy > 50,000 MW by 2020***

10 YEARS PLAN:

- ➢ **Develop Solar Energy > 200,000 MW by 2025***
- ➢ **Develop Wind Energy > 100,000 MW by 2025***

***Assuming favorable Policy, Incentives, Tariffs, and Financing is provided**

What Is Renewable Energy?

- **“ Energy that is derived from natural process that are replenished constantly ” -- defined by the RENEWABLE ENERGY INTERNATIONAL AGENCY**
- **Renewable Energy – “any sustainable energy source that comes from natural environment.”**
- **Some Aspects of Renewable Energy**
  - It exists perpetually and in **abundant in the environment**
  - **Ready to be harnessed, inexhaustible**
  - **It is a clean alternative to fossil & Nuclear fuels**
  - **Non-polluting**

Major Renewable Energy Sources

The Ministry of Non-Conventional Energy Sources (MNES) is the head agency involved in facilitating growth of Renewable Energy in India

- **The Ministry's mandate covers the entire RE sector.**

- **RE sources covered by MNES are:**
  - **Solar**
  - **Wind**
  - **Small / Mini /Micro Hydro**
  - **Biomass**
  - **Energy from Industrial Wastes**
  - **Hydrogen Energy & Fuel Cells**
  - **Geothermal Energy Sources**
  - **Tidal Energy Sources**

Challenges and Issues Facing India

- **Demand far exceeds generation** capacity
- Lack of transmission and distribution capacity
- **Remote locations too expensive** to provide electric service
- **Lack of O&M** for existing infrastructure
- **Lack of financial resources** for infrastructure development
- **Lack of development of technologies** for the generation of electricity from renewable energy sources
- **Lack of regulations and technical standards** to ensure renewable energy systems are reliable

Present India's Renewable Energy Capacity (As of January 31, 2014)

- **Wind 20,294 MW**
- **Solar Power 2,208 MW**
- **Small Hydropower 3,774 MW**
- **Biomass Power & Gasification 1,286 MW**
- **Bagasse Cogeneration 2,513 MW**
- **Waste to Power 99 MW**

OFF-GRID/ CAPTIVE POWER (CAPACITIES IN MWEQ)

- **Waste to Energy 120 MW**
- **Biomass(non-bagasse) Cogeneration 517 MW**

(Source: Ministry of New and Renewable Energy, Government of India).

Case For Renewable Energy Solutions in India

Renewable energy is the only technology that offers India the theoretical potential to service all its long-term power requirements. The Indian subcontinent is blessed with abundant renewable energy resources. For instance, taking advantage of 300 to 330 sunny days a year, India could easily generate 5000 trillion kWh of solar energy, which is higher than India's total yearly energy consumption

India could build 1,000 GW of solar on just 0.5% of its land (Approximately 4 times current capacity)

Case For Renewable Energy Solutions in India

- **Domestic coal supply is limited and poor quality**
- **Foreign supply of hydrocarbons have serious impact on country's energy security**
- **Renewable Energy (RE) sources are not depleted**
- **RE is non- polluting**
- **Reinvestment can be used for many decades w/o affecting the environment**

Renewable Energy (RE) Development Potential for India

India has Abundant Solar Energy Resources:

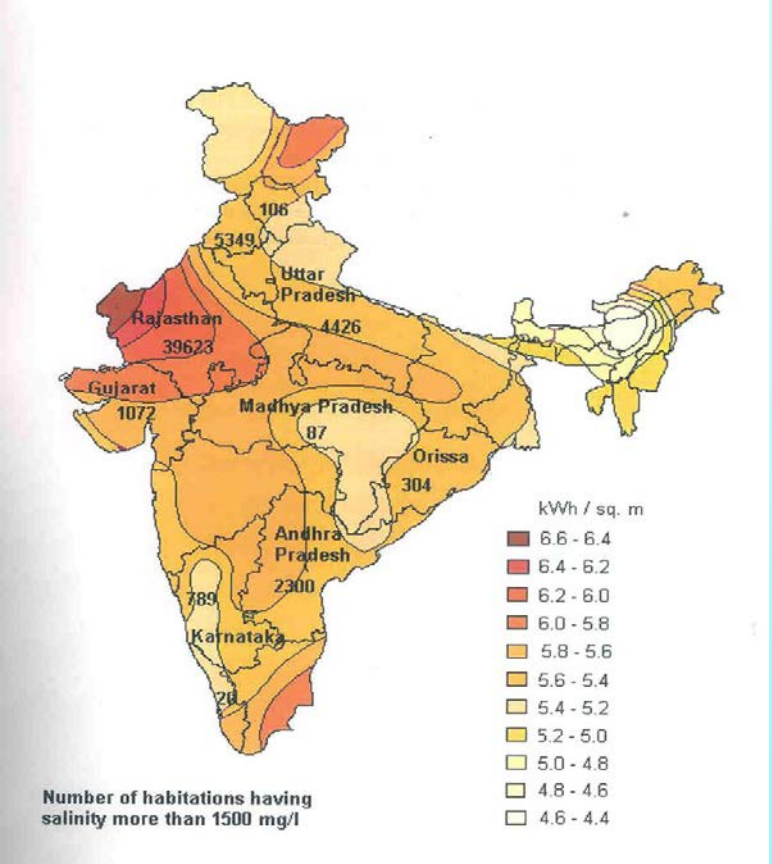
- **> 100,000 MW by 2020 * (5 years)**
- **> 200,000 MW by 2025* (10 years)**
- Harness **Wind Energy near the sea shore** and other windy sites
- **> 50,000 MW by 2020 * (5 years)**
- **> 100,000 MW by 2025* (10 years)**
- Additional potential for to tap Small Hydro Power plants, Biomass, Biogas, Geothermal, etc.

***Assuming favorable Policy, Incentives, Tariffs, and Financing is provided**

Solar Radiation in India

Most parts of India receive good solar radiation 4-7 kWh/sq. m.

Courtesy: Indian Renewable Energy Development Agency Limited New Delhi (India)



Solar Technologies Overview

Solar Energy

- **Solar Thermal Heating**
- **Solar Thermal Electricity**
- **Solar Photovoltaic (PV)**

Solar Technologies Overview

Solar Energy

- **Concentrated Solar Power (CSP)**
- **Concentrator Photovoltaic (CPV)** – New Technology (up to 50% Efficient Now)
- **Photovoltaic (PV)**
  - ✓**Wafer based**
  - ✓**Thin Film Technologies**

India – Solar Manufacturing

- **Wafer Based PV**
- **Thin Film Solar Module Silicon PV**

Solar Strategic Planning Steps
(Solar > 200,000MW by 2025)*

Methods:

- Small Solar PV Projects
- Large Solar PV Projects
- Large CSP projects
- Large CPV projects

Programs Needed

- Grid Connected (**Utility Scale) CSP and CPV installation**
- **Commercial Buildings**
- **Large scale Roof-top Solar PV** projects (all over India)
- **Irrigation (Solar Pumps)**
- **Rural electrification**
- Standalone systems

***Assuming favorable Policy, Incentives, Tariffs, and Financing is provided**

PROPOSED ACTION PLAN SUMMARY

- **Invest in Renewable Energy (FE) and Energy Efficiency**
- **Enact a National RE Standard of 20% by 2020**
- **Deploy comprehensive RE policies, PPAs, FIT, etc.**
- **Decentralized Energy; e.g., Roof-Top Solar Policy , etc.**
- **Deploy large utility-scale solar generation – Farms and cooperatives using PV, CSP and CPV technologies; & wind farms co-operatives**
- **Proper Incentives to create exponential growth of RE**
- **Phase out all conventional energy subsidies**
- **Give birth to the "Green Revolution" in India**
- **Invest in a smart & micro-grid; and smart meters**
- **Develop large-scale manufacturing "Solar Hub in India**
- **Work towards a Hydrogen (H2) Economy and fuel cells**
- **R&D facilities with IITs, Govt., industry for Tech. Devlp.**

PROPOSED ACTION PLAN

- Invest in **Renewable Energy** and **Energy Efficiency**
- Enact a **National Renewable Energy Standard of 20% by 2020** to create demand, new industries and innovation, and a new wave of **millions of green jobs**

PROPOSED ACTION PLAN

- Accelerate the development and implement nation-wide user-friendly **comprehensive Renewable Energy policies** such as **PPAs**, **FIT**, depreciation; tax holidays; financing funds; international partnerships/collaboration, incentives for new technologies; HR development; zero import and excise duty on materials; and low interest rate loans.

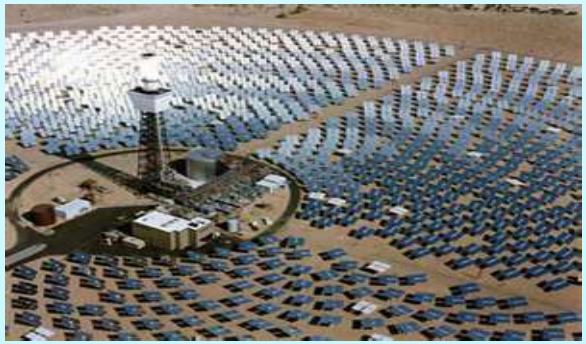
PROPOSED ACTION PLAN

- **Decentralized Energy** – Urgent need to develop a nation-wide **Comprehensive user-friendly Roof-Top Solar Policy** to promote small-scale and decentralized solar power generation and to solve the energy crises by bridging demand-supply gap. Facilitate growth in large scale deployment by installing **100 million solar roofs**, e.g., develop Solar Co-operatives like Solar Cities in CA and Wind Farm Co-operatives, etc.

PROPOSED ACTION PLAN

- Aggressively expand **large utility-scale solar generation,** using Photovoltaic (PV), Concentrated Solar Power (CSP) and Concentrator Photovoltaic (CPV) technologies






PROPOSED ACTION PLAN

- Develop, promote and establish **utility scale solar farms co-operatives, wind farms co-operatives, off shore wind farms and co-operatives**






PROPOSED ACTION PLAN

- **Develop favorable Renewable energy policies** to ease the permitting process, and to provide start-up capital to **promote the exponential growth of renewable energy**.
- **Phase out all conventional energy subsidies** including **coal, nuclear, petroleum products** to compete with other fuels.

PROPOSED ACTION PLAN

- **Give birth to the** "**Green Revolution**" - Initiate a move to electrify automotive transportation or **develop Electric Vehicles – plug-in hybrids –** such as the Nissan Leaf, Tesla Model S, or Chevy Volt, etc. Develop and implement **time-of-day pricing** to encourage charging of cars at night. Adopt nationwide charging of electric cars from solar panels on roofs, and **solar-powered Electric Vehicle charging stations around the country. Thousands of these solar-powered recharging stations could spread across India just like the present public call office (PCO).** Deployed recharging connections at shopping malls, motels, restaurants, and public places where vehicles are usually parked for extended periods;

PROPOSED ACTION PLAN

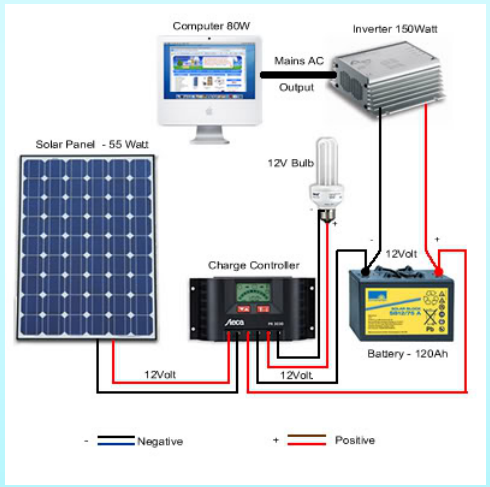
- Aggressively invest in **a smart, two-way grid** (and **micro-grid**) and **smart meters**
- Develop **large-scale solar manufacturing in India** (transforming India into a global "**Solar Hub**").

PROPOSED ACTION PLAN

- Use **all Renewable Energy options** including **solar, wind, hydro, biomass, and geothermal** to ease the strain on the present transmission and distribution system .
- **Develop waste-to-power - Biofuel and Biogas** power plants
- Engage States, industrial companies, utility companies, and other stakeholders to **accelerate the Renewable Energy investment**

PROPOSED ACTION PLAN

- **Establish R&D facilities within academia, research institutions, industry, government and private entities to guide technology development.**



PROPOSED ACTION PLAN

- Work towards a **Hydrogen** (H2**) Economy** and fuel cells for generating heat and electricity — as well as **for powering fuel cell vehicles**. Produce **H2 from renewable energy**, e.g., **solar and wind**. H2 and electricity will eventually become society's primary energy carriers for the twenty-first century.

HYDROGEN (H2) ECONOMY APPLICATIONS

PROPOSED ACTION PLAN

Work towards Energy Storage:

- ✓ **Thermal energy storage –** Solar CSP and CPV (molten or liquid salt a mixture of sodium nitrate and potassium nitrate)
- ✓ **Grid Battery Storage -** Lead acid, Li-ion, flow batteries, NaS
- ✓ **Compressed air/Gas energy storage**
- ✓ **Vehicles-to-Grid/Home**
- ✓ **Pumped hydro**
- ✓ **Fuel Cells hydrogen-based power modules**
- ✓ **Flywheel Storage**
- ✓ **Superconducting magnetic energy storage**
- ✓ **Super capacitors**

Estimated Cost Comparison Of Wind Energy In India (As of January 31, 2014)

COST COMPARISON OF WIND ENERGY

ONSHORE WIND FARMS

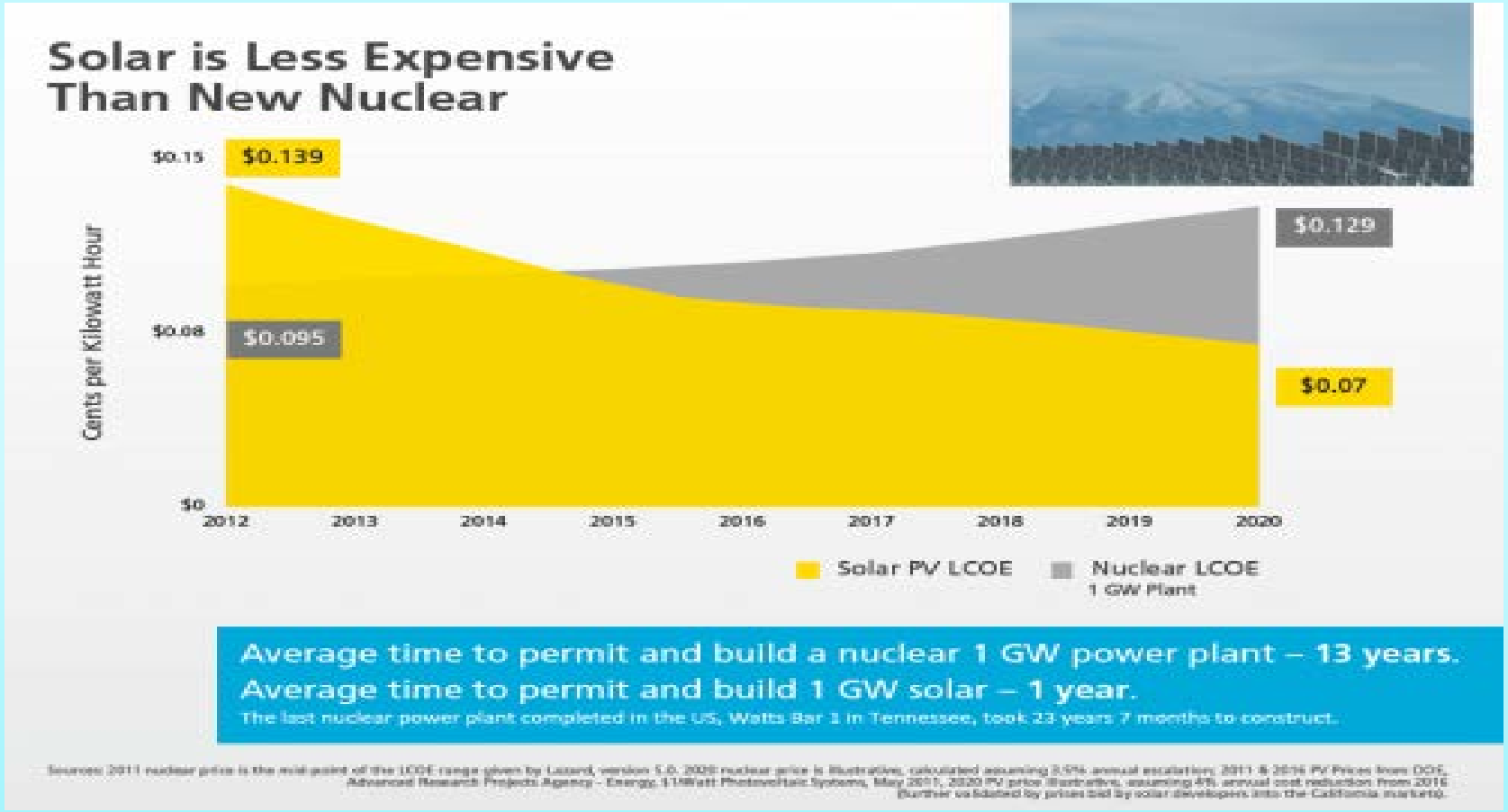
- Investment of about $1.5 million per MW
- Levelized cost of **6-7 cents per kWh**
- O&M – 1-3% of capital costs
- May be built in smaller units

OFFSHORE WIND FARMS

- Investment of $2.3 million per MW
- Levelized cost of about **10-11 cents per kWh**
- Higher O&M – 40$ per kW and 0.7 cents per kWh variable

Estimated Cost Comparison Of Solar Energy (As of August 23, 2011)

COST COMPARISON OF SOLAR VS. NUCLEAR



(Source: **CleanTechnica)**

Estimated Cost Comparison Of Solar Energy (As of August 23, 2011)

COST COMPARISON OF SOLAR VS. COAL

(Source: **CleanTechnica)**

Why Solar is the BEST Option to Meet India's Future Energy Needs

- Receives solar energy equivalent to **nearly 5,000 trillion kWh/year**
- **Solar radiation of 4 to 7 Wh/sq.m in India**
- Most parts of **India has 300~330 sunny days** in a year
- Power generation potential using **solar PV** technology is around **20MW/sqkm** and using **solar thermal** generation around **35MW/sqkm**.
- **India could build 1,000 GW of solar on just 0.5% of its land.**
- **India's Present Total Generation Capacity is about 210 GW**

Why Solar is the BEST Option to Meet Future Energy Needs

- **Decentralized** nature of **generation**
- Can be located **close to demand**
- **Reliable and predictable** performance > **25 years**
- **Low operational maintenance** Requirements
- **Domestic and freely available fuel source**
- **Zero human displacement**
- **No environmental impact**
- Most States **Tariffs** already established
- Average **Time to Build Solar is about 1 Year Vs. 13 Years for Nuclear**

Jawaharlal Nehru National Solar Mission

- Under the National Action Plan on Climate Change 8 Missions were proposed. In the Prime Minister's words "Solar Mission was its centerpiece"
- National Solar Mission is one of the major global initiatives in promotion of solar energy technologies
- To deploy solar technologies on a large scale leading to cost reduction and aiming to achieve grid tariff parity by 2022
- Deployment of 20,000 MW of solar power by 2022
- **Proposed Roadmap is not adequate**
- **Massive Power generation potential using solar technology (> 1000,000MW by 2050*)**

***Assuming favorable Policy, Incentives, Tariffs, and Financing is provided**

Present Tariff in Delhi

From 0 - 200 units 4.00 Rs per unit

From 201 - 400 units 5.95 Rs per unit

From 401 - 800 units 7.30 Rs per unit

From 801-1200 units 8.10 Rs per unit

Above 1200 units 8.75 Rs per unit

(Source: **Zee Media Bureau)**

Energy Storage Technologies

- Batteries – Lead acid, **Li-ion**, flow batteries, NaS
- Thermal energy storage – Solar **CSP** and **CPV** (**molten or liquid salt a mixture of sodium nitrate and potassium nitrate**)
- **Compressed air** energy storage
- **Pumped hydro**
- **Hydrogen Fuel cells**
- Flywheel
- **Superconducting magnetic energy storage**
- **Super capacitors**

Benefits Of Renewable Energy Options For India

- **Create millions of new good paying jobs**
- Solar energy is **environmentally friendly**
- **zero emissions** while generating electricity or heat
- **Boost the rural economy** by providing much needed energy for basic needs at affordable prices
- **Avoid the high costs new transmission capacity**
- **Avoid distribution losses**
- **Avoid recurring fuel cost**
- Enable village **co-operatives to supply their own power**
- RE also bring gains for Indian economy by way of **Clean Development Mechanism (CDM) projects**

Summary & Recommendations

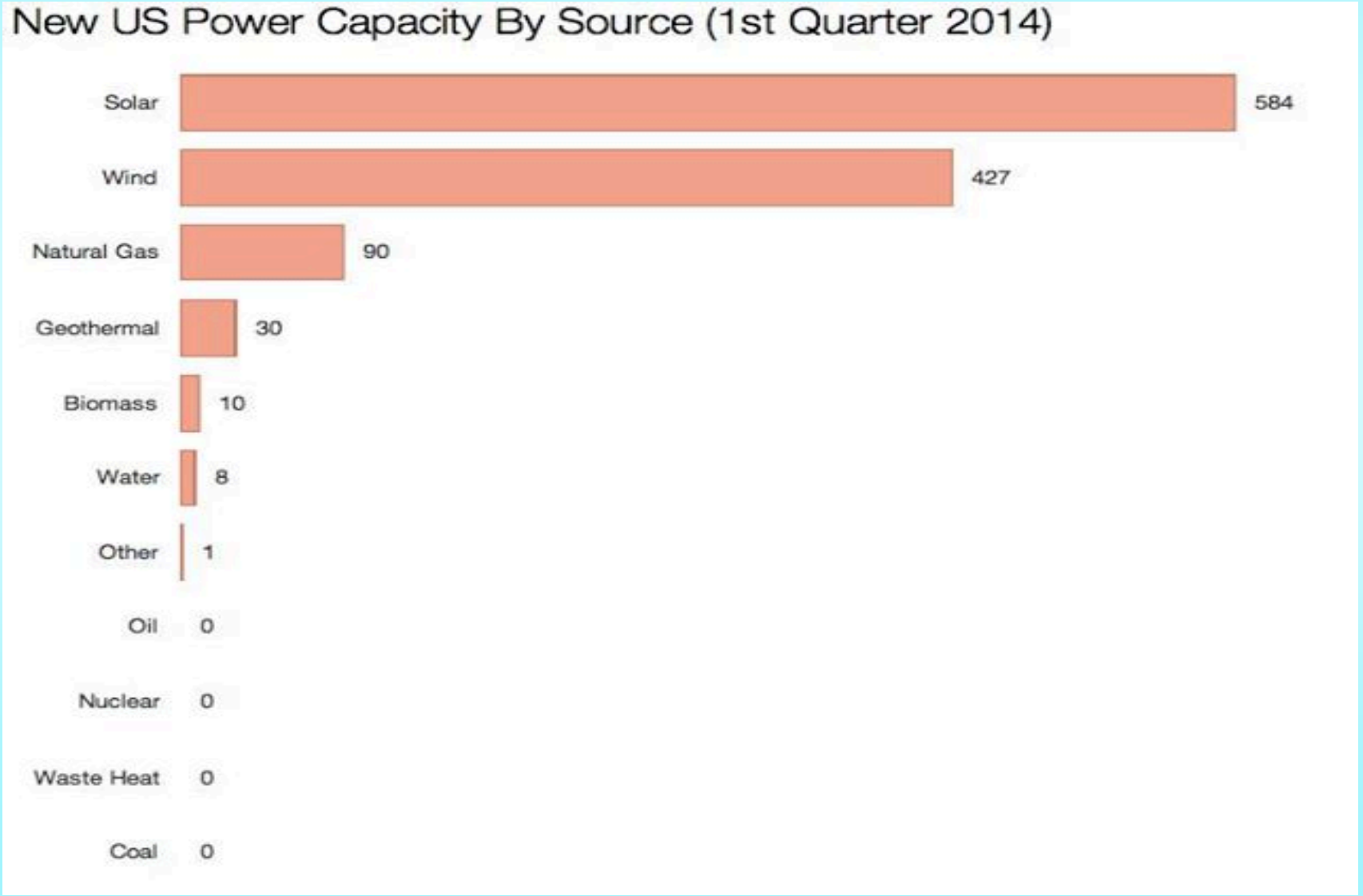
1. **National Policy - 20% by 2020**
2. **Feed-in-Tariffs (FIT) & PPA** for RE
3. **Generation Based Incentive**
4. **Make India Global "Solar Hub"**
5. **Establish Solar Parks & Solar Cities**
6. **Efficient Market Based Financial Mechanism**
7. **Establish R&D facilities at academic, research institutions, industry, Government and Civil Society to guide technology development**
8. **International Partnerships /Collaboration**
9. **HR Developments for Solar Revolution**
10. **Zero import duty on capital equipment**

Conclusions

- **RE is abundant, ready to harness & FREE**
- **RE is Non Polluting (Air, Water, & Soil)**
- **RE is a clean alternative to Fossil & Nuclear**
- **Solar (PV) power generation has emerged as a reliable and alternative source of clean energy**
- **PV market is showing robust growth world**
- **Solar cost down (10-20%/Year)**
- **Word is Developing large Utility Scale Solar Power Plants**
- **RE is in par with the fossil and Nuclear Power in many parts of the world today.**
- **Create million of jobs & Boost India's Economy**

It's The Beginning Of A New Era

New US Power Capacity By Source (1st Q 2014)



Solar Energy will Make India's Future Very Bright

THANK YOU

ENVISION INDIA POWERED ENTIRLY BY RENEWABLE S

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Reference Materials

- "**How Concentrated Solar Power Can Meet India's Future Power Needs**" by Darshan Goswami, M.S., P.E.

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- "**Solar Farming Potential in India**" by Darshan Goswami, M.S., P.E. ; E**nergyPulse.net -** http://www.energypulse.net/centers/article/article_display.cfm?a_id=2457
- "**How To empower India With Big Solar Energy Plans**" by Darshan Goswami, M.S., P.E.

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  http://www.energypulse.net/centers/article/article_display.cfm?a_id=2525
- "**Concentrated Photovoltaic Technology Carving A Compelling Niche**" by Nancy Hartsoch; SolFocus Solar Industry Magazine, June 2011
- **The Bloom Box: An Energy Breakthrough - Alternative Energy : http://www.cbsnews.com/video/watch/?id=6816773n**

How Concentrated Solar Power (CSP) Can Meet India's Future Power Needs

How Concentrated Solar Power (CSP) Can Meet India's Future Power Needs - By Darshan Goswami

http://www.triplepundit.com/2010/02/rajasthan-desert-solar/

The Sun: Goldmine of Green Energy

Solar energy is an enormous resource that is readily available in all countries throughout the world, and all the space above the earth. Long ago scientists calculated that an hour's worth of sunlight bathing the planet held far more energy than humans worldwide could consume in a year.

India's solar sunrise

- **India's solar sunrise By Darshan Goswami**
- 02 May 2012

- **Full version: India's solar sunrise** **http://www.renewableenergyfocus.com/view/25555/full-version-india-s-solar-sunrise/**

Solar Energy has the potential to re-energize India's economy by creating millions of new jobs, achieve energy independence, reduce the trade deficit and propel India forward as a 'green nation'. In short, solar offers too many benefits for India to ignore or delay its development.

CAN INDIA GO 100% RENEWABLE BY 2050?

By Darshan Goswami, M.S., P.E.; U.S. Department of Energy; Pittsburgh, PA; USA

SOLAR

POWER WORLD

http://www.solarpowerworldonline.com/2014/05/can-india-go-100-renewable-2050/

Renewable energy is the only technology that offers India the theoretical potential to service all its long-term power requirements. The Indian subcontinent is blessed with abundant renewable energy resources. For instance, taking advantage of 300 to 330 sunny days a year, India could easily generate 5000 trillion kWh of solar energy, which is higher than India's total yearly energy consumption.

ENDING INDIA'S MASSIVE POWER GRID OUTAGES – By Darshan Goswami, M.S., P.E.; U.S. Department of Energy; Pittsburgh, PA; USA

- **TriplePundit.com**

Solar energy is a game-changer for India: It has the potential to re-energize India's economy by creating millions of new jobs, achieve energy independence, reduce the trade deficit and propel India forward as a "Green Nation." Solar energy offers too many benefits for India to ignore or delay its development.

SOLAR FARMING POTENTIAL IN INDIA -

By Darshan Goswami, M.S., P.E.; Project Manager; U.S. Department of Energy

http://www.triplepundit.com/2011/08/solar-farming-potential-india/

Imagine a crop that can be harvested daily on the most barren desert and arid land, with no fertilizer or tillage, and that produces no harmful emissions. Imagine an energy source so bountiful that it can provide many times more energy than we could ever expect to need or use. Imagine that an hour's worth of sunlight bathing the planet holds far more energy than humans worldwide could consume in a year. You don't have to imagine it -- it's real and it's here. Solar energy is an abundant enormous resource that is readily available to all countries throughout the world, and all the space above the earth. It is clean, no waste comes from it, and once a system is in place, it's "free."

SOLAR ENERGY FROM THE RAJASTHAN DESERT CAN MEET INDIA'S FUTURE POWER -

By Darshan Goswami, M.S., P.E.; Project Manager; U.S. Department of Energy

http://www.eartheasy.com/blog/2010/04/solar-energy-from-the-rajasthan-desert-can-meet-india%E2%80%99s-future-power-needs/

The Government of India must take advantage of the vast amounts of energy available from the Rajasthan Desert sun (instead of oil from the Arab nations) to power its future energy needs. In addition, solar energy would not only create millions of jobs, but also sustain India's positive economic growth, help lift its massive population out of poverty and combat climate change.

HOW TO EMPOWER INDIA WITH BIG SOLAR ENERGY PLANS- *By Darshan Goswami, M.S., P.E.; Project Manager; U.S. Department of Energy*

http://www.energypulse.net/centers/article/article_display.cfm?a_id=2525

Solar energy can be the source of many benefits for India and the environment. Solar energy has the potential to re-energize India's economy by creating millions of new jobs, achieve energy independence, reduce the trade deficit and propel India forward as a "Green Nation." Solar Energy offers too many benefits for India to ignore or delay its development..

Go solar - By Darshan Goswami

LifePositive

Go solar

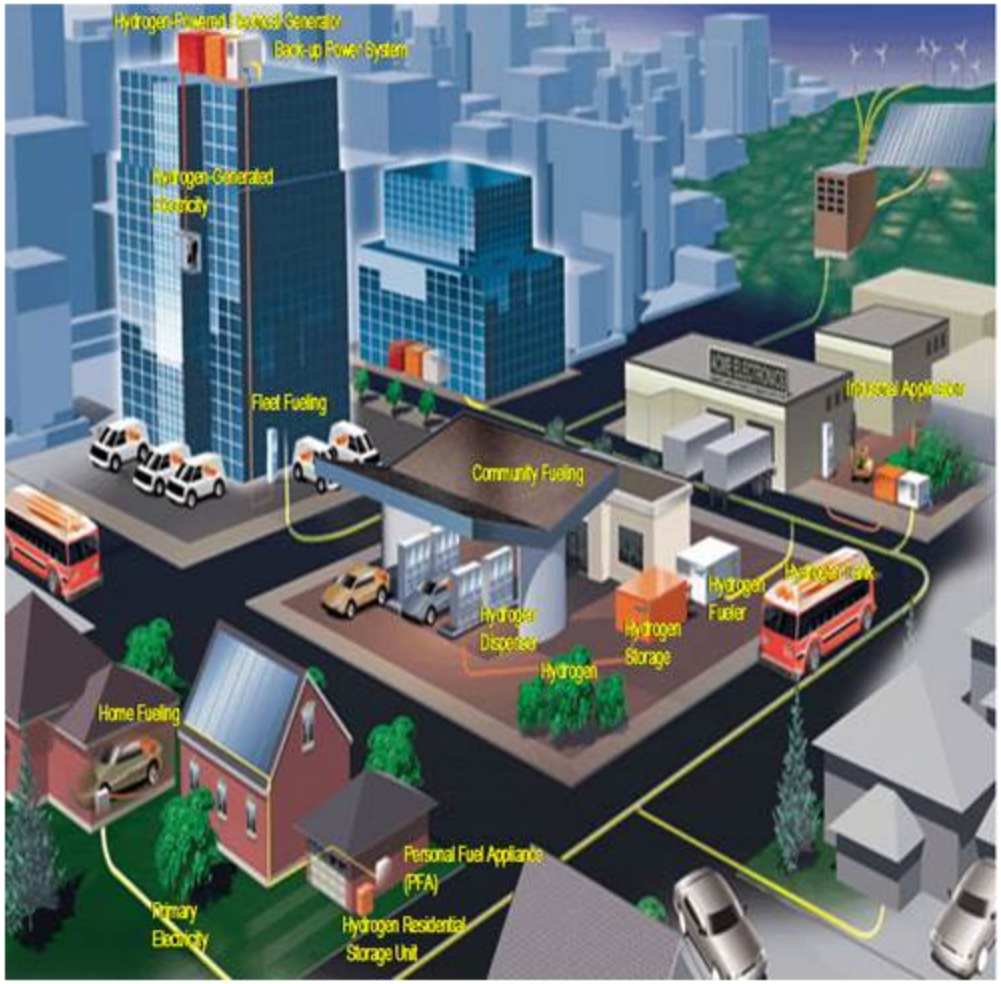
- By Darshan Goswami

http://lifepositive.com/go-solar/

June 2014

Darshan Goswami makes a strong argument for India to harness concentrated solar power, a renewable, safe and clean resource, for its future energy needs.[49]

The Hydrogen Economy – The Future of Energy



Indian Institute of Technology (Banaras Hindu University), Varanasi, India
November 6, 2012

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Summit for US-India Trade & Economics (SUITE) 2012, May 23rd – 24th, 2012 The Mason Inn Conference Center & Hotel, Fairfax, Virginia, USA

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THE SOLAR ISLANDS

Courtesy: THE SOLAR ISLANDS