a few green friendly organizations are making use of solar air conditioners. Presently, there are just a few makers of solar AC's in the country. However, China exports cheap units of solar AC's into India through a number of Chinese solar companies/suppliers.

The cost of solar PV derived electricity is declining fast worldwide. New type of applications are now being talked about on a regular basis, now including solar air conditioning. Solar based air conditioning is a technique of cooling space in buildings via an effective use of solar PV panels. Roof-top mounted panels can do the simple trick of running a conventional type air conditioning unit. However, it is still easier said than done as recourse would have to be taken to the following few measures:

- Individual houses and buildings need to be studied carefully
- Systems intended for installation need to be designed suitably so as to obtain optimum results of cooling

Key suppliers of Solar AC units

There are just a handful of manufacturers of solar AC units in India. Table 1 highlights these alongwith very brief salient features etc.

How costly is a solar air conditioner?

A solar air conditioning system still has a high initial capital cost. Take for example a 1000 W solar PV air conditioner, which would need a minimum of 2 kWp capacity panel to run on. The cost of a power producing part may be ₹100,000 going by the existing cost of ₹50 per Watt peak. So, it is expected to become cheaper as prices of PV modules drop down further.

Few case-specific examples of solar air conditioners overseas

Truck mounted system

The onset of summer months brings along a huge demand for cold drinks in the marketplace. The Coca Cola company in Hong Kong has got its trucks ferrying such drinks with solar air conditioning units. This development has become possible due to a collaborative project between

Table 1 Key suppliers of solar AC units

S.No.	Company	Location	Product type	Targeted use	Brief details
1.	Onyx India	Kerala	Hybrid solar air conditioner	Industrial customers mainly	• Mainly for industrial use • Use existing solar air conditioning technology via solar collectors • Uses conventional principle of compression techniques, evaporation and cooling • Total savings rate for Solar AC as compared to other AC's is around 60%
2.	Reliance Solar	Navi Mumbai	Solar Air Conditioner	Domestic	• Highly efficient 0.85 ton solar unit • Solar and AC grid charging option • Efficient thermostatic controller ensuring low power consumption • Reduced electricity bills • Programmable Logic Control (PLC) for an efficient charging
3.	Sharada Inventions	Nashik	Solar Air Conditioner	Industrial	• Uses no compressor and thus no costly maintenance • Uses no CFC • Uses solar thermal energy • Available in a wide range of capacities from 10 TR to 600 • TR and more • Uses centrally controlled sun tracking mechanism
4.	Arka Technologies	Pune	Solar	Industrial	• Non CFC based • Systems available for large scale centralised applications with capacities of 60 TR to 600 TR and above • Uses heat pipe type heat exchangers • Refrigeration fluid can be heated to very high temperatures

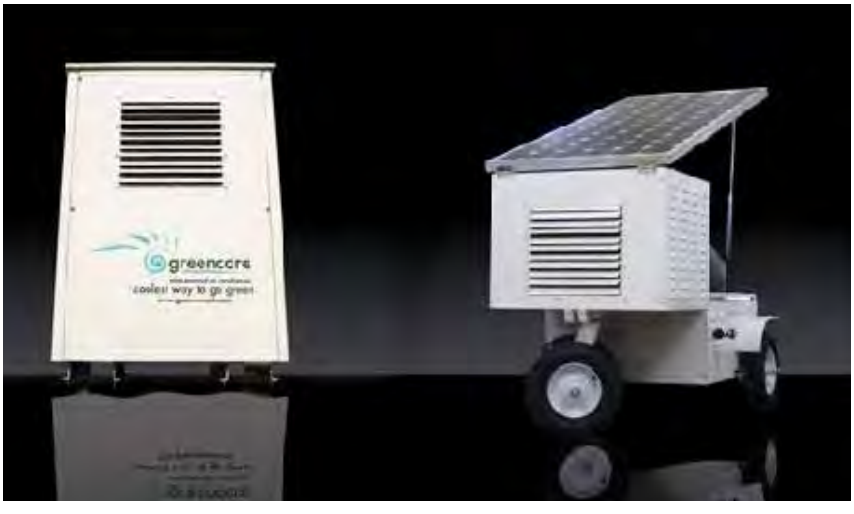
Hongkong Polytechnic University, Green Power Industrial Ltd, and Swire Coca-Cola Hong Kong.

Key features of this mobile Solar AC unit are:

- A photovoltaic panel attached to the roof of the truck's cab
- It collects solar energy to charge a specially made battery system
- The battery powers an electric motor to drive a variable frequency-driven (VFD) compressor
- Available for use on cloudy and rainy days too
- AC can be switched on when the vehicle engine is not running

Solar AC for both fixed and mobile applications

The underlying concept is simply-when it is hot, the sun is out, so why not make use of that energy to help cool down. A company in California named Greencore has developed a solar powered AC unit (Figure 2) to meet both the fixed and mobile applications. Salient features of this system are as under:



- Can cool a room of up to 600 square feet size via a single 170 Wp solar panel
- Can draw power from the grid as and when needed
- Batteries can be charged from grid power too
- A solar powered thermo statistically controlled unit offers mechanical air conditioning at a low cost
- Avoids the need for an expensive inverter by running on DC current
- Also available with an optional heating element for climate control on warm days with cool nights

The cool way forward

Sun will continue to shine brighter as before. Each one of us would like to have a cool whiff of air over our body. The million dollar question is can solar power can become cheap enough for this purpose, and how can we store sunlight for the night. ■

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2011–Harbinger of the Solar Dominance

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Year 2011 was not good. Almost everyone would like to forget the depressing impact the deepening economic crisis had on global markets, commerce, and trade. However, 2011 will be remembered for bequeathing to the world an impressive market transformation that promises a defining and dominant role for solar energy not only in the current decade but also in the long run. Grid parity, which remained a distant dream and a point naysayers harped on, all of a sudden seemed possible much earlier than previously thought. Achievements in emission reduction targets that looked over-ambitious may after all become a possibility as solar's contribution to the RE basket and to the overall energy basket along with wind grows enormously.

According to the EPIA 2011 market report, as much as 27.7 GW of new power plants were connected to the grid in 2011 taking the cumulative installed capacity close to 67 GW. Nearly 40% of the capacity addition took place last year alone. More importantly the Giga-Watt Solar Club, grew from six to nine with Australia, Belgium and China joining it. India and UK are marching fast and would soon be joining the club. For the first time in many years, Germany lost its position at the top of the capacity addition table as it added 7.5 GW of solar capacity, below Italy which added 9 GW.

Academics and industry specialists including Mr. C. Werner from Q Cells, in a symposium held in Ulm, Germany last year, brought to light the spread of solar utilization in as many as 187 countries across all continents. The study showed that several smaller and developing nations are interested in small off-grid systems. It also pointed out to some huge unexploited markets especially those in the African and South American continents

Also-ran just a few years back, China rose to a very dominant position in Solar PV in 2011. China is now the biggest global supplier with 40% of global manufacturing capacity, and the growth in Chinese capacity had a remarkable impact in the global market.

It established itself as a global supplier of modules with 40% of the global manufacturing capacity based in China and it had a huge impact on the global market in 2011. Polysilicon prices slipped to less than a tenth of the high prices of $450 / kg that prevailed in 2008, and are now available at $30 to $40/kg. Modules prices also similarly fell from around $3 per Watt in 2008 to less than $1 a Watt.

With such a rapid drop in prices driven by Chinese exports, anxiety quickly spread across the industry in all major manufacturing countries. The year thus saw sharp rise in bitter trade disputes, and pressure on governments mounted to protect local manufacturing. Private discussions in many events invariably centered on Chinese dominance and the impact it had on the global prices

Late in October 2011, a group of US PV manufacturing companies lead by Solar World petitioned to the International Trade Commission of the US Department of Commerce that the Chinese companies enjoyed several government incentives and made US products uncompetitive and sought anti-dumping duties to be levied.

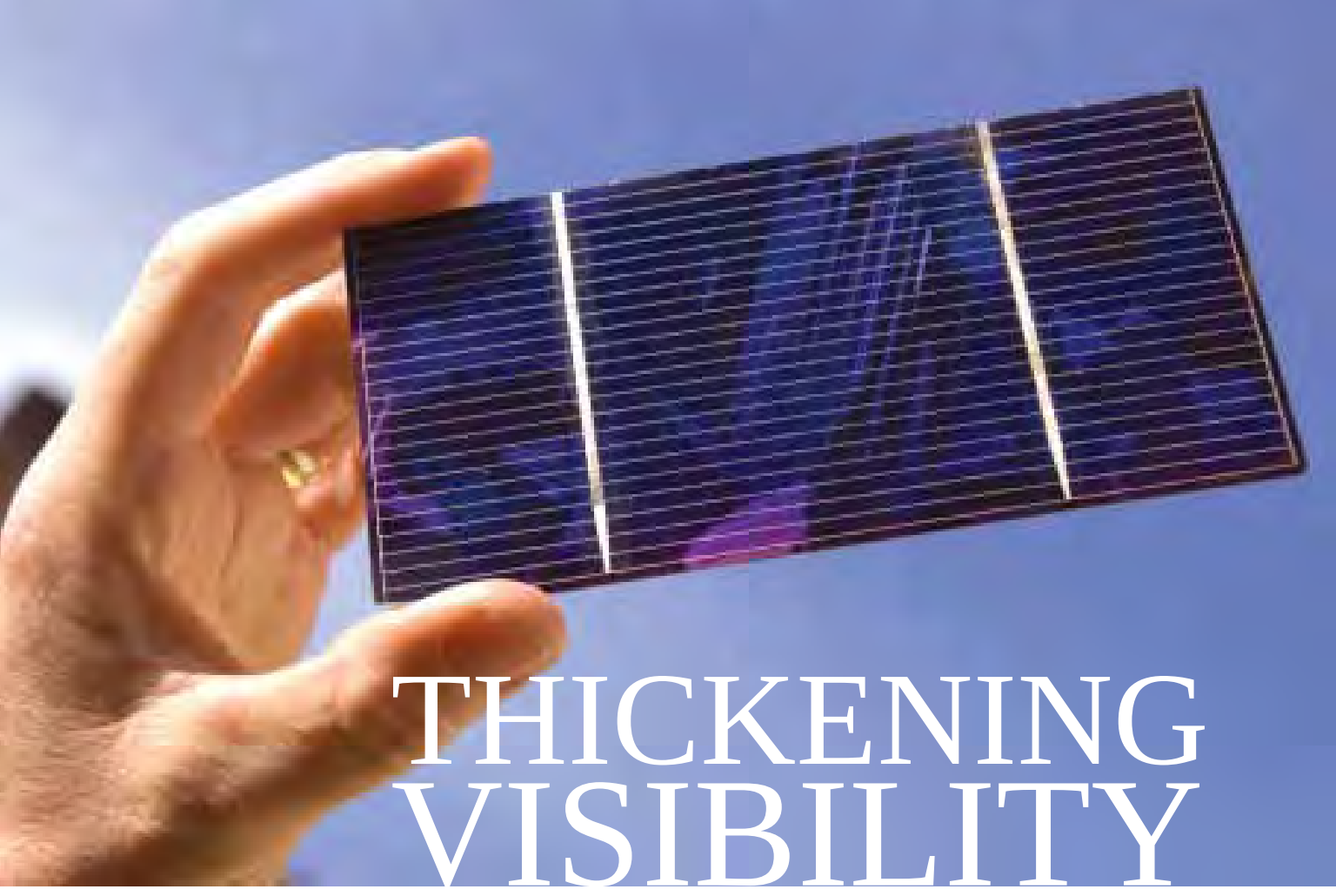
In India, the manufacturing industry, centered on crystalline silicon technology, was sore that local manufacturing content requirements of the JNNSM in no way protected their interest as it allowed unrestricted import of thin film modules. Many cell and module manufacturers were operating far below their capacity and even reputed suppliers of manufacturing equipment and material suppliers found the market uncertain and depressing.

2011 was also a great year of learning for India, with several projects under the Government of India's JNNSM programme and Gujarat Government's solar programme reaching completion. There were lessons on every front - bidding processes, issues relating to land acquisition and environment clearances, to evacuation of power and more.

The drastic drop in the price in 2011 resulted in project developers quoting very aggressive prices for projects under the 2nd batch of phase I of JNNSM projects. A French company's offer of ₹7.49/KWh took the industry by surprise. This rate, when compared to the CERC determined rate of ₹18.44. Kwh fixed only in 2010 re-emphasizes the incredible changes 2011 had on brought on.

There are many who believe that such rates are unsustainable and may even hurt the interest of the industry. Also many believe that once the economy recovers and the huge inventory pile up melts away the prices of poly silicon and solar cells will rise again. It cannot, however, be disputed that even if the prices rise it will be nowhere near the prices that prevailed before the economic recession beset the world. 2011 saw a dramatic drop in prices, the closing in on grid parity, and an intense trade war churning the intensity. No energy and emission mitigation planning of a nation or a group of nations would henceforth be complete without accounting for the burgeoning solar energy.

Indeed, 2011 would be long remembered for the overall global depression in the economy.Nonetheless, the path breaking changes it brought in the solar segment make it a milestone year in global effort at moving towards an era of clean, renewable, and sustainable energy for all. ■



THICKENING VISIBILITY OF THIN FILM SOLAR IN INDIA

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Introduction

Thin seems to be an in-thing at the moment worldwide. From ultra thin potato chips to ultra thin layers of silicon material on solar modules, the list is a long one. With electricity being in short supply every now and then, solar seems to be on a winning spree of late. Solar modules using a very thin layer (generally just a couple of millionths of a meter- i.e. microns thick) of active semiconductor seem to be favourites now. The traditional silicon wafer based modules made of crystalline silicon are being edged out for a number of reasons. Thin film modules are simpler to produce and make more efficient use of raw materials and energy. The outcome is a lower cost module besides smaller carbon footprints too. In quantitative terms, thin film PV now accounts for about 18% of global PV sales. Surprisingly, these had an almost negligible share till a decade back. India too is seeing a fast declining share of crystalline silicon modules for a variety of reasons.

Thin film module technology in brief

A typical thin film solar module is made of semiconducting material. It also has few other thin films bonded to a sheet of glass. This is then covered by another sheet of glass and sealed in with an industrial laminate. Lately, a few companies are focusing their attention on the development of several other forms of thin modules. It also includes flexible thin-film solar modules. As is well known,

thin film modules have an excellent absorption of the solar spectrum. These generally deliver stronger power generation performance in a number of environments, including high temperature environments. Importantly, thin film modules claim to live for 25 years as is true for X-Si modules.

Bringing out benefits in both

The PV industry is abuzz with claims and counter-claims of thick and thin film technologies stealing a march over one another. Table 1 presents the advantages and disadvantages of thin film technologies from several key considerations.

The initial footprints of thin film PV in India

Several research laboratories in the country began working on thin film materials like amorphous silicon and cadmium telluride way back in early

Table 1 Advantages and Disadvantages of Thin-Film PV

Advantages	Disadvantages
Enhanced performance on an annual basis due to lower temperature coefficient and lowlight performance	Possess lower solar to electric efficiencies which in turn lead to higher BOS cost
Lower LCOE potential in comparison to Crystalline silicon more efficient production process	Needs lower price for modules and/or lower BOS cost on a kWp basis so as to attain market competitiveness
Capable of obtaining efficiencies at par with multi-crystalline silicon	Largely unproven technology which poses some difficulty in getting finance; no proven performance track record in case of MW scale projects
Offer the convenience of deposition on flexible substrates	Little information available on module degradation due to which long term performance largely not known; thus it is being perceived as a high risk investment
Opportunity to optimize the size o module to decrease the balance of system (BOS) cost	Modules more prone to breakage; thus it becomes a challenge to safely handle the frameless glass modules
Potential to optimize I-V characteristics for bringing down the BOS cost	Tracking applications are not so easy to deploy

eighties. This was followed up by setting up a thin film amorphous silicon pilot plant at Gwal Pahari (Haryana) in 1991 by the Ministry of New and Renewable Energy (MNRE). Cadmium Telluride based pilot studies gained ground under the Pacer programme of ICICI, and thus came into being ECO Solar, a home bred entity at Pune. Next in the line was a CdTe venture set up under the purview of Electronic Hardware Technology Park on a EOU processing zone at Delhi-Jaipur highway. The big break for thin film technology to make a noticeable impact on the Indian market with the launch of the following two major programmes in 2010:

- Jawaharlal Nehru National Solar Mission (JNNSM)
- Solar Policy of the Gujarat Government

Till then, majority of solar energy programme development in the country hinged on the use of crystalline silicon PV technology. The large scale grid connected PV power plants paved the way for entry of thin film modules here and there.

Sharing the space in PV production capacities

The PV industry in India has relied on crystalline silicon from its very beginning in early eighties. That outlook has still not changed as our cell manufacturing capacities of around 850-1000 MW and module manufacturing capacities of around 1400-1500 MW are based on X-Si material technology. However, what has certainly changed is the growing share of thin film modules in the PV system installations. It is apt to mention here about the Special Incentive Package (SIP) announced by the Ministry of Communications and Information Technology under the ambit of its semiconductor policy in 2007. It involved grant of capital subsidy equivalent to 20% for PV manufacturing plants located in the Special Economic Zones (SEZ's) and 25% for those outside these zones. Several major players notably Reliance Industries Ltd and Moser Baer announced major capacity startups of 1000 MW and 200 MW respectively. However, only Moser Baer could go ahead with the actual setting up of much reduced thin film capacity plan of 50 MW at its Noida plant in 2009. As of now, Hindustan Hind Vacuum (HHV) possesses an annual manufacturing capacity of 10 MW and produces amorphous silicon based modules of 1 m^2 at its Bangalore facility. One more company by the name of Shurjo Energy also has a small production line for thin film modules.

Etching a major space in installation market

The state government of Gujarat has been spearheading a major PV installation programme in the country. Today around 60-70% of the PV projects taking shape under the solar policy of state incorporate thin film technology. That is not all as thin film modules have also found their way under the rooftop and other small power plant schemes run by the Indian Renewable Energy Development Agency (IREDA) as a part of JNNSM. Out of projects aggregated to 98 MW capacity, share of thin film based projects is about 40 MW. Thin film technology also enjoys a majority share in the capacity installed so far under the purview of phase I, batch I of the JNNSM.

Catalysing market entry of thin film technology

As said above thin film modules hold a major advantage over thick films in terms of reduced material intake. That obviously leads to its cheaper production in direct comparison to the traditionally expensive crystalline silicon technology. However, a larger issue worth debating is whether it is the sole reason for a visibly major penetration of thin film modules in the Indian market. Following are a few more reasons which resulted in the mainstay of thin films in the local market:

- Aggressive bidding: JNNSM projects went through a phase of aggressive bidding. Obviously the project cost turned out to be a major determinant for any allocation under the bidding arrangement. This itself created a good enough space for thin film modules to creep in the local market.
- Zero import restrictions: Thin film

Table 2 Major players in the Indian Thin Film PV Market

S.No.	Company	Parent Location	Type of Technology
1.	Masdar PV	Germany	a-Si
2.	Schott Solar	Germany	a-Si
3.	Uni-Solar	USA	a-Si
4.	Dupont	USA	a-Si
5.	NeXPower	China	a-Si
6.	T-Solar	Spain	a-Si
7.	Titan Solar	India	a-Si
8.	Moser Baer	India	a-Si
9.	First Solar	USA	CdTe
10.	Abound Solar	USA	CdTe
11.	Miasole	USA	CIGS/CIS
12.	Q-Cells	Germany	CIGS/CIS
13.	Solar Frontier	Japan	CIGS/CIS

modules open to imports at no duty

- Temperature tolerance: Thin film panels can bear the high temperatures in the desert areas like Rajasthan unlike the polycrystalline panels
- Lighting gain: Thin film modules are expected to perform better even in low and diffused light conditions

Marking the presence of international players

India has always been eyed as a potential market for market delivery of PV equipment. Perhaps the most prominent supplier in this area has been Spire Corporation. It is equally true that few key materials which go into making of crystalline silicon modules have been highly import dependent till very recently. These mainly include Tedlar, EVA and toughened glass not to talk of silicon wafers. Now with thin film making fast inroads in the Indian market, several big producers have set up their bases here. Table 2 presents a quick glance of few such players alongwith their respective locations.

Quick look at major thin film projects commissioned in India

Several MW scale PV projects based on thin films have been recently commissioned in the country by now. Table 3 gives a quick data representation of such projects.

Is price line dictated mainly by thin films sustainable in Indian market?

There is little doubt that solar power is finally being seen as a fast emerging source of power in India. The government of the day is pushing through several policies so as to attain the below mentioned objectives:

- Encourage use of green power in all possible sectors of our energy economy
- Ensure a good diversification of its energy mix

As mentioned before, the solar policy of Gujarat state and the central governments bold initiative (JNNSM) are the key drivers of solar power development in the country. In fact, nearly 70% of the capacity additions made in 2011-2012 are solely attributed to the Gujarat policy initiative. That is not all as the government has also extended support in the form of solar power purchase obligations for the state distribution utilities. Consequent to all these factors, the total solar generating capacity has progressed from a mere 20 MW in 2010-2011 to around 940 MW in 2011-12. The moot question making rounds at this stage is if, PV prices are going to nosedive any further? Top grade market analysts like CRISIL Research feel that the pace of reduction in capital costs of solar PV projects is expected to moderate in 2012.

Expectedly, it may lead to declined profitability of such players as have

Table 3 Major Thin-film Projects in India

Project Developer	Thin film technology used	Company	Location	Plant capacity
Belectric PV India Pvt Ltd	CdTe modules	First Solar	Sri City Andhra Pradesh	5 MW (uses 14000 modules spread over an area of about 5.3 acres)
Moser Baer	a-Si/CdTe	DuPont/First Solar/Moser Baer	Gunthawad (Gujarat)	30 MW
Adani Power	CdTe		Kutch Gujarat	40 MW, uses a total of 400000 solar modules mounted on 21600 structures and erected on 1, 30000 foundations

bid aggressively below ₹9/kWh under batch 2 of national solar mission. As per the available data, nearly 50% of the bids under the solar mission have been below ₹9 per unit. While as about 25% of the bids are below ₹8.5 per unit. Both these make investments highly risky according to market experts. Currently, solar power is nearly four times as expensive as conventional coal based power. State governments have now been told to procure around 0.25% of their power requirements from solar power under the solar renewable energy purchase obligation.

The thin way forward

At this moment, there is no uniform consensus on whether thin film technology is well suited to the local weather environment (s). Perhaps the logical approach is to keep on consolidating data on all key aspects of thin film module performance under the actual field operating conditions. Following which, it can well be analysed from a variety of end-use considerations. The hard fact today is that thin film panels which were considered a no no before the onset of JNNSM have etched their place in India. Only time can tell if, these will continue to stay or get dislodged for whatever reasons? Till then, it is time of mutual co-existence for both the thick and thin film technologies.■

SOLAR HIGHWAYS

CHARGING OF ELECTRIC VEHICLES BY SOLAR BASED STREET LIGHTS

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Citizens residing in metropolitan cities and towns of India are spending upto a quarter of their productive time on roads, getting exposed to dangerous levels of pollution. Further, the spiraling pieces of motor fuel (due to geo-political volatility), is causing double digit inflation, and arresting the country's growth rate. A possible solution to this vexed issue is promoting use of Electric Bikes (e-bikes), with batteries charged from street lights retrofitted with 'Solar Photovoltaic Modules' and LED lamps. This shall abet charging of EVs, besides saving of precious fuel (petrol) and mitigating GHG emissions. Under the propose model, oil marketing companies can work as ESCOs towards maintaining the solar powered street lights as a strategic diversification measure. It is estimated that 1,00,000 retrofitted street lights operated by 1000 gasoline stations (each operating 100 poles) can charge an equal number of e-bikes at a very nominal rate (10 pa/ km), and lead to saving of 12 million liters of petrol and 13 Million units of electricity, besides offsetting 10 Million Kgs of CO_2e on an annual basis. The payback period, sans any subsidy, is about 3.5 years, making it a low-hanging fruit to be captured, leading to enhanced energy security and insulating ordinary (2-wheeler driving) populace from fuel price hikes.

Introduction: transportation in India

Transportation has been touted as an important service industry, contributing enormously in the development of India. It accounts for 6.4% of our Gross Domestic Product (GDP), with the road transport taking the lions' share at 5.4% .Transportation industry has deep linkages with the rest of the economy, providing a strong multiplier effect. The increased availability of rapid transportation results in improved quality of life with an increase in per capita income, besides playing the role as a bonding agent in the society.

Issues at large: limited fuel sources

Over 70 million vehicles running on India roads guzzle out more than 140 MT of petroleum products annually . With limited availability of domestic petroleum resources, large scale imports are warranted (80% of our total requirements), jeopardizing India's energy security; it imported 159 MMT crude oil worth over ₹3700 Billion in the FY 2009-10 . Due to geo-political uncertainties, the price of petrol has increased by almost 60% since the past 2 years (from ₹48 to ₹73), leading to a surge in inflation and arresting the GDP growth of the country. Further, the under recoveries is bleeding the balance sheets of OMCs.

Transportation sector is a major GHG emitter (second highest after the power sector, with a share of 7.5%). The internal combustion engines also release of a large amount of other air pollutants, right in the heart of our cities and towns (as point sources of pollution).

Alternate fuels: food vs fuel

One of the much talked about remedy is harnessing bio-fuels (ethanol and bio-diesel), which can be sourced/ cultivated domestically and have lower polluting attributes. However, even after many years of research work towards developing these resources, the outcome is not as per expectations due to a myriad of problems, primarily being the 'Food vs Fuel' debate.

Possible solution: electric vehicles

The solution which seems viable is use of Electric Vehicles, or, EV. These battery propelled vehicles, developed by new age entrepreneurs, do not cause any pollution.

E-bike: the right fitment

Though EVs are available for all vehicle segments, the current scenario advocates promotion of low-power two wheel Electric Vehicles (e-bikes & e-scooters), due to the following reasons:

- Mainstream mode of transportation in India with 71% share ; 45 million 2-wheelers run on Indian roads
- Affordably priced
- Low speed, decreasing the probability of fatal accidents
- Easy to ride
- Provide end-to-end connectivity
- Good mileage
- Occupy little road space
- Can run on all kinds of road surfaces

E-bikes: vital stats

A typical e-bike costs around ₹20,000 (after accounting for discounts offered by MNRE) and runs over 75 km in one charge of a battery (20Ah deep discharge), requiring 1- 1.25 kWh for a complete charge. The battery, costing over ₹10,000, requires to be replaced after running 25,000 km.

Emission abatement: limited potential

CO_2 emissions from an e-bike are 40% lower than a conventional bike. We can observe from the above table that displacing petrol with electricity as a vehicle fuel leads to limited GHG reduction. Moreover, India's electricity mix is dominated by coal based thermal power stations (80% share). Looking at the large base of 2-wheeler market in India and the corresponding replacement potential from EVs (4,00,000 of e-bikes by 2012), the advantage of lower emission offered by an e-bike shall quickly get dissipated.

e-bike	Statistics
Km per charging	75
Units per charging	1.25
Units per charging (30% T&D losses)	1.67 (1.25/0.75)
Kg CO_2 /kWh	0.82
CO_2 emitted for full charging	1369
CO_2 emissions gm/ km	18
Scooter (<=100 cc)	
Km per lit	70
CO_2 Emissions/lit (gms)	2330
CO_2 emissions gm/ km	33

As such, the promotion of electric vehicles as a green mode of transportation is a misnomer and does not provide long-term sustainable solutions.

Solution: solar street lights charging EV

The answer is right there if we turn our head and look towards the sky –street lights, if fitted with Solar Photovoltaic modules can provide the true green power.

With both street lights and solar insolation being ubiquitous across India, appropriate retrofitting in the exiting street lights can meet the energy needs of EVs (charging of e-bikes) as well as lighting the street lights with solar power.

The related experience in use of off-grid solar systems (lanterns, lighting systems, street lights and mini-grids), shall provide the much needed experience.

This shall reduce dependence upon oil imports for transportation as well as provide grid independent energy solutions for lighting street lights, besides reducing GHG emissions.

Business model: OMC as ESCO

Presently, street lights are being maintained by local municipal bodies, and are found wanting in performance.

OMCs can work in an ESCO mode (Energy Service Company) and maintaining street lighting services (fitted with solar PV modules) in area of their vicinity, serving dual purposes of charging EVs and " providing illumination.

The proposed model shall present a strategic de-risking business opportunity to over 35,000 petrol stations owned by oil PSUs (due to depleting global oil resources). Each of the filling stations can operate & maintain 100 street lights in the vicinity of its operation in a cluster based approach.

With limited generation potential of solar PV modules (PLF @20%), the proposition shall become more viable if the high voltage (55W) FTL lamps in the existing street lights are replaced by low wattage LED lamps (18 W).

A 100Wp solar module shall generate over 550-600 Whrs of power daily. The power required to run an 18W LED lamp for a 10 hour period would be 180 Watt Hours. This shall leave around 400 Wh for charging of electric bikes (40% of charging).

Street light location: appropriate

Based on the structure of the street light pole, bulb wattage, location (highway/ local roads/ residential colonies), placement (side pathway/ median) and adequacy of solar insolation, the configuration of the Solar Module (module wattage & battery size) can be determined. The optimum location can in residential areas and secondary/ colony roads with light traffic.

Cost economics: payback period

With cost of LED @ ₹100/ watt, an 18 W street light would cost ₹1,800. Further, the 100 Wp PV module would cost ₹4,000 (@ $0.72/Wp). The battery and charge controller would cost around ₹ 700, making the total cost at ₹6,500.

Income from a number of sources shall be available under this business dispensation. These are as under,

1) Street light operation

The reduced lamp wattage of LED shall lead to annual savings of ₹393 per light point, due to 37W load reduction per light point. This can be paid by the ULB or the utility, depending upon the existing arrangement.

Details are as under,

Wattage per LED Lamp	18 W
Wattage of FTL Lamp	
40 W lamp+15 W Ballast	55 W
Savings per Lamp	37 W
No of hours per day for which LED lamp operate	8 Hrs
T&D Losses	25%
Daily power savings due to decentralized format	370 Wh (37*8*1.25)
Power Generation cost	3.54 ₹/ kWh
Savings per day	₹1.31
Savings per annum (300 sunny days)	₹393

2) Street light maintenance

Urban Local Bodies pay a certain amount to the power utilities for maintaining the street lights. Taking ₹73 per month per street light point, the income from annual charges towards operating a street light shall come out to be ₹876 (₹73 X 12).

3) Charging e-bikes

The effective portion of solar power available for charging e-bikes after charging solar lamps would be 0.4 units per day. The tariff for residential category is upto ₹5 per unit and the same may be charged by OMCs for charging of e-bikes, fetching them ₹600 per year (for 300 solar days).

The total earnings from all these 3 modes would be ₹1869 per annum

(₹393 + 876 + 600) projecting a very attractive payback period of 3.5 years.

If we take into account subsidy available for off-grid solar systems and carbon revenues, the payback period shall become more attractive.

Stephny battery: time saver

The long time taken for charging an e-bike may act as deterrence for a user. This can be solved if an additional battery is provided with each of the e-bike by the manufacturer, similar to spare tyre, referred in common parlance as a 'stephny'.

The spare battery can be stationed at the solar street light charging station, while the EV user can operate on the other charged battery. To make the whole transaction more secure and reliable, a unique identification number may be assigned to each battery.

It may be noted that low weight batteries have been developed for e-bikes, recently by M/s Electrotherm India Ltd, the makers of the popular electric scooters Yobykes , making it amenable to carry two batteries. Further, in the current year's budget, the government has reduced the central excise duty on batteries imported by electric vehicle manufacturers from 26% to 4%.

Charging mode: battery to battery

To minimize the time taken to charge, battery to battery charging concept can be used, which takes a very short period in comparison to normal mode of charging. Herein, battery charged during the day from the Solar power can be used to charge the e-bike battery.

Fuel and emission savings: enormous

Gasoline/ Petrol

A unit of power shall save a liter of petrol. With 40% charging of a e-bike battery made with help from a solar LED based street light, 400 ml of petrol shall be saved from one light point on a diurnal basis. If 1,00,000 street light points (powered by solar modules) are used to charge as many e-bikes, the total petrol saving would be of the order of 12 million liters per year.

Electricity

Each of the 55 W based street light consumes 440 Wh per day, or, 132 kWh per annum (assuming 300 days operation per year). If we consider 1,00,000 light points, the saving shall be over 13 MU per year.

GHG (CO_2 eq)

Taking a GEF of 0.82 kg CO2 per unit, saving of 13 MU of electricity shall effectively lead to mitigation of over 10 million tonnes of CO2 eq. GHG gases per annum.

Overall benefits: multiple

The above mechanism to charge e-bikes shall provide solutions towards a myriad of problems including -

- Enhancement of energy security
- Reduction in crude oil imports
- Curbing inflation
- Decentralized sustainable energy meeting twin needs of powering street lights and E-bikes
- Providing low cost fuelling for vehicles
- Containing air-pollution including GHG emissions from transportation
- New business model for oil marketing companies
- Providing reliable street light services for improved security in cities and towns

Way forward: large-scale rollout

The proposal can be initially taken up in mid-size Indian cities (Ludhiana, Nagpur) having around 80,000 to 1,00,000 street light poles with significant penetration of e-bikes and e-scooters. Once proven in these pilot cities, the model can be rolled over in other cities and towns across the country so as to create a multiplier impact. The success of this proposition would depend upon support/ cooperation from various stakeholders, viz., municipal bodies, utilities, OMCs, e-bike manufacturers, solar EPC companies, and off-course the ordinary citizens, aka, users of e-bikes.

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A Publication

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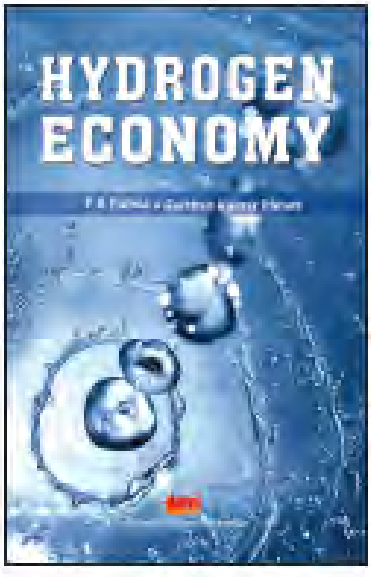

HYDROGEN ECONOMY

P K Pahwa
Gulshan Kumar Pahwa

November 2012 • ISBN: TBA
Pages: 250 • Binding: Hardback
Size: 160 x 224 mm • Price: TBA

In the future, our energy systems will need to be renewable and sustainable, efficient and cost-effective, convenient and safe. Hydrogen has been proposed as the perfect fuel for this future energy system. The availability of a reliable and cost-effective supply, safe and efficient storage, and convenient end use of hydrogen will be essential for a transition to a hydrogen economy. Research is being conducted throughout the world for the development of safe, cost-effective hydrogen production, storage, and end-use technologies that support and foster this transition.

This book discusses hydrogen economy vis-à-vis sustainable development. It examines the link between development and energy, prospects of sustainable development, significance of hydrogen energy economy, and provides an authoritative and up-to-date scientific account of hydrogen generation, storage, transportation, and safety.

Key features

- Comprehensive coverage of monitoring and evaluation of afforestation activities.
- Focus on various aspects of monitoring and evaluation of afforestation.
- Brief provided on the National Afforestation Project, including its intended monitoring and evaluation process and suggested modifications.

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• Energy and Development • Significance of Hydrogen Economy • Hydrogen Production • Hydrogen Storage • Transportation, Distribution and Utilization of Hydrogen • Hydrogen Hazards: Assessment and Safety

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HARVESTING ENERGY: UOP-HONEYWELL VP DISCUSSES ADVANCES IN BIOFUELS

Dr Jim Rekoske is Vice President And General Manager of the Renewable Energy and Chemicals business for Honeywell's UOP, a leading international supplier of process technology for the oil-refining, petrochemical, and gas processing industries. UOP's Renewable Energy and Chemicals business is focused on developing profitable and efficient ways to convert bio-feedstock, such as oils from plants and algae, greases and certain waste products, into valuable fuel and chemicals.

Jim Rekoske earned his Bachelor's and Master's degrees in Chemical Engineering from the University of Wisconsin. Additionally, he holds a PhD in Chemical Engineering from the University of Delaware, and an MBA from the University of Chicago.

After joining Honeywell in 1996, Dr Rekoske served in a number of Research and Development positions before subsequently moving into Management. He was Manager of Engineering; Technical Director for the Catalysts, Adsorbents, and Specialties Petrochemicals business; Director of Technology for Universal Pharma Technologies; and, most recently, Senior Manager for Catalysis Research and Development.

Dr Rekoske holds 20 US patents, either as the inventor or as the co-inventor, with another 10 patent applications pending. He is the author of more than 20 peer-reviewed scientific articles. He was recently awarded the 2010 Herman Pines Award from the Chicago Catalysis Club in recognition of his numerous technical breakthroughs in catalysis science.

Energy Future **caught up with Dr Jim Rekoske to ask him about current developments in the biofuel sector, and what does the future hold.**

We have made jet fuels which have powered a total of almost 27 different demonstration flights. We have flown everything thing from business jets, commercial airliners, US military aircrafts to foreign military aircrafts now as well. We have also used that to power boats.

Q1. Honeywell has been focusing on biofuels quite a bit over the last few years. This is going to be for the general audience. Why does plant oil make such good fuel?

First of all, let us start with, where does this plant oil come from in the first place, why do plants make oil? Plants make oil because they collect energy from the sun and they use some of the energy to grow and sustain themselves. But then rest of the energy is used by them to put into what is called fats or lipids in order to surround typically the seed pod that they will utilize in order to reproduce, in order to generate the seed which will generate a new plant. The oil in the seed pod acts as a fertilizer for that seed when it decomposes and falls onto the ground. The oil is a natural byproduct of the process of photosynthesis as plants grow it's just a natural product. Now that natural product is lipid is referred to as triglycerides as some people call it. It has the same carbon number chains and it is actually a very convenient forum, not much work needs to be done in order to turn that into jet and diesel fuels. We have to take the oxygen out as because the natural oil contains oxygen whereas the transportation fuels do not. And in the case of jet fuels we need to isomerize it so that it does not freeze at high altitudes. And that is really the bottom line of why it's a good fuel, why we utilize it for our processes.

Q2. Honeywell has done a lot in this area. Could you describe some of the accomplishments? I believe you have used it to power jet aero planes, run cars and it can also run generators.

We have done testing on a variety of different engines. We have completed some engine testing on heavy duty trucks and as well as cars. That engine

The United States feeds people, almost 1/3rd of the world's population, and it comes from food grown in American farms. That's not done simply because we have large land mass it's also done because we have optimized the fuel , the production of food from that land and increased the cereal grain yield for example bio factor of 20 for the last 20 years .

testing shows that the material we make is a superior fuel, in terms of its mileage and also in terms of emissions. It lowers the nitrogen emissions which are harmful for the environment as well. In addition, we have made jet fuels which have powered a total of almost 27 different demonstration flights. We have flown everything thing from business jets, commercial airliners, US military aircrafts to foreign military aircrafts now as well. We have also used that to power boats. We conducted a test recently. A liner carried goods from Europe to India. We broke the water speed record for a military boat. We were pleased to be a part of those events.

Q3. Turning plants into fuels must be a simple proposition for America, you have large amount of land and you have large resources. But in India, trying to convince the general public that land will be used to grow crops which will then be turned into fuels as supposed to crops that people will eat can met some oppositions. Don't you think it would be better for a country like India to focus more on agriculture for feeding people as supposed to feeding a machine?

Well certainly feeding people has to be the highest need and the highest use of land. I don't think there is any doubt about that, but I think we can both or all agree that agriculture in India can be more efficient and can produce more food per unit hectare than it does today. And as that happens and as the yield grows per unit land increases faster than the population there will be surplus land that would be there. It's a basic fact that the United States of America is large in terms of its land area but the United States feeds people, almost 1/3rd of the world's population, and it comes from food grown in American farms. That's not done simply because we have large land mass it's also done because we have optimized the fuel , the production of food from that land and increased the cereal grain yield for example bio factor of 20 for the last 20 years . So you can see the

massive loaf that is possible with the right levels of agricultural sciences. I think when that a curse will be excess land well I cannot wait for that as it will take generations to occur here in India. Instead what we'll do is look for opportunities to convert marginal land, which is currently not in use in production of food, or take agricultural residues that are not animal fodder or can't be used to make protein for humans but can be used in order to make fuels. So a classic example of that is cotton stalk, the stalk from cotton can't be used as fodder for animals or for any other purpose. And as cotton production in India continues to increase there will be more and more stalk available. This stock makes it a feed stock for our other technologies, Rapid Thermal Processing technology, which paralyses the stalk turns it into bio oil and that bio oil that is upgraded into transportation fuel. So we feel there is plenty of opportunity to serve the needs of both food and fuel simultaneously from one agriculture system.

Q4. What were the repercussions on the environment as a consequence of intensive farming to grow these plants? They will have an impact on the local ecosystem. Is that something Honeywell has considered?

We have and we continue to partner with folks from many different agricultural institutions around the world in order to look at ways, in order to gain the benefits without having to go high intensity farming as you referred to it. High levels of fertilizers and things like that. In fact, having the right rotational science around what crops are grown in what rotation can be a significant advantage. For example growing things such as nitrogen fixing plants which can bring nitrogen back into the soil in one season and then growing maize in one season which requires a large amount of nitrogen in the following season is a great example of that and yields can be improved by doing that process even over the artificial application in nitrogen based fertilizers because the soil now has natural nitrogen that has been produced from the previous plants that were grown on the soil. So I think there is plenty of opportunity in order for the intensity of the farming that you referred to be reduced and at the same time yield will be increased through natural agro sciences being developed today. ■

MULTIPLE ENERGY SOURCES: THE WAY AHEAD

In Conversation with Kazuo Furukawa, Chairman of NEDO

Mr Kazuo Furukawa is currently the Chairman of the New Energy and Industrial Technology Development Organization (NEDO), an IAI or Independent Administrative Institution. IAIs are government created entities in Japan that operate independently from the government bureaucracy. While governmental organizations and ministries are responsible for administrative functions, agencies such as NEDO are responsible for operating functions.

NEDO conducts various activities focusing on research and development related to conventional and alternative energy technology, technology for the efficient use of energy, and industrial technology. Its programs and projects include promotion of private sector participation in national technology development projects, support for the private sector to pursue its own research and development efforts and dissemination of newly developed technology.

Previously, Mr Furukawa has held positions, such as Senior Corporate Adviser, Hitachi, Ltd; Vice Chairman and Executive Officer, Hitachi, Ltd; and President and Chief Executive Officer, Hitachi, Ltd. He is also the President of Information Processing Society of Japan and was previously Vice Chairman of Japan Business Federation.

In January 2012, Mr Furukawa was in New Delhi for the 4th India Japan Energy Forum – Business opportunities in Energy Efficiency and Renewables, organized by The Energy and Resources Institute (TERI), in association with NEDO. The conference focussed on technological options for enhancing energy efficiency and promoting renewable energy technologies. The Forum provided an excellent opportunity for Indian and Japanese industries to dialogue, debate and share their experiences, and saw the participation of high-level officials from government and industries from both India and Japan. Energy Future's Harish Alagappa spoke to Mr Furukawa about energy efficiency, security, and the role of the Indo-Japanese partnership in the global energy sector.

Q1. During the India Japan Energy Forum, there has been a lot of discussion about energy efficiency and the role of renewables in energy security. Why do you think it is important for India and Japan to collaborate in the global energy sector, specifically in the realm of energy efficiency?

NEDO has been carrying out various activities in the area of energy efficiency in the form of energy conservation, and we believe we are

India and Japan both generate power in similar ways. When it comes to transmission and distribution of power, however, there are major differences. Therefore, I believe that it is important that India should try out Japanese technologies, specifically to find out what issues need to be addressed, and what problems need to be tackled.

among the world's leading agencies in terms of energy efficiency. We have been working on the issues of energy efficiency and renewables for a very long time, and there have been various problems which we have had to overcome during this period. The outcomes of these problems, the solutions that we developed are state of the art technology that I believe are relevant to the energy problems being faced in India. If our technology and expertise can help in overcoming the problems being faced by Indians, I think we would be very happy. NEDO has four overseas offices outside Japan, including one in New Delhi, and our relationship with TERI has been active on multiple fronts as a consequence; and we are very happy with the kind of collaborations that have been possible, and would like to express our thanks to TERI for their role in these partnerships.

Q2. It is said, if you want to see the technology that we will have in ten years, we should look at the technology in Japan today. What is, in your opinion, the best renewable energy technology available currently?

That is a difficult question to answer. When you talk about energy, there are various issues; starting with energy security, cost – including embedded or sunk cost, there are environmental considerations – which are not limited to GHG emissions, and a large number of very diverse factors that need to be taken into consideration. As far as we are concerned, and looking at the various aspects of Japan's energy policy and our desire for energy security; as a country, Japan has put a lot of effort into nuclear energy so far. However, after the events at Fukushima, the issue of earthquakes and safety has resulted in a complete change in the approach towards nuclear energy and it is necessary for us to revaluate our energy policy priorities in terms of

practical applications in this area. At the moment, we in Japan are trying to figure out what would be the best mix of energy sources that can aid our continued growth as a society. As an organization, NEDO is trying to extend greater efforts in our primary areas of focus, which are energy efficiency, renewable energy, and energy conservation; dissemination of information and technology in these areas; bringing down the cost of energy generated from renewable sources; and providing an environment, which includes creating infrastructure, where using renewable energy would be easier and more economical. These are the main areas that Japan, and specifically NEDO, is currently working on in the energy sector.

Q3. What do you feel is the ideal strategy for a developing country such as India, as far as energy is concerned? What kind of policy decisions or investments in technologies do you think would be the best move for us at the moment?

Japan has been conducting various experiments in technology and has been implementing many different policy strategies in the renewable energy front at the moment and the differences between India and Japan in terms of technology and available resources are large. We cannot say that we are necessarily in the best scenario at the moment, and our point of view is that we feel our current relationship with India is not one where we are that particularly ahead of India or that India should be envious of us. India should now focus on countering your disadvantages, see what you lack and develop it. In India, resources for renewable energy technologies, whether they are solar-based or wind-based, are abundant, and the area of India is very vast, as opposed to Japan. Concerning disseminating renewable energy, I would say that India is much better placed than Japan. We have some disadvantages; as a small series of islands, we cannot expect to have the abundance of resources India has. We want to trade-off or balance our disadvantages by developing technology to counter whatever disadvantages we have geographically or in terms of resources. India should look to develop and balance their disadvantaged areas. If Japanese technology can be used for that, it would make us very happy. The electricity network is not generation alone; it also consists of transmission, distribution, and the grid, which is a very important part of it. When it comes to generation, there are little differences between countries; India and Japan both generate power in similar ways. When it comes to transmission and distribution of power, however, there are major differences. Therefore, I believe that it is important that India should try out Japanese technologies, specifically to find out what issues need to be addressed, and what problems need to be tackled. We have been carrying out sixteen projects in India so far, which are varied levels of scope and implementation. The latest among these projects is the DMIC microgrid project at Neemrana, Rajasthan. We would like these projects to be implemented in specific locations around India as pilots, so that we can study their progress and be able to improve the technologies before we move on dissemination throughout the country. ■

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NEW RELEASE

BIOGAS TECHNOLOGY

TOWARDS SUSTAINABLE DEVELOPMENT

AUTHORS

R S Khoiyangbam
Navindu Gupta
Sushil Kumar

Description

The global demand for energy is met mainly by fossil fuels. Their excessive and indiscriminate use, coupled with increasing demand for energy, will soon deplete their existing reserves. Therefore, it is extremely important to find alternative, environment-friendly, and ecologically sound sources of energy for meeting the present and future energy requirements. Biogas Technology: Towards Sustainable Development makes an attempt to explore the potential of utilizing biodegradable biomass as fuel and manure.

Key features

- Discusses the biomethanation process in detail.
- Highlights the utility of biogas as a renewable source of energy.
- Explains the evolution, scope, and potential of biogas technology.
- Depicts popular biogas plant models.
- Provides useful information on carbon credit and highlights the environmental implications of the biomethanation process.
- Presents a knowledge base to biologists, academicians, farmers, and agricultural scientists, who will gain in terms of understanding the basic concepts and applications of the biomethanation technology.
- Provides information on installing biogas plants for meeting energy and manure demands.

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THE CUSHING TRADING HUB

Human civilization and energy have shared a complex relationship. The quest for energy has at various times inspired us to hunt, to farm, and has taken us places that we had never been to before. On other occasions, it has led to war and the destruction of nature. The world of energy affects our lives at a level that most people are only starting to comprehend now. In these articles, we wish to educate and inform you about the wide world of energy; its history, its future, how the energy industry works, how energy has affected the world, and how energy affects you and me.

In this first edition of Energy Insights, *Harish Alagappa* **looks at the role a small town in rural Midwestern USA plays in the global energy industry.**

In the last century, oil has become the world's most valuable resource, outstripping coal, gold, water, or diamonds.

The age of oil

Oil, in one form or another, has always played a significant role in the history of human civilization. Oil has been used by civilizations as old as the Ancient Babylonians, who used the substance to create asphalt for their city walls and towers and as fuel for torches and lights. The site of Babylonian-dug oil pits, near the River Issus in modern day Iraq, was later the site of Alexander the Great's decisive victory over the Persian Empire at the Battle of Gaugamela, and is still at the frontline of Kurd, US, and Iraqi conflicts. The Chinese dug oil wells using bits of bamboo as far back as 347 AD, using it to burn off brine and produce salt at salt springs. The Japanese used oil for heating and as lamp fuel, whereas the first streets of Baghdad were paved with tar that was derived from oil accessed from natural fields in the region. In the middle ages, oil found use in militaries, as Arab and Persian chemists distilled oil to produce flammable products that were particularly in vogue during sieges of large forts.

However, it was not until the late 19th and early 20th century, with the advent of the internal combustion engine – a device capable of generating more power than what the people at the time knew to do with, that the oil age truly began. In the last century, oil has become the world's most valuable resource, outstripping coal, gold, water, or diamonds. Yet, such is humanity's hubris that a resource, which had been used sparingly for millennia, has in the span of a century of unrelenting exploitation, now been almost completely exhausted. As we search in ever more desperate places for oil, ensuring that global oil prices remain stable is no longer just good business; it is a matter of global military security. Thus, one of the most significant locations in the world that dictates global energy security is a small town in the Midwestern United States with a population of less than 8,000 people.

Small town, big business

The town of Cushing was founded in 1891 and named for Marshall Cushing, Private Secretary to U.S. Postmaster

General, John Wanamaker. Located around 110 kilometres northeast of Oklahoma City in the state of Oklahoma, Cushing is strategically located right between the major centres of oil production in the United States, viz., the western United States, and the Gulf Coast region; and the major centres of demand, i.e. the Great Lakes region, and the northern United States. This has resulted in the small town of Cushing becoming one of the most important centres in crude oil storage and distribution in the world.

The year 1912 saw the discovery of oil in the town of Cushing by an oil explorer appropriately known as Thomas Baker Slick. The ensuing rush saw the town expand swiftly, and by the end of 1915, there were 710 oil wells in Cushing, which were producing 72 million barrels of oil annually. However, the oil field at Cushing was a minor one, and soon oil production started to develop in Drumright, located 20 kilometers west. Cushing quickly established itself as a base for refining and storage, with the first of 12 refineries being built by the Consumers Oil Company in 1913. Cushing's location amidst the expansive North American Great Plains were utilized to their full extent, as a series of oil companies built over 700 large steel tanks, capable of storing nearly 39 million barrels of oil.

As the oil well in Drumright and other nearby areas began drying up in the region, the refining industry in Cushing saw rampant decline. By the 1970s and 80s, there was no more oil to be found in Oklahoma, and with that, there were no more refineries in Cushing. What this meant, however, was that Cushing was left with plenty of tanks to store oil, a crisscross of pipelines that could transport up to 1.5 million barrel of crude per day to different and distant parts of the United States of America, and a strategic location that was equidistant from both coasts. As the business of energy trading took off in the late 1970s, with the New York Mercantile Exchange as the focal point of trade in energy commodities; Cushing's strategic location, its vast network of oil pipelines, and its prodigious complex of storage tanks brought the town back into the American, and later global, business market . In 1983, the New York Mercantile Exchange chose Cushing as the official delivery point from where prices for West Texas Intermediate crude oil would be settled, leading to a boom in the importance of the town of Cushing in the global energy industry.

The energy market

Founded in 1882, the New York Mercantile Exchange, or NYMEX, is the world's largest physical commodities futures market. A physical commodities

As the business of energy trading took off in the late 1970s, with the New York Mercantile Exchange as the focal point of trade in energy commodities; Cushing's strategic location, its vast network of oil pipelines, and its prodigious complex of storage tanks brought the town back into the American, and later global, business market.

market is where raw materials and their physical derivatives are traded and exchanged. NYMEX primarily deals with commodities in the Energy, Precious Metals, and Industrial Metals sectors. Here, prices are standardized for a large variety of physical commodities, ranging from Crude Oil, Coal, and Natural Gas to Electricity, Platinum, and Uranium. Thus, while many of the events that happen in stock markets such as the NYSE or the NASDAQ may not have a direct bearing on the lives of most average people, the commodities that are traded on the floor at NYMEX are ones that many regular people use every day. The floor of the New York Mercantile Exchange is where the prices of significant energy commodities used to be set. Like most exchanges, the floor has been replaced by an electronic exchange since 2006. However, NYMEX still maintains a small venue that practices the old-fashioned trading techniques of open outcries, where traders shout and employ the use of complex hand gestures on a trading floor.

Apart from facilitating the trade of commodities between investors, NYMEX also plays a crucial role in standardizing futures contracts on physical commodities. A futures contract is an agreement between two parties to exchange a given quantity of a commodity at a fixed future date, for a price defined in the present. Futures contracts were devised when commodities markets dealt largely with organic commodities, such as potatoes. Futures contracts began as a contract between a buyer and a farmer, where the buyer would promise to purchase, say, 100 kilograms of potatoes from the farmer at a price of ₹20 per kilogram at the date of harvest. At the time of

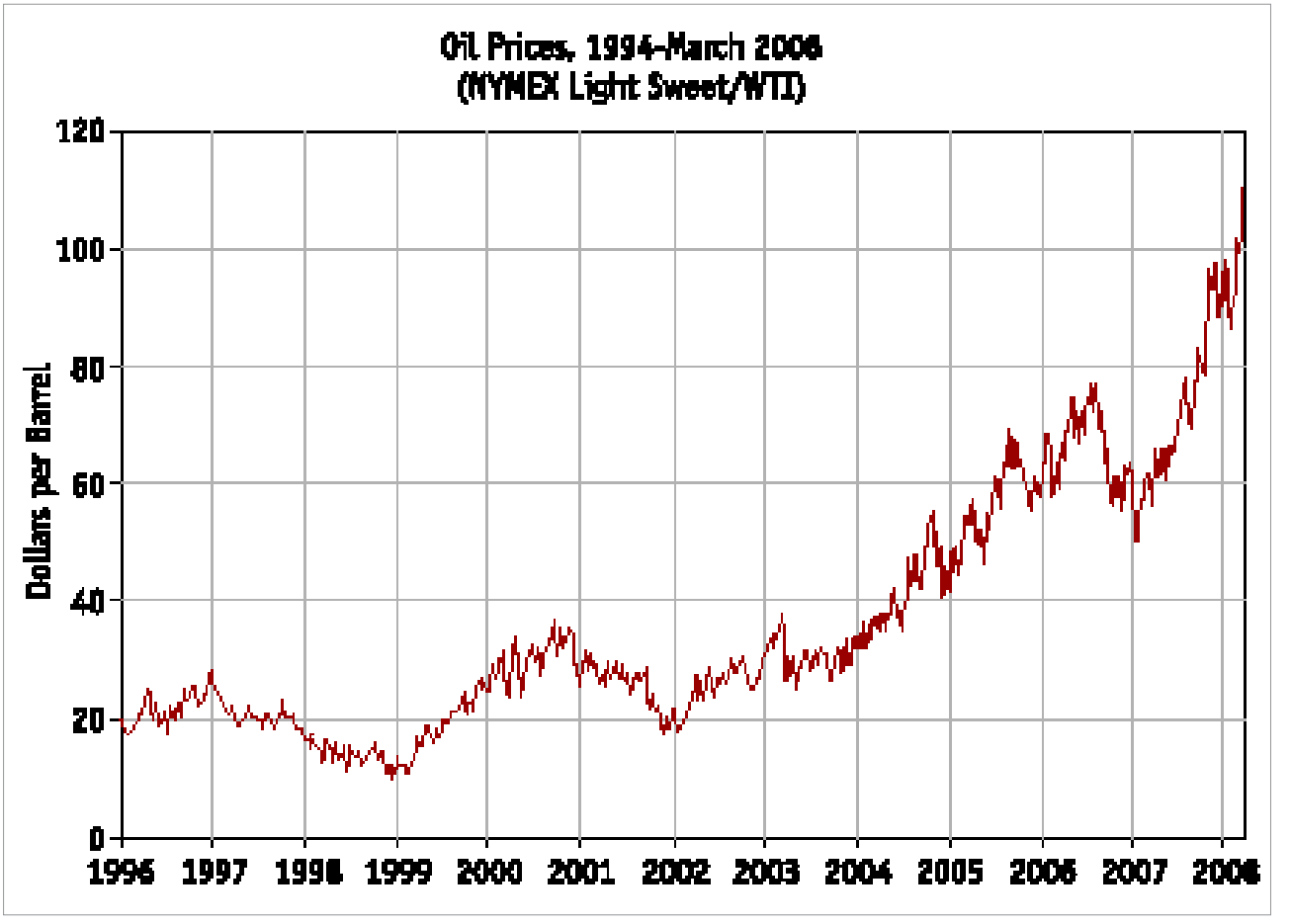
NYMEX primarily deals with commodities in the Energy, Precious Metals, and Industrial Metals sectors. Here, prices are standardized for a large variety of physical commodities, ranging from Crude Oil, Coal, and Natural Gas to Electricity, Platinum, and Uranium.

As there are many different types and grades of crude oil, which are further divided based on their specific gravity and sulphur content, WTI plays a crucial role: it acts as a standard against which other types of crude oil are measured.

harvest, the price of potatoes could be more or less than ₹20 per kilogram. If the price is more than that on the futures contract, the buyer has profited, whereas if it is less than the agreed price, it is to the seller's profit. Since the price of a commodity at a future date is impossible to gauge, futures contracts are highly lucrative, especially if the commodity is something as valuable as crude oil.

Thus, a futures contract would require the exchange to ensure that there is certain standardization in the commodity being exchanged. NYMEX ensures such standardization by maintaining trading hubs. These trading hubs store a physical commodity during the period of the futures contract and subsequently, transport the physical commodity quickly and efficiently when the contract is completed. For example, Henry Hub in Erath, Louisiana is the Natural Gas trading hub for NYMEX. Cushing is NYMEX's trading hub for Crude Oil, using its expanse of storage facilities to hold millions of barrels of crude oil that come in from refineries and oil wells across North America, and later, transferring millions of barrels of crude to locations all over the continental United States. The crude oil stored at Cushing is of a very particular type of crude oil known as West Texas Intermediate.

West Texas Intermediate, or WTI, is a light (meaning, low-density), sweet (meaning, low-sulphur content) crude oil that is stored at the Cushing Trading Hub, and is used as a benchmark for regulating oil prices in the United States. It is primarily used to produce low-sulphur gasoline, diesel, and jet fuel. As there are many different types and grades of crude oil, which are further divided based on their specific gravity and sulphur content, WTI plays a crucial role: it acts as a standard against which other types of crude oil are measured. Other types of crude oil used as a



On June 1, 2012, the amount of crude oil being stored at Cushing was 47.8 million barrels, the highest that has ever been stored at Cushing in its nearly 90-year history. This is on the back of a newfound increase in crude oil production in the U.S., which is at the highest it has been in 14 years.

benchmark outside the USA include Brent Crude, which is composed of a complex combination of crude oils from the oil wells of the North Sea in Europe and is the benchmark in nearly 75% of the rest of the world, and Dubai crude in the Middle East.

Oil's well that ends well

Thus, the Cushing Trading Hub can store and transport large amounts of WTI, based on which the price of crude oil is standardized at the NYMEX. This ensures that the drying up of a well, or a major oil spill does not cause a sudden increase in oil prices, or conversely also makes certain that a sudden increase in oil supply does not cause a sudden drop in oil prices that would cause billions of dollars in losses to oil companies and investors alike. Large oil corporations have bought storage facilities at Cushing, allowing them to store crude oil to be sold later. To this day, companies are building newer storage facilities and pipelines at Cushing. Currently, Cushing's shell capacity, which is the volume of oil that can be stored by filling each tank up to the cap, is 76.7 million barrels (12.19 billion litres) of crude oil. 62 million barrels (9.84 billion litres) of that shell capacity is currently their working storage capacity. (As of March 2012)

Recently, Cushing has once again been in the news. On June 1 2012, the amount of crude oil being stored at Cushing was 47.8 million barrels, the highest that has ever been stored at Cushing in its nearly 90-year history. This is on the back of a newfound increase in crude oil production in the

Currently, Cushing and North America are the world's most stable energy storage and distribution centres.

U.S., which is at the highest it has been in 14 years. The increase in crude oil levels comes from the oil boom being experienced by the American state of North Dakota, where recoverable oil technology is projected to extract as much as 4 billion barrels of crude oil. In addition, the further refinement of the process of extracting oil deposits from bituminous sands in the regions of Northern Alberta in Canada has led to a substantial inflow of crude oil from Canada.

The future for cushing

Reports say that China is building storage facilities that can hold up to and exceeding 100 million barrels of oil. Even if true, any oil travelling either to or from China would have to face substantial problems. The overland route would require pipelines that cross the Tibetan plateau and the Himalayas and Pamir Knot mountain ranges, among the highest mountains and most difficult terrain in the world. The sea route is hampered by the requirement of oil tankers to pass by the notorious straits of Malacca near Malaysia, known for being too shallow to let oil tankers pass through and highly prone to sea piracy. Oil travelling from China to Europe would have to pass Malacca and Aden, two of the world's most dangerous sea routes. It is unlikely insurance underwriters would be willing to risk such a journey. Currently, Cushing and North America are the world's most stable energy storage and distribution centres. However, the Age of Oil in nearing its endgame in the face of fossil fuel depletion and advances in the realm of renewable energy technology. The Cushing Trading Hub, while undoubtedly critical to the present and the immediate energy future of America, and indeed the rest of the world, is nevertheless the relic of a bygone era, where oil fuelled the ambitions of the world.■

We owe it to Mother Earth

Let us Respect Her

Let us Conserve Her

On this World Environment Day
Let us resolve to Act Responsibly

Gujarat—Caring, Conserving and Cherishing Nature

- First in Asia and fourth in the world to set up a separate department for Climate Change
- Highest carbon credit earning state in the country
- Highest increase in mangrove cover in the country since 2001 by 147 Sq. Km
- Asia's first and largest multi-developer, multi-facility and multi-beneficiary Solar Park with a generation capacity of 500MW set up at Patan
- Pioneering Wind Energy generation – A 2,885 MW capacity wind energy plant operational along the coastline of Saurashtra and Kutch
- India's only and Asia's largest Tidal Power Project set up with a total generation capacity of 250MW
- Unique Canal-Top Solar Power Project initiated with an aim to generate 1MW power per kilometer length of the Narmada Canal, also preventing water loss through evaporation

And much more...

Narendra Modi
Chief Minister, Gujarat

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SOLAR SOLUTIONS

SolarBond® InFrame is an award-winning, intelligent, innovative and instant solution for solar module manufacturing. It is applied warm in a continuous motion, ensuring both accuracy and high bonding strength immediately after contact with the glass, backsheet and frame.

SolarBond® Frame Tapes offer cost-effectiveness, easy application and durability for perimeter sealing of the PV laminate to the aluminium frame. With instant bonding, manufacturers can handle the module immediately after framing, resulting in increased production efficiency.

SolarBond® Membrane, which is used as a process aid in securing and sealing all module components with ethylene vinyl acetate (EVA) adhesive film, demonstrates outstanding durability through repeated lamination cycles. Its modified silicone-rubber material is highly resistant to EVA outgassing at high heat exposure.

Source: www.saint-gobain.com

Carrier India Unveils AquaForce 30XA Air-Cooled Screw Chiller

Carrier Airconditioning and Refrigeration Limited (Carrier India), a leader in high technology heating, air-conditioning and refrigeration solutions, introduces the India-manufactured AquaForce® 30XA air-cooled screw chiller, a high efficiency semi-hermetic twin screw compressor with multiple refrigerant circuits and compressor designs, which delivers high part load efficiency. Carrier India is a part of UTC Climate, Controls & Security Systems, a unit of United Technologies Corp. (NYSE:UTX).

The AquaForce 30XA is an excellent solution for industrial and commercial applications in which installers, consultants and building owners require optimal quality, performance and value. They are designed to meet

current energy efficiency requirements and feature flexibility of use, compact size, and the most reliable technologies available today.

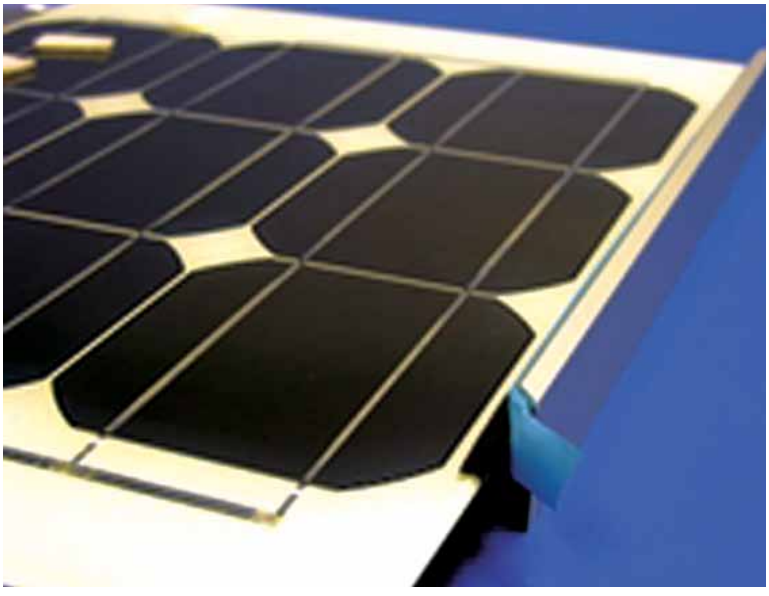
The AquaForce 30XA's electronic expansion valve precisely controls the refrigerant flow and improves unit efficiency while the advanced economizer helps improve cooling capacity. The AquaForce offers customers value, along with efficiency, at part and full load.

Using the non-ozone depleting HFC-134a refrigerant, the AquaForce 30XA also offers several additional features that enhance comfort and ease-of-use, such as the Pro-Dialog Plus Control user friendly interface. The Aquaforce 30XA liquid chiller incorporates Carrier-patented technology, such as fans, ensuring quieter operation.. These chillers also reduce on-site installation time, and have exceptional endurance and superior reliability, helping minimize chiller downtime.

Four models of AquaForce 30XA are now available with capacities ranging from 78 TR to 430 TR. Additional models will be launched later this year.

Carrier is the world's leader in high technology heating, air-conditioning and refrigeration solutions. Carrier experts provide sustainable solutions, integrating energy efficient products, building controls, and energy services for residential, commercial, retail, and transport and foodservice customers. Founded by the inventor of modern air conditioning, Carrier improves the world around us through engineered innovation and environmental stewardship. Carrier is a part of UTC Climate, Controls & Security, a unit of United Technologies Corp., a leading provider to the aerospace and building systems industries worldwide. ■

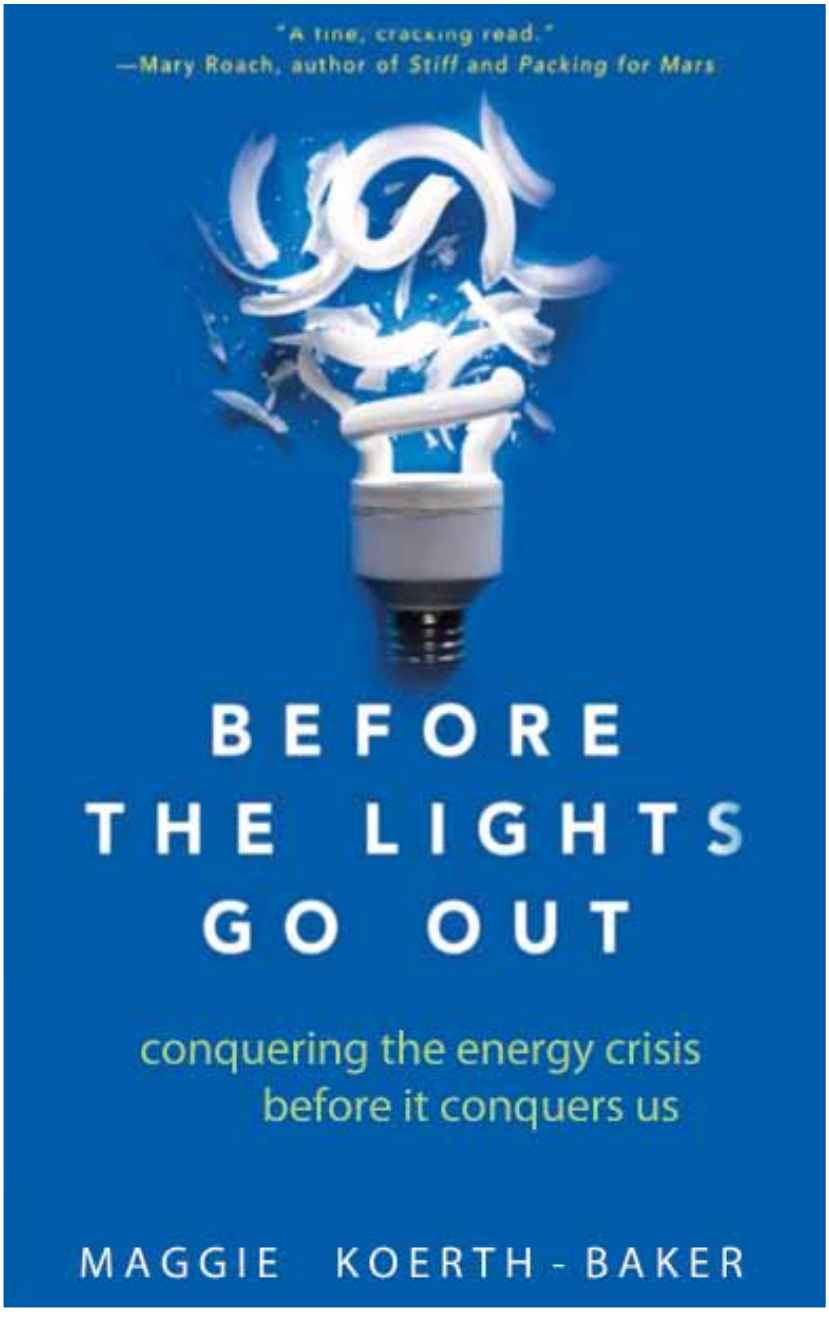
Source: www.carrierindia.com



Source: http://www.pv.saint-gobain.com

BEFORE THE LIGHTS GO OUT

conquering the energy crisis before it conquers us



Author: Maggie Koerth-Baker
Year: 2012
Pages: 290 pp.
Publisher: John Wiley and Sons

Anyone who uses the internet to read up about science and other oddities would be well versed with a website (disconcertingly) named Boing Boing. The website's resident science writer, Maggie Koerth-Baker, has earned a reputation for her ability to explain complex scientific ideas in words that the common person can understand without resorting to gross over-simplifications. In her debut full-length book, one can see Ms Koerth-Baker utilizing the full extent of her skills as a science communicator to elucidate how the road to recovery from the global energy crisis will require grit, determination, sacrifice, and hard work.

The book reads unlike most science books about energy and the environment. Rather than focusing excessively on the causes leading to the global energy crisis, Koerth-Baker starts talking about the work ahead right off the bat. Before the Lights Go Out is purportedly, a book about the energy future of the United States of America, but the issues addressed in the book and, indeed, the solutions offered are distinctly applicable at a global level.

Maggie Koerth-Baker's intention in the book is very clear: To educate people about the energy crisis without going to either extreme of the popular science book genre. Energy books are to today what books on Quantum Mechanics were following Stephen Hawking's 'A Brief History of Time' in 1988. Thus, we see a plethora of well-packaged tomes with witty titles that unfortunately end up telling the same story. Perhaps worse are their efforts to make complicated ideas understandable to a lay audience, where their unsafe use of metaphors and analogies that do not convey a very accurate picture of the science, economics, and policy behind the energy sector leave the reader either confused or misguided.

Maggie Koerth-Baker makes no such mistake. Her grasp of the subject has been honed from years of science writing on blogs and magazines. The advantage of being a science blogger is that it allows you instant feedback from your audience via the comments section. It is a very steep learning curve, but Maggie Koerth-Baker has learnt much from her experiences of writing on a forum where feedback is instant and often caustic. The book reads like an extended blog post, with the footnotes section fulfilling the role of hyperlinks. Unlike academic textbooks, however, the footnotes are unobtrusive and act more like little gifts for the more intrepid reader.

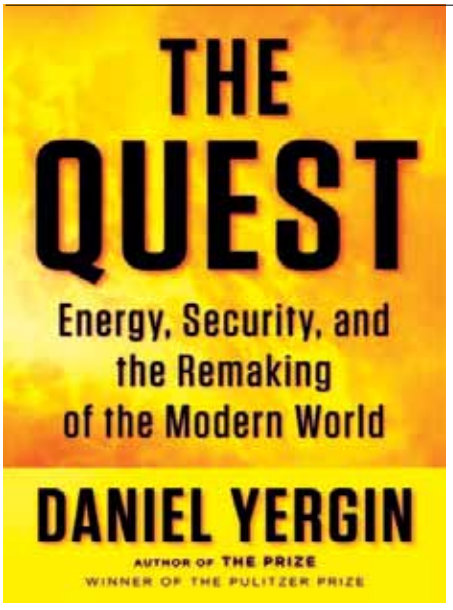
She argues that American society today may be sharply divided on the issue of climate change, but are uniformly in agreement when discussing energy. The importance of delineating the issue solving the problem of energy sources in the future with that of whether or not human civilization is affecting the climate in any way may appear to be a sacrifice, but the benefits of uniting people with different on a common and perhaps more immediately pressing need are immense. Koerth-Baker points out that the energy problem will not be solved by convincing everyone to live like its 1900, simply because that it is impractical, and generally not a good thing. Instead of reverting to the past, it is necessary to build a future where energy can be obtained from new places, used in new ways, and with greater efficiency.

The book covers a gamut of Renewable Energy options, and advocates a holistic approach towards utilizing them. "Clean coal? Natural gas? Nuclear? Electric cars? We will need them all. When you look at the numbers, you will find that we will still be using fossil fuels, nuclear, and renewables for decades to come." Renewables must not only match current energy needs, but also be able to match rising energy requirements in the future. Changing the current energy infrastructure of the United States or the world will require very heavy investment, and Koerth-Baker is clear that it is a bitter pill that we as a society must be willing to swallow to ensure sustainable growth. The author highlights the essential nature of learning about energy by stating, unequivocally that ideas such as new battery technologies, smart grids, passive buildings, decentralized generation, clean coal, and carbon sequestration may just be buzzwords used by people in the energy industry, "but they will be a part of your world soon".

Maggie Koerth-Baker's "Before The Lights Go Out: Conquering The Energy Crisis Before It Conquers Us" is an excellent introduction to the global energy challenges that face us in the future, the opportunities, the mistakes made in the past, and why the political, economic, and social security of nations in the future will be defined predominantly on the basis of their energy security. ■

"Hi, I'm the United States and I'm an oil-oholic." We have an energy problem. Moreover, everybody knows it, even if we cannot all agree on what, specifically, the problem is. Rising costs, changing climate, peaking oil, foreign oil, public safety—if the fears are this complicated, then the solutions are bound to be even more confusing. Maggie Koerth-Baker—science editor at the award-winning blog BoingBoing.net—finally makes some sense out of the madness. Over the next 20 years, we will be forced to cut 20 quadrillion BTU worth of fossil fuels from our energy budget, by wasting less and investing in alternatives. To make it work, we will need to radically change the energy systems that have shaped our lives for 100 years. In addition, the result will be neither business-as-usual, nor a hippie utopia. Koerth-Baker explains what we can do, what we cannot do, and why "The Solution" is really many solutions work together. This is not about planting a tree, buying a Prius, and proving that you are a good person. Economics and social incentives got us a country full of gas-guzzling cars, long commutes, inefficient houses, and coal-fired power plants out in the middle of nowhere, and economics and incentives will be the things that build our new world. Ultimately, change is inevitable.

NEW BOOK INFORMATION



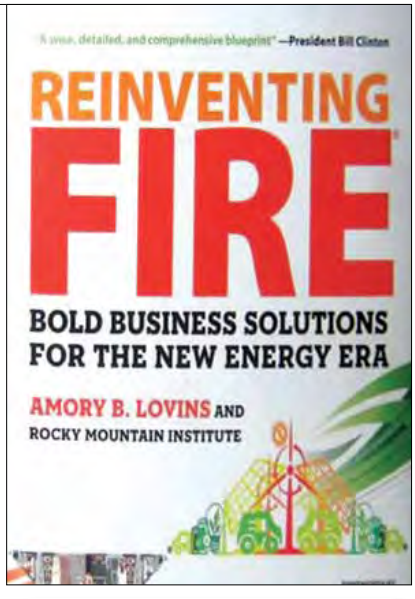
Daniel Yergin
Penguin Books • 2011

The Quest: Energy, Security, and the Remaking of the Modern World

Twenty years ago, Daniel Yergin – former Lecturer at Harvard University's two most venerable institutions, the Harvard Business School and the Kennedy School of Government – was awarded with the Pulitzer Prize for General Non-Fiction for his book, The Prize: The Epic Quest for Oil, Money, and Power. The Prize told the story of the global oil industry, starting from the 1850s and the emergence of the modern Oil Age in the early 20th century, right up to Saddam Hussein's invasion of Kuwait and the start of the Unites States' first Gulf War. The Quest continues Yergin's story, only this time, he covers the entire gamut of the energy industry. Daniel Yergin describes the on-going quest for energy security in the modern world, and relates the various efforts being taken across the Earth to meet civilization's ever-growing energy needs. Daniel Yergin's authorship brings with it an assurance of extensive research, and this 815-page book shows an extraordinary level of knowledge about diverse issues that are connected in the quest for energy security and how this quest is going to define politics, war, industry, and foreign policy in the 21st century.

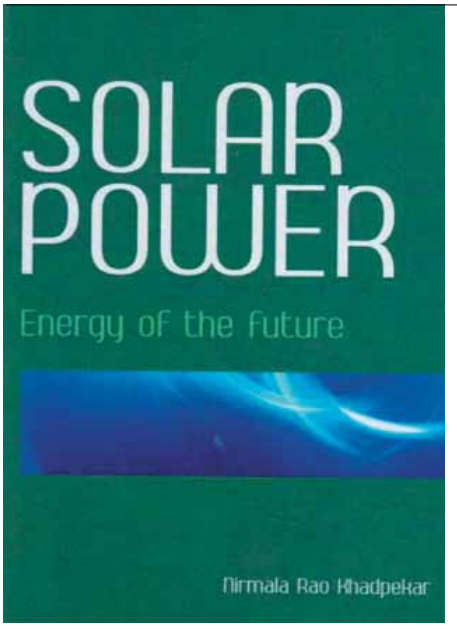
Reinventing Fire: Bold Business Solutions for the New Energy Era

Having worked for over forty years in the realm of energy policy, the Physicist, Environmental Scientist, and Writer, Amory B. Lovins, brings with him a wealth of knowledge and experience to tackle the biggest problems the world is facing today. Named as one of the 100 Most Influential People in the World by Time Magazine in 2009, Lovins begins the book in a captivating manner, with the quote: "Imagine fuel without fear. No climate change. No oil spills, dead coal miners, dirty air, devastated lands, lost wildlife. No energy poverty. No oil-fed wars, tyrannies, or terrorists. Nothing to run out. Nothing to cut off. Nothing to worry about. Just energy abundance, benign and affordable, for all, for ever." Written to inspire new solutions that are bold in their scope and application, Lovins uses a particularly grand rhetoric to try to make the challenges of the energy sector seem like epic quests, and in doing so, successfully captures the imagination of his audience.



Amory B. Lovins and the Rocky Mountain Institute
Penguin Books • 2011

NEW BOOK INFORMATION



Khadpekar N R
The ICFAI University Press, Tripura
• 230 pp • 2012

Solar power: Energy of the future

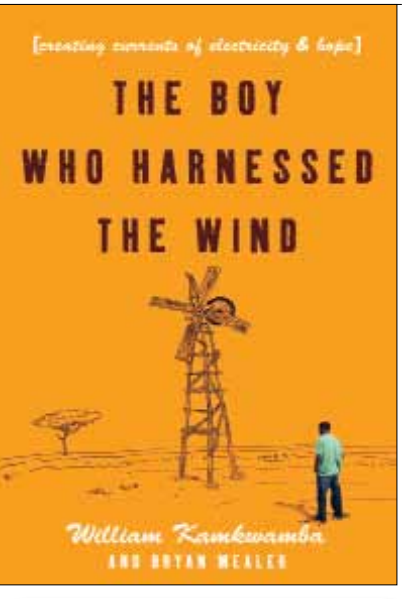
The objective of this book is to focus on solar energy as a clean source of power which is gradually moving towards achieving break even cost as compared to other grid connected options. The outlay involved, with the pros and cons are discussed in detail along with providing information about available and emerging solar technologies which can be used for generating usage and storage in various regions and climates.

The book attempts to inform the reader all about solar power generation, conversion, use and storage, costs and benefits. It looks into the practical problems involved and the novel solutions available. The emphasis is on bringing attention and inviting investments to support and develop solar technologies further. The book is meant for energy consultants, public utilities professions, policy makers, house owners, industrialists, venture capitalists, NGOs, researchers, and all those who are interested in clean technologies.

Among the various renewable energy resources available to us, solar power has become the most sought after energy source of choice to consumers who do not have the option of an electricity grid in the vicinity. It is being seen as the renewable energy of the future when all traditional sources, run out or become too costly to buy. That is the reason why energy is gaining acceptability the world over!

The Boy Who Harnessed the Wind: Creating Currents of Electricity and Hope

William Kamkwamba was born in the impoverished Sub-Saharan nation of Malawi, and at the age of 14, forced to drop out of school and help his family forage for food as thousands across his country starved and died. After coming across a textbook that described how windmills harness wind energy to generate electricity, William became obsessed with ameliorating his family's desperate situation by giving them what only 2% of Malawians can afford: electricity and running water. He fashioned a rudimentary, but working, windmill out of scrap metal, tractor parts, and bicycle halves, which he used to power a few lights and a water pump. As news of his genius and ingenuity spread, William Kamkwamba has since become a global celebrity. Now nearly 25 and studying at the prestigious Dartmouth College in New Hampshire, USA, *The Boy Who Harnessed the Wind* is William's story of determination and overcoming the odds, and a lesson on how individuals can make a difference in the energy revolution.



William Kamkwamba, Bryan Mealer
William Morrow • 2009

SOLAR TECHNOLOGY SECTION

How automation can benefit the PV industry

Although the different roadmaps for PV vary somewhat from each other, the bottom line always remains the same: exponential growth is predicted over the next 5–10 years. The latest cell technologies meet the demand for grid parity even in central Europe and PV will therefore continue to be the most popular source of renewable energy. In consequence, the whole PV industry has developed from a niche product towards mass production. Every player along the entire value chain is now faced with the need to stay profitable while meeting the ever-increasing demands of the market. Implementing suitable automation can improve competitiveness and thus pave the way to becoming or remaining successful in this turbulent market.

http://www.photovoltaicsinternational.com/technical_papers/list

3D multi-physics modelling of unidirectional solidification of mc-Si in an ingot furnace

Unidirectional solidification of large Si ingots from the melt phase is currently one of the most important technologies for producing mc-Si for PV cells. Si ingot furnaces began from casting equipment, and have been improved by DSS (directional solidification system) or DSS-like methods. To improve PV cell efficiency and reduce costs, intensive development has focused on increasing a single ingot's volume, reducing impurities and controlling the growth speed and temperature gradient. One of the latest developments of Si ingot furnaces is mono-like crystalline silicon growth using a seed preservation method and more accurate control. The Si ingot furnaces are optimized with precise control of temperature gradients and growth speed for the formation of a large unit of quasi-monocrystalline Si. This optimization can further improve a PV cell's efficiency by at least 1%. In order to obtain fundamental knowledge about the key process steps that determine the growth and electrical quality of mc-Si via directional solidification in an ingot furnace, a combined modelling-measuring approach is essential. Moreover, a mathematical model of the Si ingot casting process can be used for model-based process control.

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Selective emitter (SE) technology – from laboratory to optimization in full-scale production

The selective emitter (SE) concept features two different doping levels at the front surface of the cell. Both doping profiles are tailored individually to best suit their specific purposes, thus achieving both low contact resistance of the emitter electrode and low recombination in the emitter and at the Si/SiNx:H interface. This paper details the experience gained since the first tools for generating an SE structure were installed two years ago. The approach taken is discussed and a presentation given of the physical concept and properties of SE technology, along with the different aspects that have to be considered when integrating SE into an otherwise unchanged production facility.

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Challenges for single-side chemical processing

Wet chemical process equipment is widely used in industrial solar cell production, and inline etching systems in particular have attracted more and more attention since their introduction 10 years ago. The horizontal wafer transport within these systems has made it possible to think about single-side wafer treatments even for wet chemical process applications. Since its market introduction in 2004, the chemical edge isolation process based on the single-side removal of the parasitic emitter at the rear side of the

solar cells has gained an increasing share of the market in comparison to competing technologies that use laser techniques. However, stabilization and control of such a process under mass production conditions remains challenging. The introduction of new high-efficiency cell concepts involving passivated rear sides will increase the importance of single-side wafer treatments, as the final solar cell performance is significantly affected not only by the complete removal of the parasitic emitter but also by an ideally polished surface on the rear side of the wafer.

http://www.photovoltaicsinternational.com/technical_papers/list

Catching Some Rays: Organic Solar Cells Make a Leap Forward

At the atomic level, organic solar cells function like the feuding families as there is a strong natural attraction between the positive and negative charges that a photon generates after it strikes the cell, but in order to capture the energy, these charges need to be kept separate. When these charges are still bound together, they are known to scientists as an exciton. Lin Chen of the U.S. Department of Energy's (DOE) said that the real question that this work tries to answer is how to design a material that will make splitting the exciton require less energy.

Excitons can be thought of as a sort of "quasiparticle," Chen said, because they exhibit certain unique behaviors. When the two charged regions of the exciton -- the electron and a region known as a "hole" -- are close together, they are difficult to pry apart.

When energy is added to the system, however, the charges begin to separate, rendering the electrons and holes completely free and eventually allowing for the possibility of generating current and extracting electricity

In the new experiment, Chen and her colleagues examined how four different molecules in the polymer layer in the middle of a solar cell generated different exciton dynamics. They discovered that more heavily polarized excitons yielded more efficient polymer-based solar cells."If the conventional exciton, right after it is generated, contains the hole and electron in almost the same location, these new materials are generating an exciton that is much more polarized at the beginning," Chen said. Currently, the collaborative team is exploring new materials for high-efficiency organic solar cells based on these findings. Organic solar cells still have a ways to go to get close to the efficiency of their inorganic, silicon-based competitors, but they remain much more attractive from a cost perspective. Further research into the electronic dynamics of organic photovoltaics is essential to improving their efficiency and thus making solar power cost-competitive with conventional energy sources, Chen said.

http://www.sciencedaily.com releases/2012/06/120614182755.htm

High-Speed Method to Aid Search for Solar Energy Storage Catalysts

Plants convert sunlight to chemical energy in the form of biomass, while releasing oxygen as an environmentally benign byproduct. Devising a similar process by which solar energy could be captured and stored for use in vehicles or at night is a major focus of modern solar energy research. Efforts today are focused on electrolysis reactions that use sunlight to convert water, carbon dioxide, or other abundant feedstocks into chemicals that can be stored for use any time. A key stumbling block, however, is finding inexpensive and readily available electrocatalysts that facilitate these solar-driven reactions.

Existing technology to store solar energy is not economically viable because using the sun to split water into oxygen and hydrogen is inefficient. Water oxidation provides electrons and protons needed for hydrogen production, and better catalysts minimize the energy lost when converting energy from sunlight to chemical fuels, says Stahl.

In addition to being efficient, the catalysts need to be made from materials that are more abundant and far less expensive than metals like platinum and the rare earth compounds currently found in the most effective catalysts.

According to Stahl and Gerken, the discovery of promising electrocatalytic materials is hindered by the costly and laborious approaches used to discover them. What's more, the sheer number of possible catalyst compositions far exceeds the number that can be tested using traditional methods.

In the Angewandte Chemie report, Gerken, Stahl and their colleagues describe a screening method capable of rapidly evaluating potential new electrocatalysts. In simple terms, the technique works using ultraviolet light and a fluorescent paint to test prospective metal-oxide electro catalysts. A camera captures images from a grid of candidate catalysts during the electrolysis process, as the paint responds to the formation of oxygen. This approach turns out to be a highly efficient way to sort through many compounds in parallel to identify promising leads.

Already, the Wisconsin team has identified several new metal-oxide catalysts that are composed of inexpensive materials such as iron, nickel and aluminum, and that hold promise for use in solar energy storage.

http://www.sciencedaily.com/ releases/2012/05/120525165212.htm

Taking Solar Technology Up a Notch: New Inexpensive, Environmentally Friendly Solar Cell Shines With Potential

In particular, the device is the first to solve the problem of the Grätzel cell, a promising low-cost and environmentally friendly solar cell with a significant disadvantage: it leaks. The dye-sensitized cell's electrolyte is made of an organic liquid, which can leak and corrode the solar cell itself. Grätzel cells use a molecular dye to absorb sunlight and convert it to electricity, much like chlorophyll in plants. But the cells typically don't last more than 18 months, making them commercially unviable. Researchers have been searching for an alternative for two decades. At Northwestern, where interdisciplinary collaboration is a cornerstone, nanotechnology expert Robert P. H. Chang challenged chemist Mercouri Kanatzidis with the problem of the Grätzel cell. Kanatzidis' solution was a new material for the electrolyte that actually starts as a liquid but ends up a solid mass. Thus, the new all solid-state solar cell is inherently stable.

In the Northwestern cell, a thin-film compound made up of cesium, tin and iodine, called CsSnI3, replaces the entire liquid electrolyte of the Grätzel cell. The Northwestern cell exhibits the highest conversion efficiency (approximately 10.2%) so far reported for a solid-state solar cell equipped with a dye sensitizer. This value is close to the highest reported performance for a Grätzel cell, approximately 11 to 12%. (Conventional solar cells made from highly purified silicon can convert roughly 20% of incoming sunlight.) Unlike the Grätzel cell, the new solar cell uses both n-type and p-type semiconductors and a monolayer dye molecule serving as the junction between the two. Each nearly spherical nanoparticle, made of titanium dioxide, is an n-type semiconductor. Kanatzidis' CsSnI3 thin-film material is a new kind of soluble p-type semiconductor.

A single solar cell measures half a centimeter by half a centimeter and about 10 microns thick. The dye-coated nanoparticles are packed in, and Kanatzidis' new material, which starts as a liquid, is poured in, flowing around the nanoparticles. Much like paint, the solvent evaporates, and a solid mass results. The sunlight-absorbing dye, where photons are converted into electricity, lies right between the two semiconductors.

Chang chose to use nanoparticles approximately 20 nanometers in diameter. This size optimizes the device, he said, increasing the surface area and allowing enough space between the particles for Kanatzidis' material to flow through and set.

Technically, this new cell is not really a Grätzel cell since the hole-conducting material CsSnI3 is itself light absorbing. In fact, the material absorbs more light over a wider range of the visible spectrum than the typical dye used in Grätzel cells. In the Kanatzidis-Chang cell, the CsSnI3 plays an additional role in the operation of the cell that is not played by the liquid electrolyte couple, and that role is light absorption.

The lightweight thin-film structures are compatible with automated manufacturing, the researchers point out. They next plan to build a large array of the solar cells.

http://www.sciencedaily.com/releases/2012/05/120523133236.htm

Dye-Sensitized Solar Cells That Use Carbon Nanotube Thin Films as Transparent Electrodes Offer Significant Cost Savings

Solar energy is one of the most promising forms of renewable energy, but the high cost of conventional solar cells has so far limited its popularity. To increase the competitiveness of solar energy, scientists have turned to the development of dye-sensitized solar cells -- solar cells that use low-cost organic dyes and titanium dioxide (TiO2) nanoparticles in place of expensive semiconductor and rare earth elements to absorb sunlight. Zhaohong Huang at the A*STAR Institute of Materials Research and Engineering and co-workers1 have now reduced the cost of dye-sensitized solar cells even further by replacing indium tin oxide (ITO) -- the standard material for transparent electrodes -- with carbon nanotubes. A typical dye-sensitized solar cell comprises a porous layer of TiO2 nanoparticles immersed in an organic dye. The dye absorbs the sunlight and converts the energy into electricity, which flows into the TiO2 nanoparticles. The sun-facing side of the solar cell is usually covered with a transparent electrode that carries the charge carriers away from the TiO2 and out of the solar cell.

Carbon nanotubes conduct electricity and are almost transparent, flexible and strong, which make them the ideal material for transparent electrodes. The only drawback is that photo-generated charge carriers in the nanotube may recombine with ions in the dye, which reduces the power conversion efficiency of the solar cell.

To overcome this problem, Huang and his team placed a TiO2 thin film in between the carbon nanotube thin film and the porous layer. They found that the performance of dye-sensitized solar cells with TiO2 thin film was significantly better than those without. However, they also found that the solar conversion efficiency of their new dye-sensitized solar cells was only 1.8%, which is lower than that of conventional solar cells using ITO electrodes. This is due to the higher electrical resistances and reduced optical transparency of the carbon nanotube films, which limits the amount of sunlight entering the cell.

http://www.sciencedaily.com/releases/2012/03/120314095553.htm

Artificial Leaf Device Produces Hydrogen in Water Using Only Sunlight

This technology, which has been named artificial photosynthesis, was inspired by photosynthesis which occurs naturally (a process in which plants use sunlight to transform organic material into organic compounds, freeing chemical energy stored in the bonds of the molecule adenosine triphosphate-ATP, and obtaining energetic compounds such as sugars or carbohydrates).

The efficient production of hydrogen using semiconductor materials and sunlight constitutes a crucial challenge to make a paradigm shift towards sustainable energy technology, using inexhaustible resources that are environmentally friendly. Hydrogen is an extremely abundant element on Earth's surface, but in combination with oxygen: water (H20). The hydrogen molecule (H2) contains a great amount of energy that can be released when burned due to the reaction with atmospheric oxygen, creating water as the result of this combustion process. In order to convert water into fuel (H2), the H2O must be broken down into its separate components and so that the process can be carried out in a renewable way (without using subsoil fossil fuels), it is necessary to use a device which relies on solar power, and with no other assistance, to provoke the chemical reactions to break the water and form hydrogen in a way similar to leaves on plants. For this reason these devices are named artificial leaves.

The device is submerged in an aqueous solution which, when illuminated with a light source, forms hydrogen gas bubbles. The research group used a solution with an oxidizing agent and studied the evolution of hydrogen produced by photons.

http://www.sciencedaily.com/releases/2012/05/120523102057.htm

Tiny Solar-Panel-Like Cells Help Restore Sight to the Blind

This device -- a new type of retinal prosthesis -- involves a specially designed pair of goggles, which are equipped with a miniature camera and a pocket PC that is designed to process the visual data stream. The resulting images would be displayed on a liquid crystal micro display embedded in the goggles, similar to what's used in video goggles for gaming. Unlike the regular video goggles, though, the images would be beamed from the LCD using laser pulses of near-infrared light to a photovoltaic silicon chip -- one-third as thin as a strand of hair -- implanted beneath the retina. Electric currents from the photodiodes on the chip would then trigger signals in the retina, which then flow to the brain, enabling a patient to regain vision. The scientists are now testing the system in live rats, taking both physiological and behavioral measurements, and are hoping to find a sponsor to support tests in humans.

"It works like the solar panels on your roof, converting light into electric current," said Daniel Palanker, PhD, associate professor of ophthalmology and one of the paper's senior authors. "But instead of the current flowing to your refrigerator, it flows into your retina." Palanker is also a member of the Hansen Experimental Physics Laboratory at Stanford and of the interdisciplinary Stanford research program, Bio-X. The study's other senior author is Alexander Sher, PhD, of the Santa Cruz Institute of Particle Physics at UC Santa Cruz; its co-first authors are Keith Mathieson, PhD, a visiting scholar in Palanker's lab, and James Loudin, PhD, a postdoctoral scholar. Palanker and Loudin jointly conceived and designed the prosthesis system and the photovoltaic arrays. There are several other retinal prostheses being developed, and at least two of them are in clinical trials. A device made by the Los Angeles-based company Second Sight was approved in April for use in Europe, and another prosthesis-maker, a German company called Retina Implant AG, announced earlier this month results from its clinical testing in Europe. Unlike these other devices -- which require coils, cables or antennas inside the eye to deliver power and information to the retinal implant -- the Stanford device uses near-infrared light to transmit images, thereby avoiding any need for wires and cables, and making the device thin and easily implantable.

The proposed prosthesis is intended to help people suffering from retinal degenerative diseases, such as age-related macular degeneration and retinitis pigmentosa. In these diseases, the retina's photoreceptor cells slowly degenerate, ultimately leading to blindness. But the inner retinal neurons that normally transmit signals from the photoreceptors to the brain are largely unscathed. Retinal prostheses are based on the idea that there are other ways to stimulate those neurons. The Stanford device uses near-infrared light, which has longer wavelength than normal visible light. It's necessary to use such an approach because people blinded by retinal degenerative diseases still have photoreceptor cells, which continue to be sensitive to visible light. The scientists placed an array of photodiodes beneath the retinas and placed a multi-electrode array above the layer of ganglion cells to gauge their activity. The scientists then sent pulses of light, both visible and near-infrared, to produce electric current in the photodiodes and measured the response in the outer layer of the retinas.

http://www.sciencedaily.com/releases/2012/05/120513144617.htm

New LFP 10 Portable Solar Power Generator System

This is our new LFP 10 Portable Solar Generator system that comes with a 36w Hi Efficiency portable solar panel. This system has a 5 Amp/65W Solar Panel Charging input that uses the latest technology called MPPT which stands for Maximum Power Point Tracking and the benefit of MPPT is that is always maximizes the output of the attached solar panels so you end up with up to 30% more power at the end of the day vs a system that does not use MPPT on the solar panels. Consumer can recharge the battery from Empty to Full in 2 hours if you supply the system with 65 watts of solar panel input power. This system is super lightweight, the case weighs 4.2 pounds and the 36w solar panel weighs 3.2 pounds for a total of 7.4 pounds. Different solar panel setups are available which will increase or decrease the cost depending on which panel and what type of panel interested in. The case has a 12v Cigarette Lighter output that has a max output power rating of 200 watts or 15 Amps of power. The 10 Amp Hour battery stores 128 Watt Hours of Power. So if your devices consumes 20 watts this system could power that load for 6+ hours before it would be completely drained. A 12v to 120v AC inverter is included with the system that provides you with a regular AC Power outlet like you have at home so you can plug in all your devices that consume less than 200 watts of power. There is a build in battery voltage meter beneath the laser etched top panel that shows the current battery voltage which gives a generic indication of the state of charge of the battery.

http://www.portablesolarpowernews.com/new-lfp-10-portable-solar-power-generator-system/

How To Solar Charge iPhone, iPad, and Android Devices

As we are aware that solar charge all our USB devices like iPhone, iPad, iPod, Android, Droid, GPS, Kindle, Samsung, HTC, Razr, and many other USB devices that can be powered or recharged via their USB Port. Our 12w Portable Solar Phone charger is perfect when one need a light weight portable solar charger that is powerful enough to rapidly recharge your devices. We also carry a rechargeable battery pack that can store the power the solar panel generates during the day so you can use it during the night when the sun is no longer available.

http://www.portablesolarpowernews.com/how-to-solar-charge-iphone-ipad-and-android-devices/

CSP: TOMORROW'S TECHNOLOGY TODAY

Solar energy technology is a rapidly expanding field with many innovative solutions that strive to best harness the sun's energy. Using CSP, AREVA Solar also leverages its historical expertise in thermal technology, fluid mechanics and heat transfer to best serve utility companies. Customers can be assured that AREVA's Solar steam generators meet the highest quality assurance standards. AREVA is proud to be the first solar steam power boiler manufacturer to receive the American Society of Mechanical Engineers' "S" Stamp Certificate of Authorization – the industry hallmark of acceptance and certification. With CLFR technology, the company is able to produce superheated steam at high temperatures and pressures, up to 400°C (750°F) and 106 bar (1535 psia), which allows us to optimize the needs of power generation and industrial steam users.

http://areva.com/EN/operations-415/concentrated-solar-power-technology.html

First Solar to speed-up implantation of CdTe cell efficiency gains

Under intense pressure to remain the low-cost leader, First Solar is taking a leaf from the semiconductor industry by teaming up with materials specialists Intermolecular to fast-track R&D research in materials and processes to shorten the time-to-market for higher efficiency CdTe-based, thin-film PV modules. Taking record cell and module efficiencies from the lab to the fab has proved to be a perennial problem for all types of PV technology. Intermolecular is well-known in the semiconductor industry for its High Productivity Combinatorial (HPC) platform, which works under specified R&D projects through Collaborative Development Programs (CDPs). The company employs systems and methodologies that are claimed to radically accelerate the discovery and integration of new materials, new process technologies and even new device structures for clients. Intermolecular's informatics software system has been used by major leading-edge semiconductor manufacturers to enable new materials to be tested much faster than previously thought but provide complete tracking of things like experiments, while automatically analyzing and interpreting data.

Nearly a year ago, First Solar set a world record for CdTe-based cell efficiency of 17.3%, while volume production figures for its best line have reached 13.1% in the first quarter of 2012, while the company expects the average module efficiency by the end of 2012 to be 12.7%. With material cost reductions having been the biggest cost-per-watt driver in the last two years, further cost reduction drivers for the industry are expected to come from improved conversion efficiencies.

http://www.pv-tech.org/news/first_solar_to_speed_up_implantation_of_cdte_cell_efficiency_gains?utm_source=pvtech-feeds&utm_medium=rss&utm_campaign=news-rss-feed ■

A TERI Publication

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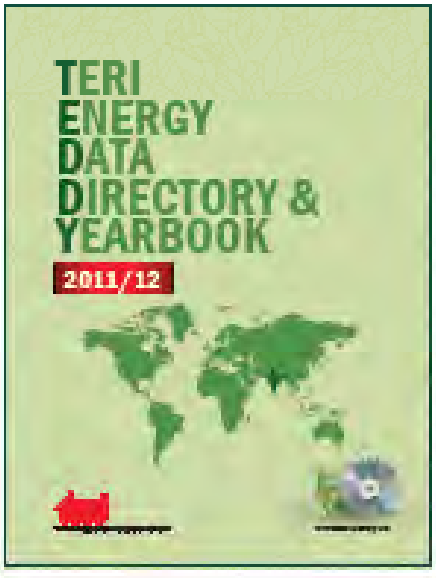

TERI Energy Data Directory & Yearbook (TEDDY) 2011/12

2012 • ISBN: 9788179933757
Pages: 430 • Binding: Hardback
Size: 220 x 280 mm • Price: ₹1995.00

TERI Energy Data Directory Yearbook, or *TEDDY*, is an annual publication brought out by TERI since 1986. TEDDY is often used as a reference in other peer-reviewed books and journals for energy and environment-related data. It gives an annual overview of the developments in sectors such as energy supply and consumption as well as the environment sector. It also provides a review of the government policies that have implications for these sectors of the Indian economy.

Key features

- Exhaustive compilation of data from energy supply and demand sectors.
- Recent data along with data for the past years presented in the form of structured and easy-to-understand tables.
- Recent advances made in the energy sectors are represented in the book.
- Self-explanatory figures showing the latest trends in various sectors are also part of each chapter.
- The "In focus" section in every chapter highlights a topical issue.
- The book comes with a complimentary CD that contains all the chapters and additional tables.

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• Overview of the Indian energy sector • Organization of the energy sector in India • Commercial energy balances and conversion factors • Energy supply: Coal and lignite, oil and gas, power, and renewable energy sources and technologies • Energy demand: Agriculture, industry, transport, and domestic • Local and global environment: Environment, climate change and energy

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CURRENT R&D SOLAR

Research on an adsorption cooling system supplied by solar energy

Energy and Buildings, Volume 51, August 2012, Pages 15-20

Robert Sekret, Michał Turski

Abstract

In the current article, research on the possibilities for ensuring thermal comfort through the use of an adsorption cooling system supplied by solar energy is presented. The main goal was to ensure an adequate level of cooling in a referential room of 40 m3 in volume. Cooling was attained by an adsorption ice water generator (AIWG) that was supplied by energy from flat-plate solar collectors. Experiments on the AIWG working conditions and an analysis of the possibilities for using solar energy in a region of Czestochowa (Poland) to supply an adsorption cooling system are also presented. The real value of the cooling efficiency of the COP coefficient for the adsorption ice water generator was 0.27, and the real global efficiency of the adsorption cooling system was 0.23. On the basis of the results, it was assumed that, in climate conditions typical for Poland, it is possible to effectively use the adsorption cooling system to keep a constant level of thermal comfort during all months in which there is a demand for cooling, i.e., between April and October.

Comparative life cycle assessment of thermal energy storage systems for solar power plants

Renewable Energy, Volume 44, August 2012, Pages 166-173

Eduard Oró, Antoni Gil, Alvaro de Gracia, Dieter Boer, Luisa F. Cabeza

Abstract

The present work compares the environmental impact of three different thermal energy storage (TES) systems for solar power plants. A Life Cycle Assessment (LCA) for these systems is developed: sensible heat storage both in solid (high temperature concrete) and liquid (molten salts) thermal storage media, and latent heat storage which uses phase change material (PCM). The aim of this paper is to analyze if the energy savings related to the stored energy of the different systems are enough to balance the environmental impact produced during the manufacturing and operation phase of each storage system. Some hypothetical scenarios are studied using LCA methodology to point out the differences between each TES system.

The system based on solid media, due to his simplicity, shows the lowest environmental impact per kWh stored of all three systems compared. In addition, the liquid media (molten salts) shows the highest impact per kWh stored because it needs more material and complex equipment.

Numerical simulation of underground Seasonal Solar Thermal Energy Storage (SSTES) for a single family dwelling using TRNSYS

Solar Energy, Volume 86, Issue 1, January 2012, Pages 289-300

Marshall L. Sweet, James T. McLeskey Jr.

Abstract

A system for capturing and storing solar energy during the summer for use during the following winter has been simulated. Specifically, flat plate solar thermal collectors attached to the roof of a single family dwelling were used to collect solar thermal energy year round. The thermal energy was then stored in an underground fabricated Seasonal Solar Thermal Energy Storage (SSTES) bed. The SSTES bed allowed for the collected energy to supplement or replace fossil fuel supplied space heat in typical single family homes in Richmond, Virginia, USA. TRNSYS was used to model and simulate the winter thermal load of a typical Richmond home.

The simulated heating load was found to be comparable to reported loads for various home designs. TRNSYS was then used to simulate the energy gain from solar thermal collectors and stored in an underground, insulated, vapor proof SSTES bed filled with sand. Combining the simulation of the winter heat demand of typical homes and the SSTES system showed reductions in fossil fuel supplied space heating in excess of 64%. The optimization of the SSTES scheme showed that a 15 m3 bed volume, 90% of the south facing roof, and a flow rate of 11.356 lpm through the solar collectors were optimal parameters. The overall efficiency of the system ranged from 50% to 70% when compared to the total useful energy gain of the solar collectors. The overall efficiency was between 6.1% and 7.6% when compared to the total amount of solar radiation incident upon the solar collectors.

Increased efficiencies on CdTe solar cells via luminescence down-shifting with excitation energy transfer between dyes

Solar Energy Materials and Solar Cells, Volume 98, March 2012, Pages 486-490

L. Danos, T. Parel, T. Markvart, V. Barrioz, W.S.M. Brooks, S.J.C. Irvine

Abstract

The external quantum efficiencies of CdTe solar cells fabricated by the atmospheric pressure metal organic chemical vapour deposition (AP–MOCVD) method have been measured with one and two dye doped luminescence down-shifting (LDS) layers on top. Excitation energy transfer between the dyes is used to extend the absorption ability of the LDS layer to λ=350 nm and increase the external quantum efficiency (EQE) of the cells for wavelengths λ<540 nm. The observed increase in the EQE corresponds to a rise in the short circuit current density of 1.88 mA/cm2 under AM1.5G illumination spectra, which is equivalent to a 10% relative solar cell efficiency increase. A simple model is presented, which accounts for the absorption and photon collection efficiencies of the LDS layer.

Energy analysis and modeling of a solar assisted house heating system with a heat pump and an underground energy storage tank

Solar Energy, Volume 86, Issue 3, March 2012, Pages 983-993

Recep Yumrutaλ, Mazhar Ünsal

Abstract

An analytical model is presented and analyzed to predict the long term performance of a solar assisted house heating system with a heat pump and an underground spherical thermal energy storage tank. The system under investigation consists of a house, a heat pump, solar collectors and a storage tank. The present analytical model is based on a proper coupling of the individual energy models for the house, the heat pump, useful solar energy gain, and the transient heat transfer problem for the thermal energy storage tank. The transient heat transfer problem outside the energy storage tank is solved using a similarity transformation and Duhamel's superposition principle. A computer code based on the present model is used to compute the performance parameters for the system under investigation. Results from the present study indicate that an operational time span of 5–7 years will be necessary before the system under investigation can attain an annually periodic operating condition. Results also indicate a decrease in the annually minimum value of the storage tank temperature with a decrease in the energy storage tank size and/or solar collector area.

Performance characterisation and energy savings of uncovered swimming pool solar collectors under reduced flow rate conditions

Solar Energy, Volume 86, Issue 5, May 2012, Pages 1511-1517

L.N. Cunio, A.B. Sproul

Abstract

The effects of reduced flow rates on the performance and effectiveness of domestic unglazed, uninsulated pool solar collector heaters are investigated. The study shows electrical energy savings in excess of 80% are achievable for typical solar collectors operating at flow rates reduced by up to 75% while collector efficiency is only reduced by approximately 10–15%. The reduction of electrical energy required for pumping and the increased COP of reduced flow through typical pool solar thermal collectors is shown to far outweigh the small loss of collector performance attributable to the change in flow rates. The ratio of thermal energy delivered to the electrical energy supplied was improved in the order of 400% for the collector tested.

Renewable and Sustainable Energy Reviews, Volume 16, Issue 1, January 2012, Pages 449-465

Solar energy: Markets, economics and policies

Govinda R. Timilsina, Lado Kurdgelashvili, Patrick A. Narbel

Solar energy has experienced phenomenal growth in recent years due to both technological improvements resulting in cost reductions and government policies supportive of renewable energy development and utilization. This study analyzes the technical, economic and policy aspects of solar energy development and deployment. While the cost of

solar energy has declined rapidly in the recent past, it still remains much higher than the cost of conventional energy technologies. Like other renewable energy technologies, solar energy benefits from fiscal and regulatory incentives, including tax credits and exemptions, feed-in-tariff, preferential interest rates, renewable portfolio standards and voluntary green power programs in many countries. The emerging carbon credit markets are expected to provide additional incentives to solar energy deployment; however, the scale of incentives provided by the existing carbon market instruments, such as, the Clean Development Mechanism of the Kyoto Protocol is limited. Despite the huge technical potential, the development and large scale deployment of solar energy technologies world-wide still has to overcome a number of technical, financial, regulatory and institutional barriers. The continuation of policy supports might be necessary for several decades to maintain and enhance the growth of solar energy in both developed and developing countries.

A review of solar energy modeling techniques

Renewable and Sustainable Energy Reviews, Volume 16, Issue 5, June 2012, Pages 2864-2869

Tamer Khatib, Azah Mohamed, K. Sopian

Abstract

Solar radiation data provide information on how much of the sun's energy strikes a surface at a location on the earth during a particular time period. These data are needed for effective research in solar-energy utilization. Due to the cost of and difficulty in solar radiation measurements and these data are not readily available, alternative ways of generating these data are needed. In this paper, a review is made on the solar energy modeling techniques which are classified based on the nature of the modeling technique. Linear, nonlinear, artificial intelligence models for solar energy prediction have been considered in this review. The outcome of the review showed that the sunshine ratio, ambient temperature and relative humidity are the most correlated coefficients to solar energy.

Greener energy: Issues and challenges for Pakistan—Solar energy prospective

Renewable and Sustainable Energy Reviews, Volume 16, Issue 5, June 2012, Pages 2762-2780

Abdul Waheed Bhutto, Aqeel Ahmed Bazmi, Gholamreza Zahedi

Abstract

Energy plays a pivotal role in socio-economic development by raising standard of living. It is becoming gradually accepted that current energy systems, networks encompassing every thing from primary energy sources to final energy services, are becoming unsustainable. Development of conventional forms of energy for meeting the growing energy needs of society at a reasonable cost is the responsibility of the Governments. In recent years, public and political sensitivities to environmental issues and energy security have led to the promotion of renewable energy resources. Diversification of fuel sources is imperative to address these issues; and limited fossil resources and environmental problems associated with them have emphasized the need for new sustainable energy supply options that use renewable energies. Development and promotion of new non-conventional, alternate and renewable sources of energy such as solar, wind and bio-energy, etc. are now getting sustained attention. Solar power is one of the hottest areas in energy investment right now, but there is much debate about the future of solar technology and solar energy markets. This investigates the progress and challenges for solar power in Pakistan according to the overall concept of sustainable development, and identifies the region wise potential of solar power in Pakistan and its current status. Barriers are examined over the whole solar energy spectrum and policy issues and institutional roles and responsibilities are discussed.

Performance of solar-desiccant cooling system with Silica-Gel (SiO2) and Titanium Dioxide (TiO2) desiccant wheel applied in East Asian climates

Solar Energy, Volume 86, Issue 5, May 2012, Pages 1261-1279

Napoleon Enteria, Hiroshi Yoshino, Akashi Mochida, Akira Satake, Ryuichiro Yoshie, Rie Takaki, Hiroshi Yonekura, Teruaki Mitamura, Yasumitsu Tanaka

Abstract

This paper shows the numerical investigation of the developed solar-desiccant cooling system applied in the East Asian climatic conditions with two different desiccant wheel coating materials – the Silica-Gel (SiO2) and the Titanium Dioxide (TiO2). The developed and validated numerical model of the system is currently used in the present study incorporating the two new materials in the desiccant wheel. The system was applied in temperate climate (Beijing and Tokyo), subtropical climate (Taipei and Hong Kong) and tropical climate (Manila and Singapore). The study showed that the specification of the solar-desiccant cooling system varies depending on the climatic conditions. It showed that the required flat plate collector area was getting larger from the temperate climate to the tropical climate. The storage tank requirement was getting bigger in the tropical climate compared to the subtropical and temperate climate.

The volumetric flow rate of air was getting higher from temperate climate to tropical climate. In the comparison of the two materials, it was found that the Titanium Dioxide (TiO2) can support lower indoor temperature and humidity ratio than the Silica-Gel (SiO2) with the same specification of the solar thermal system and desiccant cooling system. In general, the solar-desiccant cooling system can provide the required indoor temperature and humidity ratio. However, for the hot and humid climate such as in tropical, large size of the solar thermal system is needed. In addition, higher volumetric flow of air to support the high cooling load is required. With regard to the new material, Titanium Dioxide, it is proven to be a good alternative material since it can provide lower indoor temperature and humidity ratio with higher cooling performance than the Silica-Gel.

Influence of local environmental, social, economic and political variables on the spatial distribution of residential solar PV arrays across the United States

Energy Policy, Volume 47, August 2012, Pages 332-344

Calvin Lee Kwan

Abstract

This study used ZIP code level data from the 2000 US Census to investigate the influence of local environmental, social, economic and political variables on the distribution of residential solar PV arrays across the United States. Current locations of residential solar PVs were documented using data from the National Renewable Energy Laboratory's Open PV project. A zero-inflated negative binomial reression model was run to evaluate the influence of selected variables. Using the same model, predicted residential solar PV shares were generated and illustrated using GIS software. The results of the model indicate solar insolation, cost of electricity and amount of available financial incentives are important factors influencing adoption of residential solar PV arrays. Results also indicate the Southwestern region of the United States and the state of Florida are currently underperforming in terms of number of housing units with solar PV installations.

The future of organic photovoltaic solar cells as a direct power source for consumer electronics

Solar Energy Materials and Solar Cells, Volume 103, August 2012, Pages 1-10

Sebastien Lizin, Steven Van Passel, Ellen De Schepper, Liesbet Vranken

Abstract

As the search for marketable photovoltaic solar cells continues, organic photovoltaic (OPV) solar cells have been identified as a technology with many attractive features for commercialization. Most photovoltaic technologies on the market today were improved in the consumer electronics market segment. A similar evolution has been envisioned for OPV. Hence this paper investigates consumer preferences for solar cells directly powering consumer electronics. Choice experiments were designed and responses were collected using a random sample of 300 individuals from the Flemish region (northern part of Belgium). Results allow for computation of attribute importance, willingness to pay (WTP), and simulation of theoretical market share. These measures point towards OPV being able to reach considerable market share in the long run, bearing in mind that efforts are first needed in elevating OPV's efficiency and lifetime as they most determine consumers' preferences. Price is found to be the least important product characteristic for OPV solar cells to be incorporated in consumer electronics devices. We therefore warn against generalizing attributes' importance across the boundaries of market segments.

Prospects for solar cooling – An economic and environmental assessment

Solar Energy, Volume 86, Issue 5, May 2012, Pages 1287-1299

Todd Otanicar, Robert A. Taylor, Patrick E. Phelan

Abstract

Producing refrigeration and/or air conditioning from solar energy remains an inviting prospect, given that a typical building's cooling load peaks within 2 or 3 h of the time of maximum solar irradiation. The attractiveness of "free" cooling obtained from the sun has spawned a wealth of research over the last several decades, as summarized in a number of review articles. Obstacles—especially high initial costs—remain to the widespread commercialization of solar cooling technologies. It is not clear at the present time if thermally driven systems will prove to be more competitive than electrically driven systems. We therefore describe a technical and economic comparison of existing solar cooling approaches, including both thermally and electrically driven. We compare the initial costs of each technology, including projections about future costs of solar electric and solar thermal systems. Additionally we include estimates of the environmental impacts of the key components in each solar cooling system presented. One measure of particular importance for social acceptance of solar cooling technologies is the required "footprint," or collector area, necessary for a given cooling capacity. We conclude with recommendations for future research and development to stimulate broader acceptance of solar cooling. The projections made show that solar electric cooling will require the lowest capital investment in 2030

due to the high COPs of vapor compression refrigeration and strong cost reduction targets for PV technology.

Numerical investigations on a pressurized volumetric receiver: Solar concentrating and collecting modelling

Renewable Energy, Volume 44, August 2012, Pages 368-379

Y.L. He, Z.D. Cheng, F.Q. Cui, Z.Y. Li, D. Li

Abstract

The main objective of the work is to develop numerical method for improving design/simulation tools and answering to specific questions related with heat and mass transfer inside a pressurized volumetric receiver (PVR), providing fundamental basis to design new receivers for the DAHAN project later. In this paper, an idealized three-dimensional axialsymmetric computation model of a PVR with a secondary concentrator (SC) which is almost intrinsic axial symmetry is presented firstly by some simplification assumptions. A new designing method and homemade unified code of the Monte Carlo Ray-Trace (MCRT) Method for numerical investigations on solar concentrating and collecting characteristics of the PVR is proposed. Then the proposed method and code is applied to simulate and analyze the involuted photo-thermal conversion process in the PVR, covering solar concentrating, collecting and transferring process of solar energy. Solar radiation in participating medium and/or non-participating medium can be taken into account simultaneously or dividedly in the simulation. The non-uniform solar energy flux density distribution in the receiver is also calculated, which can be used to investigate the complex coupled heat transfer process of the system for further study later.

Design and dynamic simulation of a novel polygeneration system fed by vegetable oil and by solar energy

Energy Conversion and Management, Volume 60, August 2012, Pages 204-213

Francesco Calise, Adolfo Palombo, Laura Vanoli

Abstract

In this paper the integration of vegetable oil-fed reciprocating engines with solar thermal collector is investigated, seeking to design a novel polygeneration system producing: electricity, space heating and cooling and domestic hot water, for a university building located in Naples (Italy), assumed as case study. The polygeneration system is based on the following main components: concentrating parabolic trough solar collector, double-stage LiBr–H2O absorption chiller and a reciprocating engine fed by vegetable oil. The engine operates at full load producing electrical energy which is in part consumed by the building lights and equipments, in part used by the system passive loads and the rest is eventually sold to the grid. In fact, the engine is grid connected in order to perform a convenient net metering. The system was designed and then simulated by means of a zero-dimensional transient simulation model, developed using the TRNSYS software. The simulation tool developed by the authors allows one to analyze the results for different time basis (minutes, days, weeks, months and years), from both energetic and economic points of view. The economic results show that the system under investigation is profitable, especially if properly funded.

Comparative life cycle assessment of thermal energy storage systems for solar power plants

Renewable Energy, Volume 44, August 2012, Pages 166-173

Eduard Oró, Antoni Gil, Alvaro de Gracia, Dieter Boer, Luisa F. Cabeza

Abstract

The present work compares the environmental impact of three different thermal energy storage (TES) systems for solar power plants. A Life Cycle Assessment (LCA) for these systems is developed: sensible heat storage both in solid (high temperature concrete) and liquid (molten salts) thermal storage media, and latent heat storage which uses phase change material (PCM). The aim of this paper is to analyze if the energy savings related to the stored energy of the different systems are enough to balance the environmental impact produced during the manufacturing and operation phase of each storage system. Some hypothetical scenarios are studied using LCA methodology to point out the differences between each TES system.

The system based on solid media, due to his simplicity, shows the lowest environmental impact per kWh stored of all three systems compared. In addition, the liquid media (molten salts) shows the highest impact per kWh stored because it needs more material and complex equipment.

A review on solar-powered closed physisorption cooling systems

Renewable and Sustainable Energy Reviews, Volume 16, Issue 5, June 2012, Pages 2516-2538

H.Z. Hassan, A.A. Mohamad

Abstract

Cooling, refrigeration, and air conditioning processes are considered essential needs and major requirements for all human beings in our world today. However, the traditional vapor compression machines are dominating electricity consumers and their operation and propagation cause high electricity peak loads during the summer, especially in

those countries with tropical climate. That is besides their refrigerants having high global warming as well as ozone layer depletion potentials. Providing cooling by utilizing a green energy such as solar energy is the key solution to electricity and pollution problems. Adsorption refrigeration systems that are driven by solar energy are mature technologies. They are proven to be suitable and applicable for refrigeration as well as air-conditioning applications. Solar adsorption cooling technology is divided into physisorption and chemisorption systems. The physisorption machines include open and closed cycle operation. This paper presents a review on previous researches and developments of the solar driven closed physisorption refrigeration systems. The discussion includes, experimental and numerical simulation studies as well as methods that are suggested to improve the system performance.

An empirical examination of the development of a solar innovation system in the United Arab Emirates

Energy for Sustainable Development, Volume 16, Issue 2, June 2012, Pages 179-188

Georgeta Vidican, Lisa McElvaney, Diana Samulewicz, Yasser Al-Saleh

Abstract

We apply the sectoral innovation systems (SIS) approach to analyze the emergence of a solar energy sector in the United Arab Emirates (UAE), a hydrocarbon-rich Middle Eastern nation with limited industrial and technological capabilities. Using qualitative research, we examine two research questions: (1) What is the current performance and functional patterns within the emerging solar system of innovation (SI), and (2) What are the main factors that have the potential to either sustain or potentially undermine the development of a SI in the country? Our analysis contributes to the literature in several ways. While earlier studies have focused on how the innovation process evolved in retrospect, our analysis of an emerging SI allows us to examine the current forces behind the creation of a new renewable energy industry. Our empirical examination of the UAE solar energy sector also reveals the prevalence of several blocking mechanisms, as well as a few factors that could facilitate the 'catching-up' process for the UAE solar SI, currently at its formative stage of development. These research findings may also be relevant to other Middle Eastern countries which seek a competitive position in the renewable arena but are currently in early stages of industry development.

Production Hall and Inventory Shade Lighting by Solar Energy System and Economical Lighting (LEDs)

Energy Procedia, Volume 14, 2012, Pages 1811-1818

Ahmad K. Jassim, Fouad K. Abood

Abstract

Due to the increasing energy and environmental concern in the world, one must look for alternatives to nonrenewable energy resources and the polluting fossil fuels. The renewable energy sources play an important role in electricity generation as well as many other useful applications. Various renewable energy sources like wind, solar, geothermal, ocean thermal and biomass can be used for generating electricity and meeting our daily energy demands. The solar energy can produce most of the world's requirements of the energy that is produced by the sun and collected on earth. Clean and sustainable energy protect our environment. The solar energy system with economical lighting (LEDs) can be used for lighting the production hall and inventory stores to reduce the energy consumption (watts) to less than a quarter of the normal consumption (high pressure, light HPL) and that will reduce the cost of energy. In addition, using the sun tracker will increase the efficiency of overall daily output of the solar panels more than 34% of the fixed panel. This will make the system more reliable and more economical.

Incorporating shading losses in solar photovoltaic potential assessment at the municipal scale

Solar Energy, Volume 86, Issue 5, May 2012, Pages 1245-1260

Ha T. Nguyen, Joshua M. Pearce

Abstract

Recently several algorithms have been developed to calculate the solar photovoltaic (PV) potential on the basis of 2.5D raster data that can capture urban morphology. This study provides a new algorithm that (i) incorporates both terrain and near surface shadowing effects on the beam component; (ii) scales down the diffuse components of global irradiation; and (iii) utilizes free and open source GRASS and the module r.sun in modeling irradiation. This algorithm is semi-automatic and easy to upgrade or correct (no hand drawn areas), open source, detailed and provides rules of thumb for PV system design at the municipal level. The workflow is pilot tested on LiDAR data for 100 buildings in downtown Kingston, Ontario. Shading behavior was considered and suitable roof sections for solar PV installations selected using a multi-criteria objective. At sub-

meter resolution and small time steps the effect of occlusion from near object was determined. Annual daily horizontal irradiation values were refined at 0.55 m resolution and were shown to be lower than those obtained at 90 m by 30%. The robustness of r.sun as capable of working with different levels of surface complexity has been confirmed. Finally, the trade off of each computation option (spatial resolution, time step and shading effect) has been quantified at the meso scale, to assist planners in developing the appropriate computation protocols for their regions.

An analysis of solar energy and irrigation systems in Turkey

Energy Policy, Volume 47, August 2012, Pages 478-486
Ramazan Senol

Abstract

Pumping water is considered a common need all around the world. Standalone PV technologies are being increasingly used for midsize pumping applications. PV powered pumping systems offer simplicity, reliability, and low maintenance for irrigation systems. PV powered pump is particularly appropriate for water supply in remote areas where no electricity grid is available. In this paper, the technical and economical feasibility of photovoltaic pumping of water in Turkey has been studied. Here, the study has focused on small and medium-size mobile applications using energy and water-conserving forms of drip irrigation to apple orchard on up to 0.5 ha of land in Eλrdir District. Life cycle cost (LCC) method has been applied to determine the economic life of the PV modules, and the diesel pumping in Turkey taken as 25 years.

Effect of flow distribution on the photovoltaic performance of a building integrated photovoltaic/thermal (BIPV/T) collector

Solar Energy, Volume 86, Issue 5, May 2012, Pages 1518-1530
F. Ghani, M. Duke, J.K. Carson

Abstract

The phenomenon of non-uniform flow distribution and its influence on thermal performance within a traditional solar thermal collector is well known. Its effect on the photovoltaic conversion of a hybrid photovoltaic/thermal (PV/T) collector however has received little attention. In this study an investigation has been carried out to determine what effect flow distribution will have on the photovoltaic yield of a BIPV/T collector of various size. A three step numerical analysis was conducted to model flow distribution, temperature variation, and photovoltaic yield for a PV/T collector of various design (manifold sizes), geometric shape (aspect ratio), and operating characteristics (mass flow rate and flow direction in manifolds) in order to vary flow uniformity within the collector. The results revealed that flow distribution within the collector will have a significant influence on the photovoltaic performance of a hybrid PV/T collector. For the scenario where flow distribution was most uniform, photovoltaic performance was improved by over 9% in comparison to a traditional photovoltaic (PV) collector operating under the same conditions. For poor flow however, performance was only improved by approximately 2%. Parameters found to influence flow distribution include the manifold to riser pipe ratio where a ratio of 4:1 was found to be ideal and that increasing to a 6:1 ratio offered negligible improvement. Additionally it was found that array geometry (characterised by its aspect ratio in this study) plays an important role on both flow distribution and photovoltaic yield. This study has identified that the optimal mass flow rate is dependent on the shape or aspect ratio of the array.

Modeling of the photovoltaic cell circuit parameters for optimum connection model and real-time emulator with partial shadow conditions

Energy, Volume 42, Issue 1, June 2012, Pages 57-67
Riad Kadri, Horia Andrei, Jean-Paul Gaubert, Traian Ivanovici, Gérard Champenois, Paul Andrei

Abstract

Photovoltaic (PV) power has been successfully used for over five decades. The output characteristics of a PV array vary nonlinearly when temperature or irradiance conditions change. At the beginning of this paper, the performance of PV panel is analyzed, for parallel and series connections of solar cell elements exposed to the same light conditions and temperature by using the Brune's conditions of interconnection. Therefore the parameters of the equivalent circuits for each typical PV cell connections are characterized by a new set of matrix equations. A Lab View application is implemented to prove the theoretical models. Moreover, the grid connected PV systems have become more popular because they do not need battery back-ups to ensure maximum power point tracking (MPPT). However, partial shading is one of the main causes that reduces energy yield of PV array. In this respect, the second part of the paper refers to the influences of different irradiance conditions on the PV array performance in order to achieve MPPT under shaded array conditions. Consequently, PV array emulator is crucial for the operational evaluation of system components. The purpose of this study extension is to design and develop a new real-time emulator of PV array output characteristics based on closed-loop reference model.

Life Cycle Assessment of a ground-mounted 1778 kWp photovoltaic plant and comparison with traditional energy production systems

Applied Energy, Volume 97, September 2012, Pages 930-943

Abstract

Photovoltaic system is a technology for the production of electricity from renewable sources that is rapidly expanding thanks to its capability to reduce the energy consumption from traditional sources and to decrease the air pollution. During the operational phase, there are no emissions and the only input is represented by solar power. However, it should be noted that, considering the entire life cycle of a plant, photovoltaic systems, like any other means of electricity production, give rise to emissions, that focus especially in the manufacturing stage and installation of components.

The present work aims at evaluating the environmental impact, and therefore the actual sustainability of this technology, examining a ground-mounted 1778.48 kWp photovoltaic plant, realized by TerniEnergia S.p.A. and located in Marsciano (Perugia, Italy). The analysis is conducted using the methodology of Life Cycle Assessment (LCA), which allows to consider all stages of the life cycle, from the extraction of raw materials to the plant's disposal ("from a cradle to grave perspective"). In particular, the study takes into account the soil preparation, the installation of fence and electrical substations of low and medium voltage, the mounting of support structures, also with reference to hot dip galvanizing process, the production of modules, their installation, the wiring apparatus and the network connection. The transport of all components to the installation site is considered for each stage that is examined. The end of life scenario of the plant is also evaluated. The possibility to collect many detailed information in the construction site, during the building phase, adds value to the study. The analysis is carried out according to UNI EN ISO 14040 and UNI EN ISO 14044, which regulate the LCA procedure.

The LCA modelling was performed using SimaPro software application and using Eco Indicator 99 methodology. The results of the analysis allows to calculate some important parameters like EPBT (Energy Pay-Back Time), EROEI (Energy Return on Energy Invested), CO2 emissions and GWP100 (Global Warming Potential). Finally, the environmental impact of photovoltaic plant is compared to that of some traditional energy production systems.

Indoor and Outdoor Characterizations of Photovoltaic Module Based on Mulicrystalline Solar Cells

Energy Procedia, Volume 18, 2012, Pages 857-866

K. Agroui

Abstract

One of the main missions for the photovoltaic laboratory concerns the preparation and development of norms and standards for photovoltaic (PV) systems. To reach this objective, we have initiated a program research to identify the present of state of the art to develop specific measuring methods and test procedures for photovoltaic module and also, to develop laboratory test. Within this program we have executed since several years series of performance characterizations in indoor and outdoor testing on PV modules produced in industry and covering both series and prototype designs. This work describes the methodology, basic procedures and instrumental employed by our laboratory for the determination of photovoltaic module characteristics. According to this methodology, the main electrical and thermal parameters were determined for multicrystalline PV module under diverse conditions. The tests were based on IEC 61215 specification which had been prepared especially for this purpose and which are used as an international standard.

Real-time simulation model development of single crystalline photovoltaic panels using fast computation methods

Solar Energy, Volume 86, Issue 6, June 2012, Pages 1826-1837

Jee-Hoon Jung, Shehab Ahmed

Abstract

Real-time simulation and rapid prototyping of power electronics, critical loads, and control systems have prompted recent interest in accurate electrical terminal models of photovoltaic (PV) panels and array systems. Advancement in computing technologies, such as parallel computing and digital signal processing techniques for real-time simulations have allowed the prototyping of novel apparatus to be investigated in a virtual system under a wide range of realistic conditions repeatedly, safely, and economically. This paper accesses numerical iteration methods, selects appropriate techniques, and combines them with model construction methods well suited for boosting the computational speed of an electro-thermal dynamic model of a PV panel. The target computational engine is a parallel processor based real-time simulator to be used in a power hardware-in-the-loop (PHIL) application. Significant improvements resulting from the proposed modeling approach in computation time and numerical convergence speed are verified using experimental results for the target PV panel using Opal-RT's RT-Lab Matlab/ Simulink based real-time engineering simulator.■

ENERGY FUTURE

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SOLAR PV SIMULATION SOFTWARES

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Dr Suneel Deambi, Consultant, TERI. sdeambi@airtelmail.in

Introduction

Solar modules are exposed to outdoors all day long. These face the extremes of nature like high temperatures, wind speeds, dust and dirt accumulation, rainfall etc. A solar manufacturer rates the modules produced in a factory in terms of Watt peak under the Standard Test Conditions (STC). However, these conditions may or may not be met in an outdoor environment. Due to this the power available from the modules undergoes some change. It is mostly lower than its STC value by as much as 20%, if, not more. Thus it is of significant interest to get an idea of power derating value of the module via an energy simulation software. The software seeks the site specific values like latitude, temperature, solar insolation, wind speed, soiling factor etc.

We have so far covered various solar energy specific energy simulation packages available internationally in the previous issues of," The Solar Quarterly (old name of Future Energy magazine). In this specific issue, it has been planned to deal with PV*SOL*Expert 5.0. The progression of this level software can be seen in terms of the following few upgradations:

*PV*SOL Basic*

It is a tool basically used for PV design and sales for residential and commercial energy systems up to a limited capacity of 300 Kwp. The software has databases for climate data besides industry information for solar modules and inverters.

*PV*SOL@PRO*

It is a dynamic simulation program mainly used for design and calculation of both grid connected and off-grid solar PV systems

*PV*SOL*EXPERT*

Courtesy: Valentin Software

It is an advanced design and simulation tool, which includes 3D visualisation and 3D shading analysis. The software offers a major new feature that makes it possible for the users to visualize mounted PV systems in a 3D mode using a standard PV*SOL mounting system. The mounted systems are automatically sized to the roof. Further tools are available to optimize both the distance between the rows and the mounting angle. Further, the PVSOL standard mounting system can be edited fully. Individual rows of modules can also be edited, or added and removed in groups. These can be jointly configured to operate as sub-array.

Few more salient features of PV*SOL*Expert 5.0 are given as under:

• It is now possible to assign modules to a particular configuration across the rows

• It is possible to observe Inter-row shading so as to account for the yield simulation

• It is possible to adapt the design of mounted system to the prevailing shade conditions. It can thus ensure the best possible system yields

• It is now possible to make use of extensive module (7150) and inverter (1690) databases

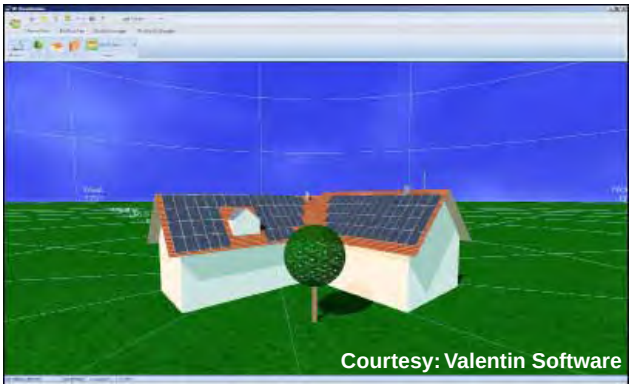
Few common questions on user's mind

A user may come up with several questions while carrying out the energy simulation exercise for a PV system. Few of the important one's are highlighted below for an easy understanding:

IS there any limit to system output in this software?

This software enables you to work out a system size up to 1 MWp.

Is it possible to plan the roof coverage for a PV system from the roof dimensions?


Courtesy: Valentin Software

Yes it is possible to find the number of modules by using the dimensions of roof. For this, you need to choose the option," Determine output from the roof surface" in the technical data window.

Is it possible to calculate the system output with a tracking feature?

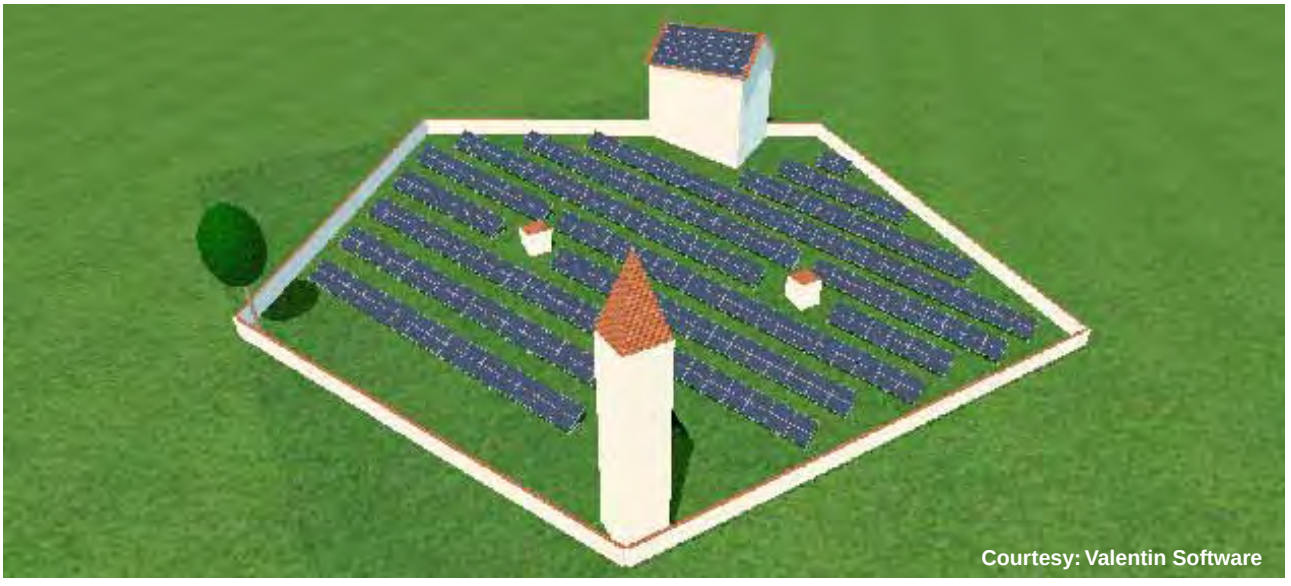
Yes, you can choose between single axis and dual axis tracking. Remember the dual axis tracking evaluates the scenario with movement of both rotation axes

Is it possible to make system simulation calculations using thin film module technologies?

Yes, it allows a user to calculate the efficiency curves for the full range of commercially available thin film technologies

Is it possible to set up a user defined," Feed-in-tariffs:"?

Feed-in-tariffs have been the key drivers to push the PV market growth significantly. FIT's as these are known vary from one country to the other and can thus be inputted as per the user choice. For this, you can choose the feed in option within the database menu and then your preferred location i.e. the country of use. Then you can go further by inserting the validity period of the tariff, etc. ■


Courtesy: Valentin Software

RENEWABLE ENERGY AT A GLANCE

S.No.	Source/system	Estimated potential	Achievement as on 31 January 2012
I	**Power from renewables**		
A	**Grid-interactive renewable power**	(MW)	(MW)
1	Wind power	45,195	16,179.00
2	Bio power (agro residues and plantations)	16,881	1,142.60
3	Bagasse cogeneration	5,000	1,952.53
4	Small hydro power (up to 25 MW)	15,000	3,300.13
5	Energy recovery from waste (MW)	2,700	73.66
6	Solar photovoltaic power	—	481.48
	Sub total (A)	**84,776**	**23,129.40**
B	**Captive/combined heat and power/distributed renewable power**		(MW)
7	Biomass/cogeneration (non-bagasse)	—	347.85
8	Biomass gasifier	—	148.26
9	Energy recovery from waste	—	92.93
10	Aero generator/hybrid systems		1.45
11	Water mills/micro hydel	—	2025 nos.
12	Solar PV power plants and street lights (>1 kW)	—	81.01
	Sub total (B)	**—**	**671.50**
	Total (A+B)	**—**	**23800.90**
II	**Remote village electrification**	—	9,009 villages/hamlets
III	**Decentralized energy systems**		
13	Family-type biogas plants	1.20 million	4.31 million
14	Solar photovoltaic systems		
	i. Solar street lighting system	—	1,22,697 nos
	ii. Home lighting system	—	6,56,707 nos
	iii. Solar lantern	—	8,17,369 nos
	iv. Solar power plants	—	2.92 MW_p
	v. Solar photovoltaic pumps		7,495 nos
15	Solar thermal systems		
	i. Solar water heating systems	140 million m^2 collector area	4.98 million m^2 collector area
	ii. Solar cookers		.66 million
16	Wind pumps		1,352 nos
IV	**Awareness programmes**		
17	Energy parks	—	511 nos
18	Aditya solar shops	—	302 nos
19	Renewable energy clubs	—	521 nos
20	District advisory committees	—	560 nos

MW – megawatt; kW – kilowatt; MW_p – megawatt peak; m^2 – square metre; km^2 – kilometre square
Source www.mnre.gov.in