naturally in the Earth's atmosphere, it is also one of the greenhouse gases that trap heat in the atmosphere. At the same time, burning methane produces far less carbon dioxide in comparison to the burning of coal or oil.

In an April 2004, in the Meeting of the Agricultural Sub-Committee of the MNRE, in a presentation on the advantages of setting up biogas plants across rural India—one of the biggest features that came across was the its efficiency as well as return on investment. The presentation spoke about the merits of building household biogas plants that took in cattle manure and vegetable waste—usually let to decay in extremely unhygienic conditions in most parts of rural India.

Case studies conducted nearly 15 years ago show that even though a small- to medium-sized biogas plant produced only 5 to 25kW power, it is sufficient to meet the requirements of a small village. Another case study of the 1 MW cattle manure-based biogas plant in Ludhiana showed that the plant load factor (which in simple terms means a power plant's efficiency even though it does not function at full capacity) is around 90%.

Apart from that, it produced 21000 kWh and about 70 tonnes per day of organic manure from 235 TPD of cattle refuse.

These numbers—from a time when technology was not so advanced—show how much of untapped potential there is in just organic waste.

The Great Indian Challenge

In India, despite the staggering numbers of waste generated, the waste-to-energy ratio is abysmal due to multiple factors. And it begins with the improper disposal and lack of due segregation.

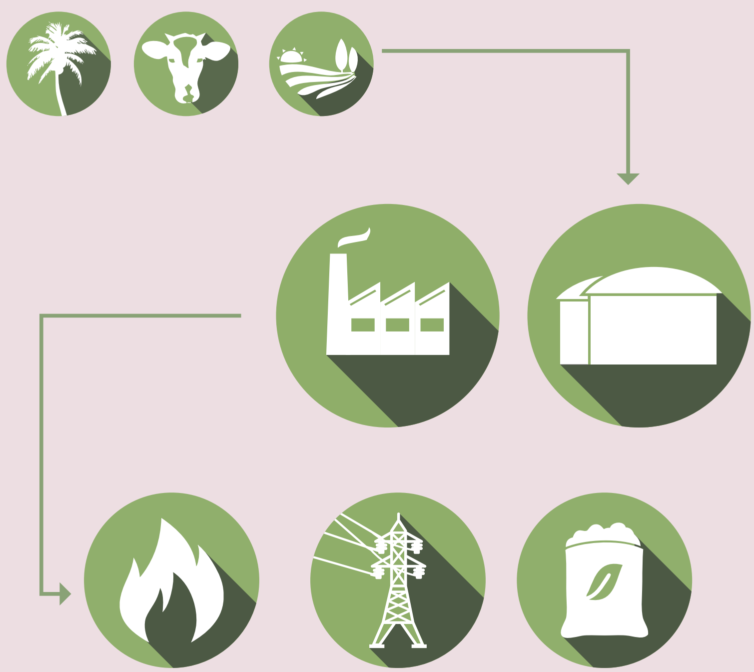
Take for example the case of the first ever waste-to-energy plant set up in Timarpur, New Delhi. Even though the plant had the capacity to process 300 tonnes of waste per day, the plant has not been efficient, and, for the past decade, has been embroiled in a controversy; it has also become the bane of existence for residents in nearby areas. Even as the capital looks at the opening of its third and the largest ever waste-to-energy plant, the Timarpur plant faces serious flak due to untested technology used for incineration as well as not meeting pollution control norms while being operational.

And the most important and perhaps, most overlooked part of this failure has been the incapacity to segregate waste at the source. Despite the government's repeated campaigns, what should have been a harbinger of a new-age in the capital's power woes, became a nightmare for the Delhi government due to repeated and continuous litigations.

According to the statistics acquired from the Planning Commission (now NITI Aayog), Delhi had three MSW processing units in 2011, but not one of them had composting or vermicomposting or biomethanation or even palletization. The only waste-to-energy method was incineration.

In India there are several megacities: Mumbai with over 18 million population, Delhi with its 16.3 million residents, Kolkata (14.1 million), Chennai (8.6 million), Bengaluru (8.4 million), Hyderabad (7.7 million), and Ahmedabad (6.3 million) are just some of the Indian megacities. And yet not many of these cities have an efficient solid waste management programme in place. Worse yet, the segregation at source is non-existent, and those who earn their livelihood by segregating the recyclables at garbage dumpsites—before they make their way to the landfills—are also prosecuted now for doing something for everyone's benefit. Waste segregation at source is a distant dream, let alone being the first step towards waste-to-fuel efficiency.

While the Centre has run multiple long-term campaigns about Swachh Bharat, the basic awareness that 'cleanliness' is not just personal hygiene but also a community cleansing campaign has been completely disregarded. The mandate of segregating waste at source is not executed properly which is probably why almost 80% of waste, just in the national capital region, that goes to the landfills can be recycled. However, the local civic bodies have done away with 'ragpickers' who had been one of the



best sieves to have taken out at least a percentage of the recyclable waste that goes to landfills.

Even while the central government is trying to reclaim landfills in over 20 cities, while not letting newer ones spawn, the current ones are running in critical condition in most places. In India, like many developing nations, waste is dumped rather than managed. This kind of dumping has several adverse impacts—the recent and frequent reports of lakes being on fire in Bengaluru and increasing incidents of water-borne and parasite-borne diseases in Mumbai and Delhi are just some of those impacts.

The environmental and public health issues that grow from improper disposal of waste is not something that no one knows; it's just that everyone chooses to ignore it. One such big, but long-term impact than everyone has turned a blind eye to is methane production in open dumps—methane released from decomposition of organic waste is a ticking bomb, quite literally. Methane is combustible, and this can cause fires and explosions. It also happens to be a greenhouse gas and more potent than carbon dioxide because its heat holding capacity is four times that of carbon dioxide.

In Mumbai, every year open burning of waste releases about 22,000 tonnes of pollutants into the atmosphere. Apart from the general issues of odour from untreated and unmanaged waste, there are the invisible and non-olfactory problems associated with the traditional waste dump grounds that have been converted to landfills in India. Decomposition of organic and biodegradable waste not just releases methane into the atmosphere, it also releases, at times, toxic leachates into the ground—which have the potential to contaminate ground water.

However, these impending waste-led doomsday announcements are not new. The challenge that presents itself to the Centre is a thought-through policy and its stringent implementation. Apart from that, the procurement of technology that can help solve the existing waste management issue is capital heavy—the policymakers need to see that it is a long term investment and not a one-time buy, because the waste is here to stay, and breed a very unhappy, dirty, and unhealthy nation.

Further Reading

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THE ADOPTION OF JOULE AS ENERGY UNIT

Though the Joule, a unit of work or energy in the International System of Units (SI), is hardly used in India, there are strong grounds for adopting it as the principal energy unit, from legal, practical, and policy perspectives. **Vijay S Laghate**, through this article, advocates for the adoption of Joule as a standard unit of measurement of energy.

Introduction

India's energy sector comprises a significant feature of the country's growth trajectory since utilization of energy is directly connected to the progress of manpower with ever growing population, improvement in the standard of living, and industrialization of the developing countries. However, a major difficulty with understanding the energy sector is that it uses many different measurement units. The calorie is used to define the calorific value of fuels. The British thermal unit (Btu) is used in the natural gas sector, to define price and measure quantities transacted. For larger quantities, such as national production or reserves, the units used are million tonnes of oil equivalent, billion cubic metres, trillion cubic feet, tera watt hours, etc.

National statistics report gas imports in metric tonnes and consumption in cubic metres. Multiple energy units are used even in the same sentence: a purchase tender seeks supply of '10,394,091 mm Btu of Natural Gas at GCV of 9880 Kilo calories/sm3 …'. This is like asking for supply of ten million pounds of cement in 50 kg bags! Any analysis or discussion requires preparatory calculations to convert the data to a common unit. If the sector adopts a single unit of energy for all its data, conversion factors will not be required. In addition to simplifying day-to-day operations, it will lead to acquiring a better understanding of the energy sector which will facilitate policy formulation and decision making.

As explained by the Government of India's Central Statistics Office (CSO), "For more meaningful comparison in the trends and patterns of growth of different energy resources, it is desirable to convert all the resources to their energy equivalents by applying appropriate conversion factors and express them in energy units (Joules/ Peta Joules/ Tera Joules)".[1]

National and International Compliance

Compliance with Indian law

In fact, Joule is the only unit prescribed for measuring energy, under the Legal Metrology Act ("LM Act") and the Legal Metrology (National Standards) Rules ("LMNSR"), which came into force in April 2011.

Section 4 of the LM Act requires that: "Every unit of weight or measure shall be in accordance with the metric system based on the international system of units." This provision disallows non-metric units, such as the Btu.

Sections 10 and 11 of the LM Act require that the prescribed units shall be used for all transactions, for pricing, for indicating quantities, and for publishing any documents. The Second Schedule of the LMNSR prescribes that: "The unit of energy, work and quantity of heat shall be the joule. (Symbol: J)".[2] Also, "The unit of specific energy shall be the joule per kilogram",[3] and "The unit of energy density shall be the joule per cubic metre."[4] Section 13 of the same Rules prohibits the use of any other units. Thus, calorific values should not be given in calories per kg (coal) or calories per cubic metre (natural gas).

The LMNS Rules acknowledge the calorie to be a metric unit, but "outside the International System" (Eighth Schedule). Hence, it "shall not ordinarily be used except for the purpose of scientific and technological research and no such unit shall ordinarily be used for the purpose of imparting education" (Sec 18).

In sum, the law requires the use of only the Joule, and not the Btu or calorie. No leeway is available, since Section 3 of the LM Act states that it overrides the provisions of any other law.

Compliance with UN recommendations

An important endorsement for the Joule comes from the United Nations Statistical Commission, whose document the "International Recommendations for Energy Statistics" (IRES) provides the "internationally agreed standard for energy statistics"[5] in an effort towards involved 35 countries (including India) and over 20 international energy organizations as well as OPEC, World Coal Institute, International Monetary Fund, The World Bank, etc.

All countries are expected to adopt the UN IRES.

The relevant recommendations are:

» "The only energy unit in the International System of Units is the joule and it is usually used in energy statistics as a common unit, although other energy units are sometimes also applied (e.g. 'toe', GWh, Btu, calories, etc.). The use of the joule as a common unit is recommended."[6]

» "Calorific values or heating values of a fuel express the heat obtained from one unit of the fuel. … (they) should preferably be in terms of joules … per original unit, for example gigajoule/ metric ton (GJ/t) or gigajoule/ cubic metre (GJ/m3)."[7]

» Data about Gases (eg. Natural Gas) should be disseminated in terms of Energy, in terms of Joules.[8]

The first two recommendations vindicate the stance of Indian laws. The third recommendation is a logical corollary.

Joule—The Undisputed Choice

At this juncture, let us learn about the use of Joule as a practical choice for measuring energy.

Easy handling of large quantities

Though the Joule is a small quantity of energy, it is possible to describe any magnitude all the way up to global consumption, by use of the prefixes framed under the International System of Units (Table 1).

These terms have legal sanction in India, as they appear in the LMNSR (Third Schedule).

Deficiencies in Calorie and Btu

Table 2 explains the energy units. Both the calorie and the Btu have multiple

Table 1: Prefixes framed by the International System of Units for indicating magnitudes

Amount in words	Amount in numbers	Prefix	Name and Abbreviation	
One	1	..	Joule	J
Thousand	1000 = 10 ^ 3	kilo	kilo Joule	kJ
Million	1,000 kilo = 10 ^ 6	Mega	Mega Joule	MJ
Billion	1,000 Mega = 10 ^ 9	Giga	Giga Joule	GJ
Trillion, or thousand billion	1,000 Giga = 10 ^ 12	Tera	Tera Joule	TJ
Quadrillion, or thousand trillion	1,000 Tera = 10 ^ 15	Peta	Peta Joule	PJ
Quintillion, or thousand Quadrillion	1,000 Peta = 10 ^ 18	Exa	Exa Joule	EJ

The prefix changes in steps of 1,000. The sequence of increasing magnitude k-M-G-T-P-E may be remembered with help of a mnemonic: "Kids May Go To Play Early"

definitions, which cause confusion. The data book, India Petroleum & Natural Gas Statistics 2016-17 ("PNGS"), published by Ministry of Petroleum and Natural Gas, lists three variants of the calorie – and all are defined in terms of Joules. The energy sector uses the 'International Table' (IT) variants of the calorie and Btu.

The Btu is defined in terms of non-metric units - pounds, degrees Fahrenheit and square inch – all prohibited in India. Yet, the Btu is widely used by the gas sector in India.

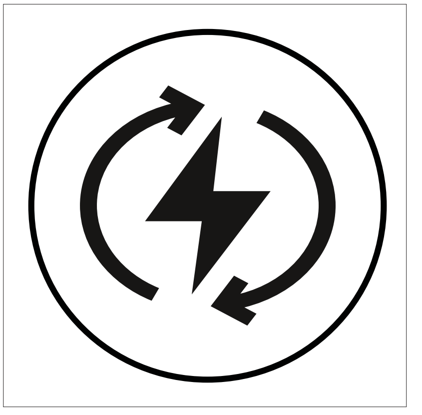
The Btu is often used with the prefix mm, as in mmBtu, which denotes one million Btu. This is confusing, since 'mm' usually means 'millimetre'. Normally, million is represented by the capital letter M, as in MW for Mega Watt.

In contrast, the Joule is defined in clear scientific terms. It is great advantage is that it is a 'neutral' unit, not connected to any particular source or form of energy.

Comparison with other Energy Units

Since crude oil is the principal source of energy for the world, it is often used to express total energy supply from all sources in terms of the Oil Equivalent (Table 3, A row). Many international organizations and countries, including India, use the 'toe' for aggregating energy data. Reserves of Natural Gas are also described in Billion Cubic Metres ("BCM") or Trillion Cubic Feet ("TCF"). LNG volumes are often reported in million tonnes. Coal data is given in Tonnes of Coal Equivalent ("tce"). Electrical energy is given in Watt hours.

It is worth noting that all these get defined in terms of the Joule, either via the calorie or directly. Though the visible unit is 'toe', the underlying unit is the Joule.



In future, the 'toe' will become outmoded, since climate change issues are forcing a global reduction in consumption of fossil fuels, including oil. The Joule is a suitable replacement, as it is neutral to energy sources or forms. A precedent does exist for replacing

Table 2: Understanding Energy units

Calorie	Heat required to raise temperature of one gram of water by 1 degree Centigrade. Variants: From PNGS Appendix VIII, page 193 1 calorie (Thermochemical) = 4.184 J 1 calorie (15 deg) ≈ 4.1855 J 1 calorie (International Table) = 4.1868 J – also given in Eighth Schedule of LMNSR 1 kilo calorie = 4.1868 kJ 10,000 kilo calorie = 41.868 x 1000 kJ = 41.868 MJ
British thermal unit (Btu)	"The quantity of heat required to raise the temperature of 1 pound of pure water from 59 degrees Fahrenheit to 60 degrees Fahrenheit at an absolute pressure of 14.696 pounds per square inch"[9] Commonly used: 1 Btu = 1,055.06 Joules = 1.055 kJ 1 mmBtu = 1 million Btu = 1 million x 1.055 kJ = 1.055 GJ
Joule (J)	Energy imparted to (or Work done on) an object when a force of one Newton acts on that object in the direction of its motion through a distance of one Metre. 1 Newton = the force that gives a mass of one kilogram an acceleration of one metre per second per second.

one energy unit by another; the IRES says: "In the past, when coal was the principal commercial fuel, the ton of coal equivalent was commonly used as an energy unit. However, with the increasing importance of oil, it has been replaced by the ton of oil equivalent."[10].

Some countries consolidate national energy data in terms of Watt-hours. As this unit is used globally for measuring electrical energy, this method gives undue prominence to one form of energy, which meets just one-fifth of world demand. The neutral Joule should be preferred, which can easily express electrical energy (Table 3 para E).

Usage of Joule in India and internationally

India participated in the IRES work through the CSO. Its annual compilation of national Energy Statistics uses the Joule for reporting:

» Total Production of Energy by Commercial Sources, total consumption of energy per capita energy consumption, and Energy Intensity.[11]

The Coal Ministry's Coal Directory also presents data in Peta Joules for production of primary sources of commercial energy[12]. The PNGS data book, Ministry of Petroleum & Natural Gas, mentions the Joule in conversion tables, but does not use it.

In the European Union, members must statutorily report energy data in Joules, and calorific value in Joules per unit.[13] Table 4 is an extract from

Table 3: More Energy Units in terms of Joules

Conversion norms drawn from the Appendices in the PNGS book. The mnemonic 'Kids May Go To Play Early' helps to understand this table.

A] Crude Oil, and Oil Equivalent	Oil Equivalent is based on a notional crude oil having calorific value of 10,000 kilocalories/ kg. 1 kg Oil Equivalent = 1 kgoe = 10,000 kilocalories = 41.868 MJ. 1 Tonne Oil Equivalent or 1 'toe' = 1,000 kgoe = 41.868 GJ.
B] Natural Gas volumes in sm3, BCM and TCF	Energy content varies with gross calorific value (GCV) ; if it is 10,000 kcal/sm3, 1 sm3 of gas = 41.868 MJ energy. 1,000 sm3 = 41.868 GJ energy 1 mil sm3 = 41.868 TJ energy 1 BCM = 1 Billion Cubic Metres = 1,000 mil sm3 = 41.868 PJ energy 1 TCF gas = 1 trillion cubic feet= 1000 billion cubic feet. Since 35.31 cubic feet make one cubic metre, 1 TCF= 1000/35.31 BCM = 28.32 BCM. 1 TCF = 28.32 x 41.868 PJ = 1,186 PJ of energy.
C] LNG in tonnes	1 tonne LNG = 1,314 sm3 after re- gasification. At GCV of 9,880 kcal/sm3, energy content of 1 tonne LNG is 1314 sm3 * 41.868 x 0.988 MJ/sm3 = 54,354 MJ = 54.35 GJ 1,000 tonnes of LNG = 1,000 x 54.4 GJ = 54.4 TJ 1 mil tonnes of LNG = 1 million x 54.4 GJ = 54.4 PJ
D] CNG Compressed Natural Gas	CNG obtained from Regasified LNG will have same energy content. So, 1 tonne of CNG = 54.4 GJ 1,000 tonne CNG = 54.4 TJ = 0.054 PJ
E] Electrical energy kWh	1 Watt of electrical power applied for 1 second is defined as 1 Joule of energy. 1 watt-second of electricity = 1 Joule of energy 1 watt-hour = 1 watt x 1 hour = 3600 watt-seconds = 3600 Joules = 3.6 kJ 1 kilowatt-hour = 1,000 watt-hours = 3.6 MJ. 1 MWh is 1,000 kWh = 3.6 GJ.

Statistical Pocketbook 2017 about EU Energy. Note that the kgoe data is based on the Oil Equivalent defined in eleventh row in terms of kJ.

As regards Natural Gas, the same EU regulation requires that [14]"Quantities of natural gas shall be declared by its energy content, i.e. in Tera Joules, based on the gross calorific value. Where physical quantities are required, the unit is in 10^6 m^3 (at reference gas conditions) ... "Calorific values shall be declared in kJ/m^3 ... "Peak output, Regasifying and Liquefying Capacity shall be declared in 10^6 m^3 /day ... " (for LNG terminals)

Thus, EU regulations conform to UN IRES recommendations. Also, LNG terminals must use a common unit, to describe their operations; in contrast, Indian terminals use one unit for capacity (million metric tonnes) and another for regasification output (trillion Btu).

Similar provisions are given in the Energy Statistics Manual, which guides member countries of the International Energy Agency, European Union, and OECD on how to report energy data. [15] Thus, IEA reports calorific value of gas in kilo Joules/sm^3 (Table 5).[16]

Table 4: EU Energy 2017 - Calorific values in kilo Joules

Appendix 11 - Average Calorific Values			
	Energy Content		
		KJ (NCV)	**kgoe (NCV)**
Hard Coal	1 kg	17 200 - 30700	0.400 - 0.733
Recovered Hard Coal	1 kg	13800-28303	0.330-0.676
Patent Fuels	1 kg	26800 - 31 400	0.640 - 0.750
Hard Coke	1 kg	28500	0.681
Brown Coal	1 kg	5 600 - 10500	0134 - 0.251
Black Lignite	1 kg	10500 - 21 000	0.251-0.502
Peat	1 kg	7800-13800	0.186-0.330
Brown Coal Briquettes	1 kg	20000	0.478
Tar	1 kg	37 703	0.900
Benzol	1 kg	39500	0.943
Oil Equivalent	1 kg	41868	1
Crude Oil	1 kg	41600-42800	0.994–1.022
Feedstocks	1 kg	42 500	1.015
Refinery Gas	1 kg	50000	1.194
LPG	1 kg	46000	1.099
Motor Spirit	1 kg	44000	1051
Kerosene, Jet Fuel	1 kg	43000	1.027
Naphtha	1 kg	44000	1.051
Gas Diesel Oil	1 kg	42 300	1.010
Residual Fuel Oil	1 kg	40000	0.955
White Spirit	1 kg	44000	1051
Lubricants	1 kg	42 300	1.010
Bitumen	1 kg	37 700	0.900
Petroleum Cokes	1 kg	31 400	0.750
Other Petro Products	1 kg	30000	0.717
Electrical Energy	1kWh	3600	0.086

Table 5: IEA - Calorific values of Natural Gas in Joules/m^3

Top ten producers in 2016	**kJ/m^3**
United States	38267
Russian Federation	38230
Islamic Republic of Iran	39356
Canada	39040
Qatar	41400
People's Republic of China	38931
Norway	39275
Algeria	39565
Saudi Arabia	38000
Australia	39028

Note: To calculate the net calorific value, the gross calorific value is multiplied by 0.9

As India is now an 'Association member' of IEA, it will have access to IEA methodologies.

The Joule in Natural Gas Transactions

In India, Natural Gas was earlier priced in /sm^3 and supplied in cubic metres, with calorific values defined in kcals/sm^3, thus remaining within the metric system. In 2007, Government adopted the mmBtu for pricing gas produced in India. Consequently, the industry started using the mmBtu for measuring gas quantities, and for pricing activities such as regasification, transmission, etc. Effectively, the gas sector went back to the non-metric system which India had abandoned in the 1950s.

The matter may be easily corrected if Government declares domestic gas prices in Joule terms. Presently, the concerned notifications[17] require price to be declared in "US$ per MMBTU". This may be replaced by "$/GJ". No change is required in the methodology for determining prices; the final number may be converted from $/mmBtu to $/

GJ by dividing by 1.055 (ref Table 2 row 2). Thus, price in India will comply to Indian law, and match UN IRES.

Applying this to gas produced in India during October 2018–March 2019, the declared prices of $ 3.36/ mmBtu and $ 7.67/mmBtu (difficult fields) will become $ 3.18/GJ and $ 7.27/GJ, respectively. They are lower than the mmBtu rates, because the GJ is 5.5% smaller than the mmBtu. Correspondingly, gas supplies in mmBtu will be 5.5% larger when expressed in GJ. The change from Btu to Joule has no commercial implications. Industry will adapt to the Joule, just as it did to the Btu.

Calorific values should also change from kilocalories to Mega Joules MJ, using the conversion factor 1 kcal = 4.1868 kJ, from Table 3, row B2. Thus, a gas with calorific value of 9,880 Kcal/sm3 will be described as 41.366 MJ/sm3; this may be rounded to 41.4 MJ/sm3, which is higher by a negligible 0.08%.

An illustration of replacing Btu and calories by Joules

With this background, we can revisit the Natural Gas tender mentioned earlier that used two energy units simultaneously: "…10,394,091 mmBtu at GCV of 9880 Kilo calories/sm^3". It can be re-written as: "10.966 Peta Joules at GCV of 41.4 Mega Joules/sm^3".[18]

This simplification enables easy calculation of the volume of gas required; dividing the energy required (PJ) by energy content (MJ/ sm3) gives the answer as 265 million sm3.[19] No conversion formulae required, only magnitudes have to be taken care of, using the mnemonic in Table 1.

Thus, there are practical advantages in replacing the Btu and Calorie by the Joule in commercial transactions.

Benefits of using Joules for National Gas data

The national gas data published in government handbooks uses multiple units. We now show that additional insights become available when this data is expressed in a common unit of Joules.

Table 6 collates official data; it is given in three different units (cubic metres, cubic feet, and tonnes). These are converted, assuming GCVs as indicated; those with access to actual GCVs can prepare more accurate data.

Once all the data is in Peta Joules, many hidden relationships become visible, or easier to grasp:

- Reserves can meet about 25 years requirements at present level of consumption,
- Prognosticated CBM resources are twice as large as conventional Reserves,
- Established CBM resources are five times present consumption.
- Implication: CBM should be given high priority
- Imports and production are at similar levels,

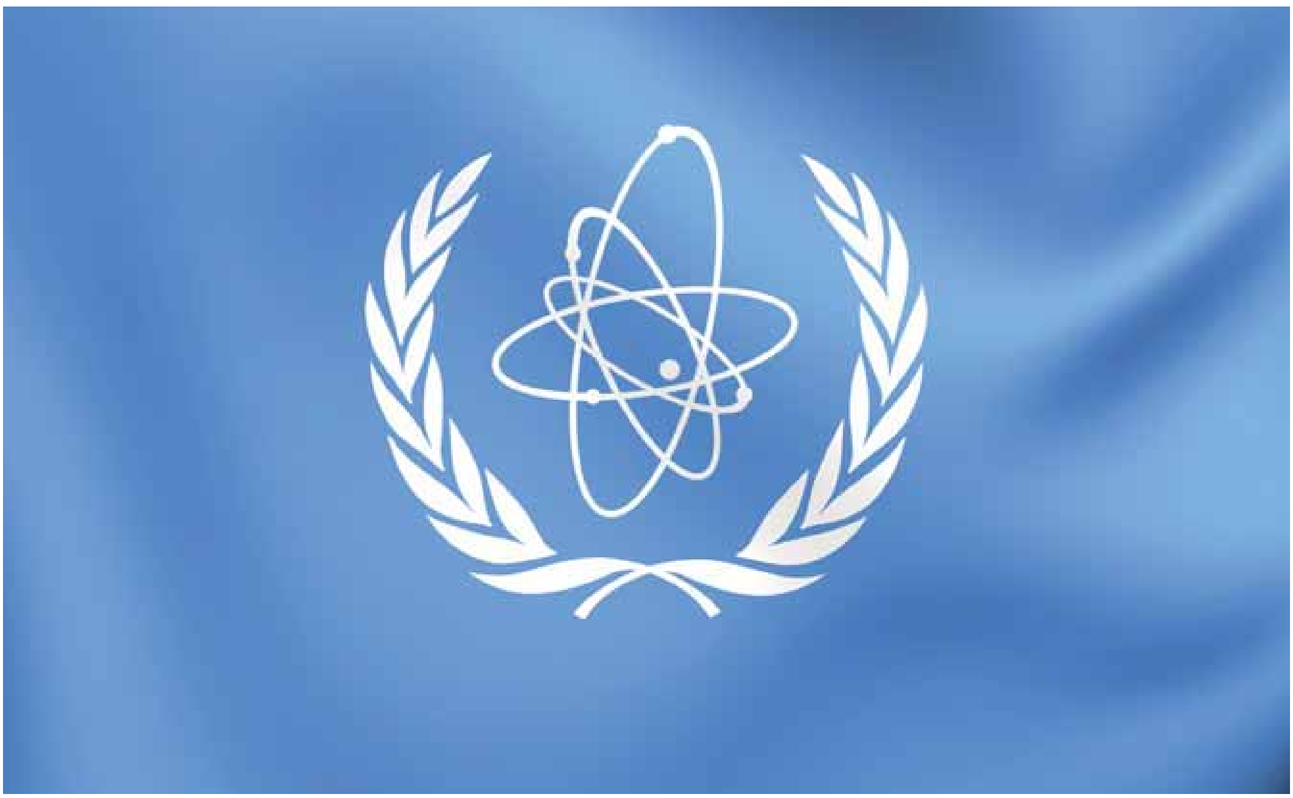


Table 6: Natural Gas Sector India - data for 2016-17 in Joules

Data from PNGS pages 10, 34 & 46, and Petroleum Planning and Analysis Cell Ready Reckoner March 2018 ("RR") page 15								
Aspect	**Base Data**		**GCV of Natural Gas**		**Data in Peta Joules**		**Source**	**Conversion factor Table 3**
	Units	**Quantity**	**kcal/sm^3**	**kJ/sm^3**	**Units**	**Quantity**		
Reserves	BCM	1289.81	9,200	38,519	PJ	49,682	PNGS	B – 4
CBM resources								
Prognosticated	TCF	92	8,500	35,588	PJ	92,724	RR	B – 5
Established	TCF	9.9	8,500	35,588	PJ	9,978	RR	B – 5
Consumption	mil sm^3	50,778	9,500	39,775	PJ	2,020	PNGS	B - 3
Net Production (Sales)	mil sm^3	24,992	9,200	38,519	PJ	963	PNGS	B – 3
LNG imports	'000 mts	18,631	9,880	41,366	PJ	1,013	PNGS	C – 2
LNG terminals capacity	Mil tpa	26.7	9,880	41,366	PJ	1,451	RR	C– 3
Gas Pipelines capacity	mil scmd	345.62	9,500	39,775	PJ/day	13.7	PNGS	B – 3
Gas Pipelines throughput	mil scmd	151.35	9,500	39,775	PJ/day	6.0	PNGS	B– 3
Gas Pipelines capacity annualised (350 days)	mil sm^3	120,967	9,500	39,775	PJ	4,811	Derived	B – 3
CGD Sales	mil sm^3	7,350	9,500	39,775	PJ	292	PNGS	B – 3
CNG Sales	'000 mts	2,366	9,500	39,775	PJ	124	PNGS	C – 2
PNG Sales	No data in PNGS or RR				PJ	169	Derived as CGD less CNG	

» LNG terminals have enough capacity to support 40% more imports,

» Capacity of gas pipelines is more than double the present consumption,

» Significant spare capacity in both LNG terminals and pipelines indicates the potential for increasing gas sales by importing more.

» PNG sales are not given in Base data; it can now be estimated at 169 PJ, as the difference between CGD and CNG.

Thus data presented in a common energy unit significantly improves the understanding of the sector.

The Way Forward

Since Joule is the prescribed energy unit by law, the calorie and Btu need to be discontinued. As custodian of the Legal Metrology Act, the Ministry of Consumer Affairs, Food & Public Distribution, may need to take the initiative in ensuring compliance from Government, industry and commerce. The CSO, which had participated in UN IRES preparation, can provide valuable guidance.

The related Ministries and regulatory authorities should ensure that each concerned entity reports its data in the statutory unit of Joules.

All stakeholders need to come together to prepare a transition path. For example, all new documents may be prepared in terms of Joules, mentioning prevailing units also; for existing documents, conversion guides or revisions may be issued. Old and new units may continue in parallel for some time, after which old units are discontinued. The Ministry of Petroleum and Natural Gas has an important opportunity to adopt the Joule as the authorised unit in the Gas Trading Exchange that it is setting up shortly.

Endnotes

1 Chapter 3, para 3.1, page 31, Energy Statistics 2018 Annual Data book. CSO: Ministry of Statistics and Programme Implementation.

2 Sl.10, Part II, Second Schedule, Legal Metrology (National Standards) Rules, 2011.

3 Sl. 6, Part III, Second Schedule, Legal Metrology (National Standards) Rules, 2011.

4 Sl. 8, Part III, Second Schedule, Legal Metrology (National Standards) Rules, 2011.

5 "International Recommendations for Energy Statistics", published by Statistics Division, Department of Economic and Social Affairs, United Nations, 2018. para 1.12, page 3.

6 IRES, Paras 4.27, 4.65, and Table 4.4

7 IRES, paras 4.29 and 4.30

8 IRES, para 4.66 and Table 4.4

9 From a Gas Sales agreement of a major supplier in India.

10 IRES, Para 4.21,

11 Energy Statistics 2018, Central Statistics Office, Government of India, New Delhi. Tables 3.2, 6.2 and 6.3,

12 Coal Directory 2013-14, Coal Controller's Organisation, Ministry of Coal, Government Of India, Kolkata - Table 1.3 page 1.17.

13 Regulation (EC) No 1099/2008 of the European Parliament and of the Council of 22 October 2008,on Energy Statistics.

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15 Pg 56, Energy Statistics Manual, 2004 published by IEA, OECD and EuroStat.

16 Pg 72 of Key world energy statistics 2017, published by IEA

17 New Domestic Natural Gas Pricing Guidelines 2014 - No.22013/27/2012 - ONG D.V. dt 10 Jan 2014, and Guidelines for marketing and pricing freedom for gas produced from high pressure-high temperature-deep water- ultra deep water fields - - File O-22013/27/2012-ONG-D-V (Vol-II) dt 21 Mar 2016

18 10,394,091 mmBtu = 1.055 x 10,394,091 GJ = 10,965,766 GJ = 10.966 PJ.

19 Energy required in Joules "E" =10.966x 10^15 J. Calorific value "CV" = 41.4 x10^6 J/ sm3. Gas quantity in sm3 = E / CV = 10.966x 10^15 / 41.4 x10^6 = 0.265 x 10^9 = 265 million sm3. EF

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MNRE's SOLAR PUMPS PROGRAMME

Supporting National Agricultural Priorities

Since 2010, the Ministry of New & Renewable Energy has provided subsidies through state nodal agencies for provision of solar irrigation facilities. With the Union Budget of 2018, this amount has been exponentially increased to a whopping ₹140,000 crore. The new outlay envisages 2,750,000 solar water pumps to be installed with subsidy,[1] which is more than 18x growth over the current installed base of 1,42,000 solar pumps. Ostensibly, financing schemes from banks will be developed and innovation in pump design will bring the subsidy capital down. In this light, **Sandeep Nath**, evaluates how farmers in the country have fared so far with the MNRE-invested Solar Pumps Programme.

Introduction

According to the Dalberg[2] report, published in 2017, on the Impact Assessment of the National Solar Pumps Programme in four states— Uttar Pradesh, Bihar, Rajasthan, and Tamil Nadu—of India, at least 26,000 pumps have been sanctioned/ approved in the four study states up until 2014–15, though actual installation is lower. Rajasthan, Uttar Pradesh, and Tamil Nadu have installed approximately ~50% of pumps sanctioned for their states while Bihar has installed 6%. This perspective implies how huge subsidy money allocated for assets has not been installed at the farm level.

Such issues could be directly addressed if there had been a mechanism to monitor every solar pump asset installed. Is it connected? Is it performing? Is the performance optimal? What is the average breakdown time? When is the farmer ceasing to depend on it? While various such questions are answerable with performance data, such data is not available. Although, around 2016, each state nodal agency (SNA) incorporated the need for remote monitoring in its tenders, what remained loosely documented was the scope of monitoring, sharing of data, and the basis for data-driven action and planning.

In late 2017, the Ministry of New and Renewable Energy (MNRE), Government of India, and the US State Department, who jointly operate the PACESetter Fund (PSF) to accelerate clean energy innovation in off-grid applications, awarded Shri Shakti Alternative Energy Ltd (SSAEL) a grant for Remote Performance Monitoring & Centralized Service Management of Solar Pumps through an online portal with pilot demonstration projects in the states of Andhra Pradesh and Chhattisgarh. This fund is part of the Program for Advancement of Clean Energy under the Indo-US Energy Dialogue. And this project intends to perform the critical job of integrating the outputs of solar pumps installed by all manufacturers, with pumps of all types, make, and capacities. It also envisages mapping the MIS on a GIS platform making it extremely user friendly for MNRE, SNAs, manufacturers as well as commercial users of big data. For the farmer, it will build access to the data cloud on his smartphone, so that a service request can be triggered from the farm itself and—like a radio taxi service—he connects with the nearest technician for rapid support.

Aligning with National Priorities

The pointers discussed in the rest of this article capture the current national agricultural priorities. Since SSAEL is building the abovementioned platform under the PACESetter project, data-

1 https://www.financialexpress.com/economy/kusum-scheme-all-about-pm-modis-rs-1-4-lakh-crore-solar-power-scheme-for-farmers/1194616/

2 http://shaktifoundation.in/wp-content/uploads/2018/01/SolarPumps_Assessment-in-four-states.pdf.

points have been extracted from a study commissioned by SSAEL to evaluate the solar pumping programme at the start of this project.[3] The field-work was conducted in November–December 2017 in select districts; Krishna, Ananthapur, and Kurnool in Andhra Pradesh and Raipur and Bematara in Chhattisgarh. The aim was to study the operating solar pumps and their financial, environmental, and social impacts, besides other changes brought about by solar pump installation over the last 1 to 3 years of installing them. The study is a subset and part of the PSF grant project and was covered within the sanctioned funding for the project and is limited to the project area of Shri Shakti and does not cover the solar pumping programme at the national level.

The findings, however, serve as the baseline to study and how these impacts will change once a comprehensive remote performance monitoring system (to record performance data of any make, type, manufacturer, size, capacity, AC or DC pump), on a web-based GIS and MIS platform, with centralized service management, is deployed for all pumps. The impact will be studied again after 18 months of system deployment.

In his 2018 budget speech in the Parliament on 1 February, the Union Finance Minister, Government of India, made direct references to the following aspects that have deep relevance to MNRE's programme and its outcomes over the current year and beyond:

1. **Export Power from Pumps**: There is a need for net metering for export of surplus power generated by solar irrigation pumps. The Power Minister further stated that, "Under the scheme, farmer would be able to use solar power and sell excess generation which makes it very attractive proposition". However, the Honourable Minister pointed to the need to set up processes and regulations with Discoms and State electricity regulatory commissions (ERCs) (due to gaps in the regulatory mechanisms for the same) and the imminent need to monitor the pump-sets, which will be fulfilled by this project.

According to the Study Report, so far (in the sample considered), nobody has connected their Solar Water Pump (solar pump) to the grid. The solar pumps are underutilized to the extent of upto 73% after the farmer's own water requirements are met and the excess generation is untapped, as the panels are lying unused thereafter. For perspective, in a district with 500 solar pumps on an average, that is about 5.84 MWh available every day (1,752 MWh per year), considering an average of 4 hours of unused availability for each pump!

Further, 98% of the pumps were AC in nature. Secondary research and qualitative findings indicate that there is a grid line passing in the vicinity of over 90% of them. Therefore, there is the potential for net-metering and grid interconnection to export the surplus power, however, there is practically no awareness about both as well as the possibility and the complexity of doing it. Even the Andhra Pradesh and Chhattisgarh Electricity Regulator's documents are silent on the subject of agri-feeders and net metering for solar pumps.

[3] Full study report available here: https://www.ssael.co.in/images/Library/files/Solar-Pumps-Impact--SSAEL-Report.pdfSandeep Nath is CMO, Shri Shakti Alternative Energy Ltd (SSAEL)

Hence, there is a need for the presence of trained manpower around the farmers, empowered to educate at multiple levels and MNRE is aggregating the same under the PACESetter initiative.

2. **KUSUM Scheme (Kisan Urja Suraksha Utthaan Maha Abhiyaan)**: With an outlay of ₹140,000 crore, it will result in installation of 27.5 lakh off grid solar farm pumps with subsidies and bank loans. This is more than 10 times the current base and a robust universal performance monitoring platform is of critical importance for MIS and programme monitoring.

The study indicates that currently there is very limited understanding among farmers of how solar pumps are to be maintained; what is the impact of dust on panels and other aspects of operating efficiency. No sustainable attempt has been made proactively to address the same. The height of the panels from the ground prevents ease of cleaning and dust accumulation may be thwarting productivity of this large base of subsidized assets.

Further, farmers are unable to progress, in certain cases, beyond flood irrigation / rice cultivation because of lack of cash flow availability; concerns about multi-cropping; concerns about theft and damage of pipes, panels, and wires; and safety and security of crops from animals.

On the flip side, despite various issues however, the study shows that the solar irrigation pumping programme in the districts studied in both states has been a great success in the context in which it has been conceived. Farmer incomes and farm productivity is on the rise with solar pumps facilitating a change in cropping pattern from tobacco and Bengal gram to red chilles, floriculture and mosambi orchards in lands that did not have electricity access earlier.

Hence, while conceptually 18x growth is welcome, farmer awareness enhancement on technical aspects is also critical. To truly increase crop yields, the abovementioned common pool of resource persons will also need to be trained in water-use aspects in order to advise the farmer on better farming practices and show him the impact of well-informed energy and water-use decisions.

Further, being technically-oriented they are best-fit to advise the farmers on technology adoption, such as drip irrigation, greenhouses, water harvesting, multiple crop cycles, System for Rice Intensification (SRI), Zero Budget Natural Farming (ZBNF), and whatever is appropriate for the soil types, crops, and cropping patterns. In fact, with the addition of sensors for soil moisture levels and temperature, groundwater levels, and flow rates, the data-based control system can potentially proactively throw up options for changing land use and cropping patterns for better yields, while conserving water.

3. **New Financial Model**: The implementation of a new financial model wherein the State and Centre collectively provide for 60% of cost of solar pumps as subsidy while banks provide a loan of 30% and remaining 10% is paid by farmers has been planned. Such implementation increases the base of financial partners (banks) whose confidence can be enhanced with real-time monitoring of their financed assets. It also integrates service and maintenance aspects which this project attempts to aggregate and monitor.

The study reports that as a consequence of using solar irrigation pumps, the number of farmers who earn more than ₹100,000 per annum has more than doubled, from a mere 26% to a strong 58%. On an average, 45% farmers saw an increase of 50% or more in their annual incomes and 70% farmers began to earn 25% extra.

Owing to the availability of subsidy across the board, the price paid by farmers has been between ₹7000 and ₹80,000 depending on the size/capacity of the pump, district, and scheme of purchase. This is lower than the annual cost of irrigation water from direct purchase or from installing a diesel pump-set. The electric pump is still a cheaper option at prevailing rates. Hence, payback rates and viability ratios need to be carefully examined.

Availability of performance data on cloud (as envisioned in the project) will also help provide a feedback system to the farmer to enhance productivity as he would know over a phone call (or app), how much below the benchmark he is producing – and what he can do about it.

Datasets can be generated based on real time monitoring, for bringing all the manufacturers and financiers on the same page. Insurers, commodity traders, and banks could use this Big Data to plan better financial models. Such a convergence on data by banks and commercial channels will make way for a self-sustainable payback mechanism to come about.

4. **Agri-Energy Nexus:** The MNRE's solar pump programme can support the Ministry of Agriculture's efforts to achieve the Prime Minister's vision of "doubling farmer incomes by 2022" which, as stated earlier, is a national priority of the Government of India.

In order to actually achieve this, the technical resources and workforce available to the farmer needs to be integrated. So far, the service to pumps is completely separate and distanced from technical inputs for use of water for drip irrigation, fish-culture, greenhouses or other tech applications. The vision of the project is to implement a singular management system that is driven by technology-cloud platform and mobile app, remote performance monitoring and service delivered by a common pool of technicians and engineers who interface with the farmer / pump owner on a regular basis.

According to the study, current serviceman availability, in the target districts, was from an average distance of 45 km. As few as 32% farmers marked 'Yes' for ease of service access in Chhattisgarh. With a delta-change in this, there will be a magnitude-change in farmer confidence and consequent adoption of technology.

5. More Crop per Drop: According to a study by The Council for Energy, Environment and Water (CEEW), solarizing individual grid-connected pumps is the costliest approach for the government to expand irrigation cover. The report encourages sharing of solar pumps among farmers through farmer extension programmes.

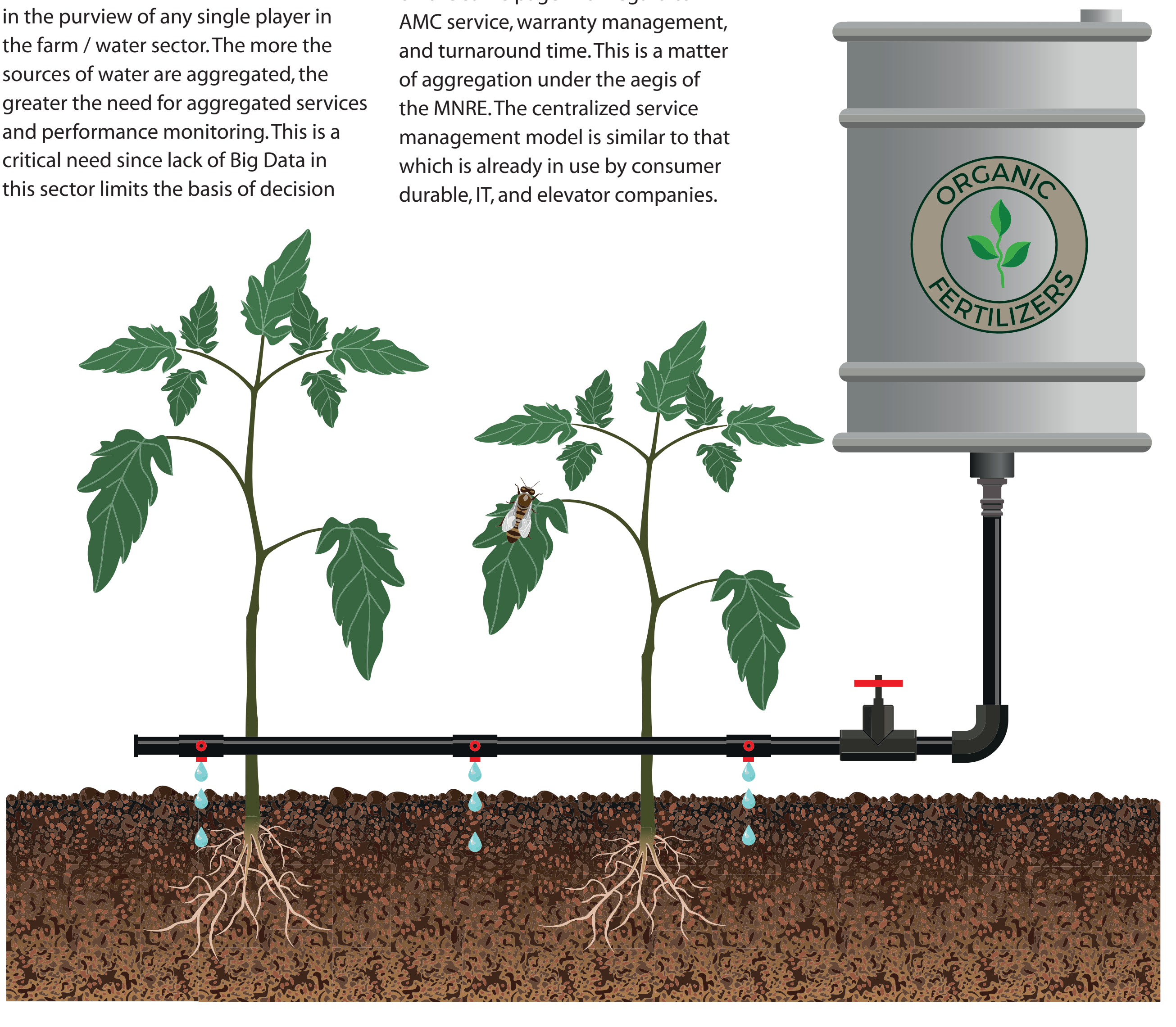
There is a strong need for entrepreneurship and community mobilization for the above to fructify. So far, that does not lie as a key deliverable in the purview of any single player in the farm / water sector. The more the sources of water are aggregated, the greater the need for aggregated services and performance monitoring. This is a critical need since lack of Big Data in this sector limits the basis of decision making. A recently launched decision support tool by CEEW in partnership with GIZ, though impressive, uses groundwater data from way back in 2011, that too at the district-level.

The missing link for MNRE, SNAs, and Pump Service Providers comprises real-time farm-centric data that is agnostic of pump types, manufacturers, and installers. Since (ostensibly) the costs of retaining manpower to service warranties over five years and to upload and mine data may not have been adequately provided in the tender bids, MNRE's idea of aggregating technical strengths is a winner.

It is, therefore, crucial to bring the manufacturers and system integrators on the same page with regard to AMC service, warranty management, and turnaround time. This is a matter of aggregation under the aegis of the MNRE. The centralized service management model is similar to that which is already in use by consumer durable, IT, and elevator companies.

Solar pump manufacturers will gain also from scale-based economies of data transfer and cloud hosting costs, besides leveraging a common pool of service manpower.

With SSAEL's PACESetter-funded Project, MNRE is therefore proactively taking the right steps and nudging the stakeholders in the desired direction to deliver on national agricultural priorities! EF



RELEASE OF MISSION POSSIBLE REPORT:
Net-zero carbon emissions from harder-to-abate sectors is technically and financially possible by mid-century

Reaching net-zero carbon emissions from heavy industry and heavy-duty transport sectors is technically and financially possible by 2060 and earlier in developed economies and could cost less than 0.5% of global gross domestic product (GDP), according to the report published by the Energy Transitions Commission (ETC). The report Mission Possible: Reaching net-zero carbon emissions from harder-to-abate sectors by mid-century, released on November 20, 2018, outlines the possible routes to fully decarbonize cement, steel, plastics, trucking, shipping and aviation—which together represent 30% of energy emissions today and could increase to 60% by mid-century as other sectors lower their emissions.

The Mission Possible report was developed with contributions from over 200 industry experts over a sixmonth consultation process. Its findings show that full decarbonization is technically feasible with technologies that already exist, although several still need to reach commercial readiness. The total cost to the global economy would be less than 0.5% of GDP by mid-century, and could be reduced even further by improving energy efficiency, by making better use of carbon-intensive materials (through greater materials efficiency and recycling) and by limiting demand growth for carbon-intensive transport (through greater logistics efficiency and modal shift).

The report also shows that this would have only a minor impact on the cost of end consumer products. For example:

» Green steel use would add approximately US$180 on the price of a car.
» Green shipping would add less than 1% to the price of an imported pair of jeans.
» Low-carbon plastics would add 1 US cent on the price of a bottle of soda.

In India, the decarbonization of heavy industry and heavy-duty transport is crucial, not only to reduce the carbon in the atmosphere, but also to improve air quality and enhance the quality of life and health of Indian citizens. The Indian industry is growing and has the opportunity to build new industrial capacity with state-of-the-art technology.

In heavy-duty transport, electric trucks and buses (either battery or hydrogen fuel cells) are likely to become cost-competitive by 2030, while, in shipping and aviation, liquid fuels are likely to remain the preferred option for long distances but can be made zero carbon by using bio or synthetic fuels. Improved energy efficiency, greater logistics efficiency and some level of modal shift for both freight and passenger transport could reduce the size of the transition challenge.

In industry, more efficient use of materials and greatly increased recycling and reuse within a more circular economy could reduce primary production and emissions by as much as 40% globally—and more in developed economies—with the greatest opportunities in plastics and metals. Reaching full decarbonization will require a portfolio of decarbonization technologies, and the optimal route to net-zero carbon will vary across location depending on local resources.

Across all sectors of the economy:

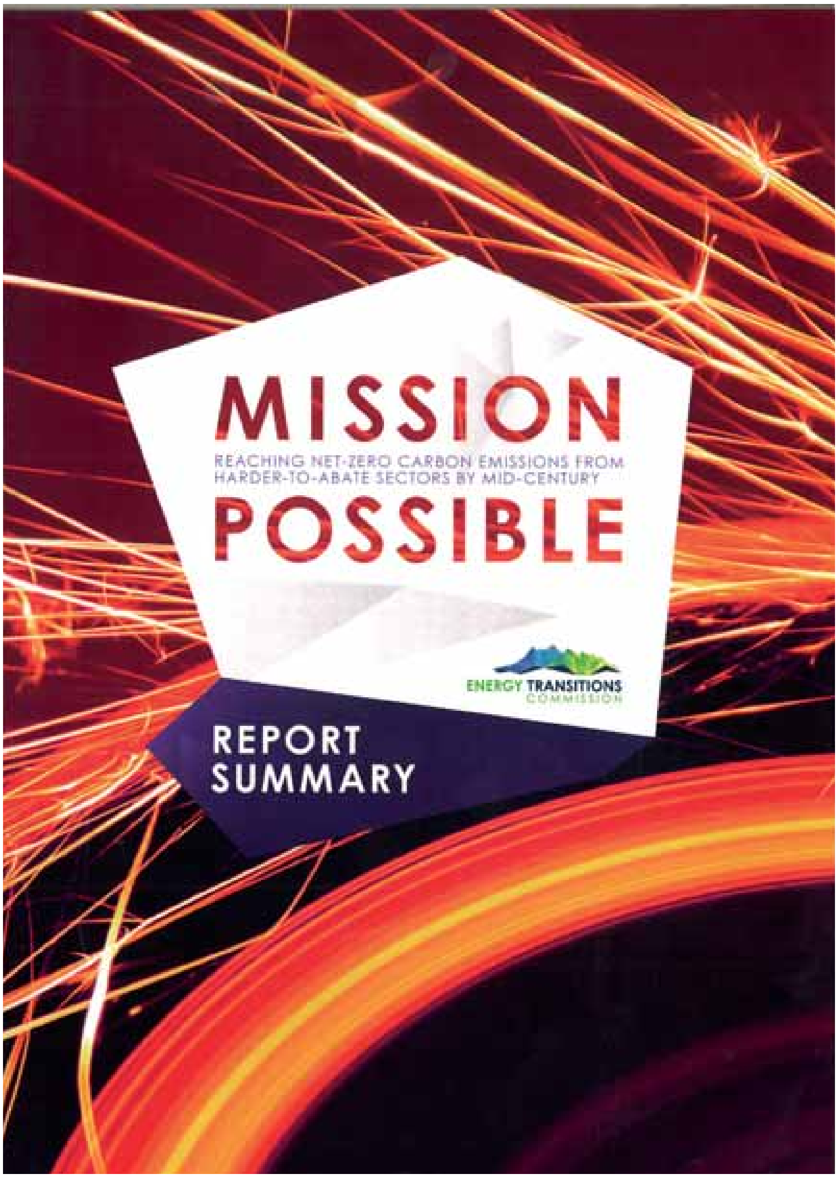
» Direct and indirect electrification (through hydrogen) will likely play a significant role in most sectors of industry and transport, leading to a sharp increase in power demand—growing 4–6 times from today's 20,000 TWh to reach around 100,000 TWh by mid-century).
» Hydrogen use will almost certainly increase dramatically (7–11 times by mid-century), with two routes to zero-carbon hydrogen: electrolysis, which will likely dominate in the long term, and steam methane reforming plus carbon capture and storage.
» Bioenergy and bio-feedstock will be required in several sectors, but will need to be tightly regulated to avoid adverse environmental impact (such as deforestation), and its use should be focused on priority sectors where alternatives are least available or more costly, such as aviation and plastics feedstocks.
» Carbon capture (combined with use or storage) will likely be required to capture process emissions from cement and may also be the most cost-competitive decarbonization option for other sectors in several geographies. However, it does not need to play a major role in power generation, with the storage needs required could be less than many scenarios suggest. Tight regulation of storage is essential to ensure safety and permanence.

The Mission Possible report concludes that the most challenging sectors to decarbonize are plastics, due to end-of-life emissions, cement, due to process emissions, and shipping because of the high cost of decarbonization and the fragmented structure of the industry.

The Energy Transitions Commission supports the objective of limiting global warming ideally to 1.5 °C and, at the very least, well below 2 °C. In the wake of the Intergovernmental Panel on Climate Change (IPCC)'s urgent call for action, the Mission Possible report sends a clear signal to policymakers, investors and businesses: full decarbonization is possible, making ambitious climate objectives achievable.

Key policy levers to accelerate the decarbonization of harder-to-abate sectors include:

- Tightening carbon-intensity mandates on industrial processes, heavy-duty transport and the carbon content of consumer products.
- Introducing adequate carbon pricing, strongly pursuing the ideal objective of internationally agreed and comprehensive pricing systems, but recognizing the potential also to use prices which are differentiated by sector, applied to downstream consumer products and defined in advance.
- Encouraging the shift from a linear to a circular economy through appropriate regulation on materials efficiency and recycling.
- Investing in the green industry, through R&D support, deployment support, and the use of public procurement to create initial demand for 'green' products and services.
- Accelerating public-private collaboration to build necessary energy and transport infrastructure.



Industries and investors can anticipate the profound transformation in industry and transport they will eventually face by innovating and investing in decarbonization technologies and low-carbon infrastructure. The ETC provides the fact base for industry groups and private companies to develop roadmaps, collaborations and projects aiming for net-zero carbon emissions in their sectors. It also encourages businesses across multiple sectors to question their procurement practices and make commitments to buying "green" products and services.

The members of the Energy Transitions Commission are committed to achieving the Paris objective of limiting the rise in global temperatures to well below 2 ˚C and as close as possible to 1.5 ˚C. They are convinced that succeeding in that historic endeavor would not only limit the harmful impact of climate change, but would also drive prosperity and deliver important local environmental benefits.

Adair Turner, co-chair of the ETC said, "This report sets out an optimistic but completely realistic message – we can build a zero-carbon economy with a minor cost to economic growth. We should now commit to achieving this by 2060 at the latest, and put in place the policies and investments required to deliver it."

Ajay Mathur, co-chair of the ETC added, "Climate change imperatives, underlined most recently in the IPCC Special Report to limit global warming to 1.5°C, require the world to move to near-zero carbon emissions by the 2060s or so – when many of the investments we make today would still be operational. The ETC report provides pragmatic steps to move towards zero-carbon technology options in these harder-to-abate sectors, providing both hope as well as strategic directions in these sectors."

TECHNIPFMC IS COMMITTED TO CHALLENGE CONVENTION, INTEGRATE FOR IMPACT, AND TRANSFORM CLIENTS' PROJECT ECONOMICS

As an organization uniquely positioned to deliver greater efficiency across project lifecycles from concept to project delivery, TechnipFMC, through innovative technologies and improved efficiencies, unlocks new possibilities for clients in developing their oil and gas resources. It is pertinent to note at this juncture that TechnipFMC is a global leader in subsea, onshore, offshore, and surface technologies. In this context, **Ms Swayantani Ghosh**, Head—Communication and CSR, TechnipFMC, in an email conversation with **Ms Anushree Tiwari Sharma**, for *Energy Future*, speaks about the sustainability initiatives undertaken by the organization in line with the Sustainable Development Goals, a culture of innovation, and the quest for sustainability.

Describe, in brief, about TechnipFMC and your role and responsibilities with TechnipFMC. Also, for how many years have you been in the CSR domain?
Envisioned to enhance the performance of the world's energy industry, TechnipFMC prioritizes the protection of the planet by constantly seeking and implementing sustainable solutions. We support our employees and the communities we serve by driving workplace gender diversity, nurturing local economies and fostering long-term, positive and enduring social impacts.

On my part, I am responsible for spearheading internal and external communications, corporate social responsibility (CSR), and sustainable development activities of TechnipFMC in India aligned to global purposes and national content. I have been in the CSR domain since 2015.

Could you enumerate about the organization's sustainable and integrated village development programme in Suva, and other villages, with a focus on sanitation and cleanliness.
The TechnipFMC Group's sustainability roadmap aims to nurture local economies and foster long-term, positive social impact in communities where we live and work. In alignment with the organization's three pillars of sustainability—supporting communities, advancing gender diversity, and respecting the environment—TechnipFMC in India has initiated an integrated village development programme in Suva and other villages in Dahej, Gujarat, the location of our 1,50,000 sq. m modular manufacturing yard. In partnership with SEED NGO, we have performed a need assessment in Suva village pertaining to education, health, and sanitation facilities. Based on the assessment report, the scope of the village development programme was outlined in line with the United Nations Sustainable Development Goals (SDGs)—Good Health and Well-being, Quality Education, Gender Equality, Clean Water and Sanitation, Affordable and Clean Energy, Decent Work and Economic Growth, and Climate Action (3,4,5,6,7,8 and 13).
We have worked towards:

- Improving education infrastructure through revamp of local schools and aanganwadi
- Encouraging financial literacy and promoting micro-enterprises for women
- Enhancing awareness on healthcare through health camps and mobile health care units
- Improving hygiene, sanitation, and social infrastructure through the construction of toilets and installation of waste bins and plantation
- Creating livelihood opportunities for local youth through skill development centers

Till date, we have constructed 43 toilets in the villages, conducted awareness sessions for villagers on collecting and disposing waste in a sustainable manner, and held camps to discuss the importance of hygiene and cleanliness. It is vital to sensitize one about environment at an early age. Therefore, particularly for Suva school students, we have designed interactive awareness programmes, such as clean your classroom, clean your neighbourhood contests, and so on. These simple activities are easy to implement but are impactful in changing social behaviour towards the environment. After school, these children encourage their parents to adopt healthy hygiene habits. And, we all know children have a great influence on parents!

Enumerate about the culture of innovation set up by TechnipFMC, particularly in Floating LNG (FLNG) and float over technologies.
TechnipFMC's vision to enhance the performance of the world's energy industry is supported by its commitment to challenge convention, integrate for impact, and transform clients' project economics. Our industry environment is constantly evolving. Therefore, technological innovation, smart collaboration, thinking ahead of time to deliver end-to-end with greater efficiency are all keys to stay ahead of the game. Our culture of innovation has been helping us to pioneer the market for floating facilities with FLNG and Spars, making us a leading player for shallow and deep water solutions (FPSO, semi-submersible, TLP, etc.). Drawing on experience across all component areas, such as early studies, procurement, construction and project management for all platform types, proven technologies, right alliances and effective interface management of clients and partners, we are uniquely positioned to design and deliver floating LNG facilities. It is this culture of purposeful innovation that inspires our 37,000+ women and men across the world to develop new tools, solutions, and adapt existing methods to meet the needs today and in the future.

Can you share a recent accomplishment you are especially proud of in your CSR & sustainability role?
TechnipFMC in India has been sponsoring the 'Enhanced-Education, Ensured Future' programme of Arpana Trust. Arpana Trust is engaged in an intensive, multifaceted community development programme for inhabitants of Gautampuri, a slum resettlement colony in south Delhi since 2002. Recently, I attended the felicitation of 75 students coached by Arpana Trust who passed their 10th and 12th standard exams in 2018 with flying colours. I was touched to see the potential, determination, and value system of these children, hailing from challenging socio-economic backgrounds, whose dreams have no boundaries. On congratulating one of the students who scored 95% in the 10th standard, I asked him about his

aspirations for the future. Beaming with confidence, he replied that his aim was to study at IIT Delhi. His response was echoed by many more such dreams from other students who are determined to get rid of the 'underprivileged' label. That day I felt grateful and proud for being part of an organization that helps millions in their journey towards success.

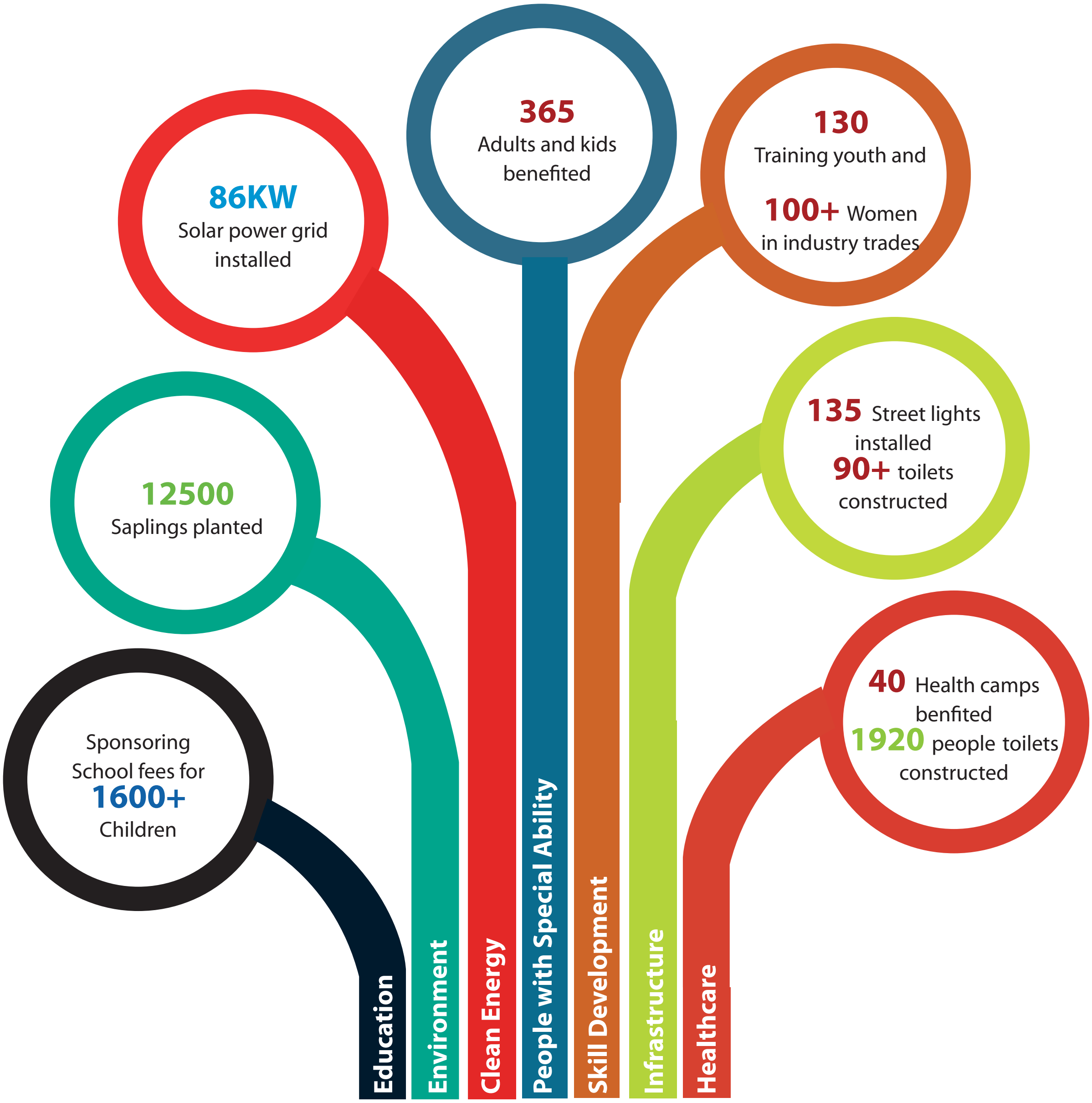
TechnipFMC has tied up with Arpana Trust to provide educational support for school going children from slum areas to prevent drop outs and improve their academic score.

The scope of the project entails:

» Providing quality, interactive, and participatory-based learning to children up to Class V
» Regular training and capacity building of teachers/educators to ensure provision of quality education to children
» Ensuring zero school drop outs through regular tracking, monitoring, and parent– teacher interactions
» Fostering talent, creativity, and self-confidence through theatre, dance and music workshops and encouraging participation in cultural events that strengthen cross-cultural harmony and empathy
» Promoting a habit of reading and love for books through library activities and computer literacy from Class II onwards

Where do you see CSR initiatives 10 years down the line?

Though many companies have been changing the social landscape by undertaking CSR activities in India for decades, 2013 onwards, India CSR Mandate of 2% has suddenly turned the spotlight on Corporate Social Responsibility. NGOs, implementation agencies, social consultants have increased by manifolds with companies talking about CSR in their boardrooms. Today, CSR has become a key component of brand image and overall strategy. I personally think CSR in India is yet to mature and transform beyond charity, publicity stunt and ad hoc donations. We need to have a new approach to CSR with a more well-defined policy framework, paying attention to measurable outcomes and transparency. Initial enthusiasm of doing CSR as a mandated requirement amongst corporates is now settling down and Companies are at crossroads – where focus is shifting from social responsibility towards making social impact. Companies need to be more innovative in their products and processes to tackle today's requirement without compromising the ability of future generations to meet their own needs tomorrow. Cross sector partnership will bring core competencies and skill of different businesses together to create a sustainable impact. In addition to complying with international and national policies, standards, and guidelines, companies need be sensitive enough to design a customized approach to tackle local social and economic problems. There



is also a requirement of developing Generally Accepted Sustainability Practices (GASP) standard, much like the Generally Accepted Accounting Practices (GAAP), to include consensus principles, methods, and approaches for measuring and disclosing CSR. CSR rating agencies can also be formed 10 years down the line. A trend is already setting in emergence of specialists in climate, biodiversity, human rights, community development, gender diversity, and so on, leaving no CSR aspect behind, with an aim to integrate CSR issues into day-to-day functional areas, such as human resources, marketing, finance, etc.

As described on your website, the CSR programmes in India are referred to as 'seed of hope'. Please describe these initiatives as a snapshot along with their outcomes.

'Seed of Hope' is the name of TechnipFMC India's flagship CSR programme. This name was chosen through employee polls and it aptly captures the essence of our sustainability—sowing the seed or taking steps to build a 'better future'. All our CSR initiatives are aimed to create a long term, positive impact for our stakeholders. Since 2015, we have undertaken approximately 25 projects in the fields of education, skill development training, micro-enterprises for women, healthcare, supporting people with disabilities, disaster response drive for flood, drought or earthquake victims, community well-being with improved infrastructure for sanitation, waste management, and so on. The impact of 'Seed of Hope' is enclosed here through a schematic diagram. Currently, we are looking into developing sustainable, affordable, and clean energy infrastructure in selective areas at a pilot scale. EF

CURRENT R&D RENEWABLE

Education and Training Gaps in the Renewable Energy Sector

Solar Energy, Volume 173, October 2018, Pages 449–455

Hugo Lucas, Stephanie Pinnington, and Luisa F Cabeza

One of the barriers to achieve the expected renewable energy market development is the shortage of qualified human resources. Global data on education and training on renewable energies was analysed in order to gain an understanding of the current education supply worldwide. Findings are: (i) the shortage is more acute in developing countries; (ii) there is a mismatch between education system offer and industry demand; (iii) there is also a mismatch in the suitability of the curricula; (iv)students and educators are moving towards online training for collaborating and learning. While it remains a challenge to increase, improve, and facilitate access to renewable energy education and training, the high interest of females in renewable energy education represents an opportunity to counter the scarcity of professionals in the sector. EF

Renewable and Non-renewable Energy, Regime Type and Economic Growth

International Journal of Electrical Power & Renewable Energy, Volume 125, September 2018, Pages 755–767

Samuel Adams, Edem Kwame Mensah Klobodu, and Alfred Apio

The paper analyses the effect of renewable and non-renewable energy consumption as well as the regime type on economic growth in 30 Sub-Saharan African (SSA) countries over the period 1980–2012. Using heterogeneous panel co-integration and panel-based error correction tests, we find long-run relationships between the variables. However, short-run results are not robust, which suggest that energy sector investments are long-term in nature. Specifically, the results show that while both renewable and non-renewable energy have significant positive effect on economic growth, non-renewable energy has a greater growth enhancing effect than renewable energy. A 10% increase in renewable energy consumption is associated with an increase in economic growth by 0.27%, while a 10% increase in non-renewable energy consumption leads to an increase in growth by 2.11% ceteris paribus. Further, the findings of the study show that democratic states experience higher growth rates than autocratic states. EF

Estimation of Environmental Kuznets Curve for CO2 emission: Role of Renewable Energy Generation in India

Renewable Energy, Volume 119, April 2018, Pages 703–711

Avik Sinha and Muhammad Shahbaz

The existing literature on environmental Kuznets curve (EKC) is mainly focussed on finding out the optimal sustainable path for any economy. Looking at the present renewable energy generation scenario in India, this study has made an attempt to estimate the EKC for CO2 emission in India for the period of 1971–2015. Using unit root test with multiple structural breaks and autoregressive distributed lag (ARDL) approach to co-integration, this study has found the evidence of inverted U-shaped EKC for India, with the turnaround point at USD 2937.77. The renewable energy has found to have significant negative impact on CO2 emissions, whereas for overall energy consumption, the long run elasticity is found to be higher than short run elasticity. Moreover, trade is negatively linked with carbon emissions. Based on the results, this study concludes with suitable policy prescriptions. EF

India's Energy Future: Contested Narratives of Change

Energy Research & Social Science, Volume 44, October 2018, Pages 75–82

Aniruddh Mohan and Kilian Topp

In this perspective article, we undertake a brief empirical analysis of the dominant narratives in debates around India's energy future. India has ambitious goals for increasing renewable energy and enabling universal energy access, but there is little social consensus on how these goals should be achieved. We find two compelling narratives in energy policy debates in the country: 'energy for development' that privileges energy as critical to economic growth and long term strategic security; and 'energy for all' that prioritizes the role of energy for basic development and ending poverty. We find that while these narratives find common ground on certain issues, such as the role of coal, they clash in the socio-technical imaginaries they represent about India's energy future. Indian energy policy has been characterized so far by top down, centralized policymaking. With this article, we highlight the societal choices that are inherent in discussions about transformations in India's electricity sector and call for further research on the socio-cultural dimensions of future energy pathways in India.

Multi-criteria Decision Analysis for Renewable Energy Integration: A Southern India Focus

Renewable Energy, Volume 121, June 2018, Pages 474-488

J Vishnupriyan and P S Manoharan

In recent days, sustainability is considered as an important mechanism due to contemporary increase in demands and worldwide limited resources. This paper presents the possibility of integrating a renewable energy system with an existing grid to meet electrical energy demand of institutional buildings located in Indian state of Tamil Nadu. Currently, the Tamil Nadu state electric-grid power is not surplus and experiencing 40% short fall in generation. In this present paper, a modern approach for the optimum planning of electric power system (EPS) is proposed based on the Analytic Hierarchy Process (AHP). An intertwined analysis on energy management and techno-economic optimization of grid connected renewable energy system is proposed. The prospects of different fixed tilt solar panels and peak load shifting based energy management are performed through HOMER Energy® simulation. The AHP multi-criteria decision analysis reveals that annual optimum tilt grid connected photovoltaic system is the optimum configuration for study location. The effectiveness of the AHP approach is evaluated with best-worst method and stochastic multi-criteria acceptability analysis for prioritizing the renewable energy system options in order to select best EPS. In addition, the optimum configuration is implemented in the institutional buildings and performance is analysed under varying climatic conditions.

Exploring peer-to-peer Returns in off-grid Renewable Energy Systems in Rural India: An Anthropological Perspective on Local Energy Sharing and Trading

Energy Research & Social Science, Volume 46, December 2018, Pages 194–213

Abhigyan Singh, Alex T Strating, N A Romero Herrera, Debotosh Mahato, David V Keyson, and Hylke W van Dijk

Within the areas of distributed, off-grid, and decentralized energy, there is a growing interest in local energy exchanges. A crucial component of an energy exchange is a return provided by an energy-receiver to an energy-giver for the energy provided. The existing energy literature on such returns is primarily limited to monetary returns and lacks a critical discussion on the different types of monetary and non-monetary returns possible and variation in people' preferences for these. Based on an ethnographic 'research intervention' study conducted at two off-grid villages in rural India for 11 months, this article presents a socio-cultural understanding of returns. The article presents a classification of returns consisting of three types, that is, in-cash, in-kind, and intangible, and proposes a conceptual model of 'returns-continuum.' The article showcases how people's preference for a type of return varies with the nature of their social relationships with each other and suggests that configuring a return is not merely an economic act but a complex socio-cultural process. Finally, the article recommends energy researchers and practitioners to enable diversity in returns, to acknowledge dynamics of social relations in returns, to interconnect energy economy with the local in-kind economy, and to engage with ethnographic approaches.

DON'T WASTE THE WASTE

CONVERT YOUR KITCHEN WASTE TO COMPOST

Indian cities generate a massive amount of waste and the majority of this goes untreated. If somehow people are able to learn ways of recycling and utilizing this waste, it shall be simpler to manage the waste intelligently and scientifically.

In this context, Eco Bin is one such innovative product. Offering end-to-end solid waste management solutions, the product helps in keeping the home and its surroundings and the landfills free from the burden of managing waste. This is possible with innovative waste management solutions that promote a better environment, improve recycling processes, lower transportation costs, and lessen the impact on the overloaded landfills.

Eco Bin also helps streamline all waste processing operations and identify cost savings, as well as helps to generate new revenue sources by taking advantage of lucrative recycling opportunities that are currently under-utilized. At the same time, Eco Bin demonstrates how to lower trash bills, reduce waste hauling requirements, improve compliance of waste processing, and increase productivity with their durable, efficient, quality waste, and recycling solutions.

The product offers tailor made solutions, in the form of a range of waste segregation products, targeted for the urban market, enumerated as follows:

» Eco Bin Indoor Composter - Bokashi and Aerobic Composter
» Community Composters-Eco Bin Bakasura

How Eco Bin works

Eco Bin is custom made using high-quality food grade UV Stabilized LDPE impregnated plastic, making it easy-to-use in residences, apartments, schools, restaurants, corporates, and so on.

Eco Bin composter is a one-stop solution for all your kitchen waste, green waste, food waste, veg, non-veg, dairy products, citrus fruits, bread or cake, and so on. Eco Bin recycles all this waste into nutrient rich organic compost, which also acts as a 'soil conditioner'.

The Eco Bin composter kit comes along with complete user instructions and a pack of Magic Microbes Bokashi bran (for Bokashi) and Coco Magic block (for aerobic). As the kitchen waste is fed into the Eco Bin and the microbes are released, they get on with their job of accelerating the composting process, while eliminating odour and deterring pests.

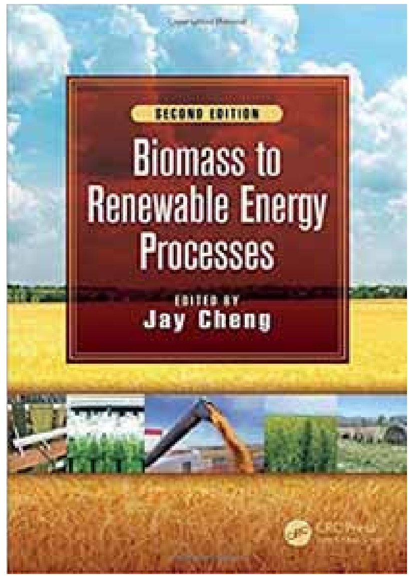
In fact, the real champions are the microbes present in the Bokashi Bran. The strainer and the drain tap work in tandem by allowing the moisture released by the food waste to be drained out to prevent spoiling the composting process. And this liquid (termed as leachate), can be used fertilizer for plants (1:100 dilution) or to clean the kitchen and bathroom drains (undiluted).

For aerobic composting, the microbes are present in the Coco Magic block. Here, it must be ensured that the liquid that is drained out from the tap must be poured down the sink. The need to stir, add dry leaves, add remix powder, saw dust, brown matter, and so on, has however been eliminated.

Eco Bin has been helping many people, associations, and organizations to plan, organize, and implement waste management strategies and waste handling solutions. They service all aspects of waste collection and administration and also help save money by shifting waste costs to recycling revenues. Eco Bin adapts the most effective method of composting and caters to compost either through the anaerobic (without air) or aerobic (with air). Adopting Eco Bin ensures to ferment and pickle food waste or to breakdown and compost in less than half the time of conventional composting methods. EF

For further information, visit: <info@myecobin.in

Biomass to Renewable Energy Processes



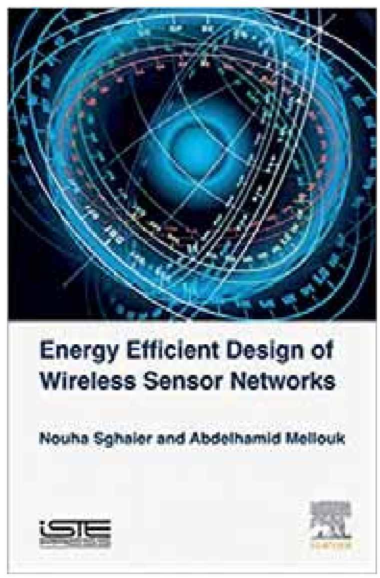
Author: J Cheng Jay
Publisher: Taylor & Francis Group

Continuously increased consumption of fossil fuels, decreased availability of easily accessible fossil fuels, significant contribution to climate change, and wildly fluctuating fuel prices have combined to challenge the reliability and sustainability of our current energy supply. A possible solution to this energy challenge, biomass energy production, heavily dependent on sugarcane and corn production, is vulnerable to the fluctuation of the feedstock price. New technologies need to be developed to convert abundant biomass, such as lignocellulosic materials, into energy products in a cost-effective and environmentally-friendly manner.

An introduction to fundamental principles and practical applications, Biomass to Renewable Energy Processes explains the theories of biological processes, biomass materials and logistics, and conversion technologies for bioenergy products, such as biogas, ethanol, butanol, biodiesel, and synthetic gases. The book discusses anaerobic digestion of waste materials for biogas and hydrogen production, bioethanol and biobutanol production from starch and cellulose, and biodiesel production from plant oils. It addresses thermal processes, including gasification and pyrolysis of agricultural residues and woody biomass. The text also covers pretreatment technologies, enzymatic reactions, fermentation, and microbiological metabolisms and pathways. It explores the engineering principles of biomass gasification and pyrolysis and potential end-products.

Editor Jay Cheng has assembled contributors from multiple engineering disciplines, reflecting the breadth and depth of the field. These experts discuss the fundamental principles of the processes for bioenergy production, supplying the background needed to understand and develop biofuel technologies. They provide the foundation for future work and development on what can be a clean, green, renewable, and sustainable energy source for years to come.

Energy Efficient Design of Wireless Sensor Networks



Editors: Nouha Sghaier and Abdelhamid Mellouk
Publisher: ISTE Press – Elsevier, forthcoming

Energy Efficient Design of Wireless Sensor Networks explores how to optimize energy supply in wireless sensor networks (WSNs), which is more complex than in conventional wired networks because it involves not only reducing the energy consumption of a single sensor node, but also maximizing the lifetime of an entire network. The book focusses on mobile wireless sensor networks characterized by poor connectivity, examining ways to exploit the mobility of nodes to optimize their energy consumption and maximize the lifetime of the entire network on two main levels, the neighbour's discovery phase and data transfer methods.

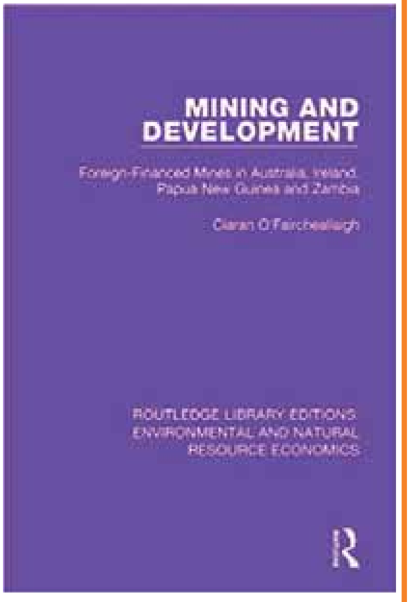
- Focusses exclusively on mobile sensor networks
- Exploits mobile WSN specificities to conserve the maximum energy initially deployed on sensors to extend the lifetime of the whole network
- Offers a new paradigm of conservation and energy optimization techniques in two levels, the neighbour discovery phase and data routing method

Examines the idea of how to exploit the mobility of nodes to optimize their energy consumption EF

Mining and Development: Foreign-Financed Mines in Australia, Ireland, Papua New Guinea and Zambia (Routledge Library Editions: Environmental and Natural Resource Economics)

This book, first published in 1984, examines the economics and political issues raised by foreign investment in mineral development. It is an attempt to identify, as far as possible, what occurs in and between countries when foreign investments are made in mineral development, concentrating on two main themes: on the nature of the transactions which constitute the process of foreign investment on the physical level—money and instruments of credit, objects, information and people as they cross national boundaries—and on the nature of the relationships which are created between foreign investors and governments in the countries where the investments are made.

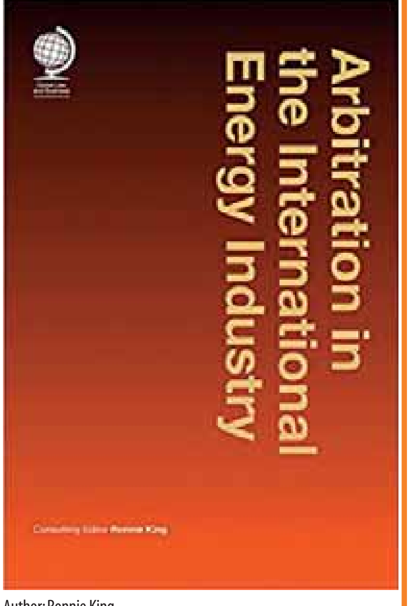
The author argues that the nature of physical transactions plays a crucial role in determining the character of host country-foreign investor relations, and the policies and attitudes adopted by host country authorities exercise an important influence, in turn, on the physical effects of foreign investments. As such, the book constitutes a comprehensive overview of the economic and political factors involved in mining and its development. EF



Author: Ciaran O'Faircheallaigh
Publisher: Routledge, forthcoming

Arbitration in the International Energy Industry

The international energy industry frequently gives rise to complex, high-value disputes. As economic and commercial circumstances change, joint venture partners may disagree over operations, sellers and buyers may manoeuvre to amend pricing terms, and states may seek to improve their take from investment projects. Any of these outcomes can have significant consequences for the long-term prospects of companies operating in the sector. These are just some of the issues covered by this title, which provides a practical, user-friendly overview of the essentials of international arbitration in the energy industry. Leading practitioners from international law firms and global companies consider, among other things, the effective drafting of arbitration clauses, how to keep international arbitration affordable, gas price arbitrations, EPC and construction arbitrations, investment treaty disputes under the Energy Charter Treaty, third party funding in international arbitration and enforcement of arbitral awards. Edited by Ronnie King, Tokyo Managing Partner and international arbitration expert at international law firm Ashurst LLP, this title will be of practical value for all lawyers advising in the energy industry, and for others who have an interest in the important issues discussed. EF



Author: Ronnie King
Publisher: Globe Law and Business, forthcoming

RENEWABLE ENERGY TECHNOLOGY DEVELOPMENT

Wind technology advancements continue to drive down wind energy prices

Wind energy pricing remains attractive, according to an annual report released by the U.S. Department of Energy and prepared by Lawrence Berkeley National Laboratory (Berkeley Lab). At an average of around 2 cents per kilowatt-hour (kWh), prices offered by newly built wind projects in the United States are being driven lower by technology advancements and cost reductions.

"Wind energy prices, particularly in the central United States, and supported by federal tax incentives—remain at all-time lows, with utilities and corporate buyers selecting wind as a low-cost option," said Berkeley Lab Senior Scientist Ryan Wiser of the Electricity Markets & Policy Group.

Wind power capacity additions continued at a rapid pace in 2017. Nationwide, wind power capacity additions equaled 7,017 megawatts (MW) in 2017, with $11 billion invested in new plants. Wind power constituted 25% of all US generation capacity additions in 2017. Wind energy contributed 6.3% of the nation's electricity supply, more than 10% of total electricity generation in 14 states, and more than 30% in four of those states (Iowa, Kansas, Oklahoma, and South Dakota).

Bigger turbines are enhancing wind project performance. The average generating capacity of newly installed wind turbines in the United States in 2017 was 2.32 MW, up 8% from the previous year and 224% since

1998–1999. The average rotor diameter in 2017 was 113 m, a 4% increase over the previous year and a 135% boost over 1998-1999, while the average hub height in 2017 was 86 m, up 4% from the previous year and 54% since 1998-1999. Permit applications to the Federal Aviation Administration suggest that still-taller turbines are on the way. Increased rotor diameters, in particular, have begun to dramatically increase wind project capacity factors. The average 2017 capacity factor among projects built from 2014 through 2016 was 42%, compared to an average of 31.5% among projects built from 2004 to 2011, and 23.5% among projects built from 1998 to 2001.

Low wind turbine pricing continues to push down installed project costs. Wind turbine equipment prices have fallen to $750–$950/kilowatt (kW), and these declines are pushing down project-level costs. The average installed cost of wind projects in 2017 was $1,610/kW, down $795/kW from the peak in 2009 and 2010.

Wind energy prices remain low. Lower installed project costs, along with improvements in capacity factors, are enabling aggressive wind power pricing. After topping out at 7 cents per kWh in 2009, the average levelized long-term price from wind power sales agreements has dropped to around 2 cents per kWh—though this nationwide average is dominated by projects that hail from the lowest-priced region, in the central United States. Recently signed wind energy contracts compare favourably to projections of the fuel costs of gas-fired generation. These low prices have spurred demand for wind energy from both traditional electric utilities and nonutility purchasers, such

as corporations, universities, and municipalities.

The domestic supply chain for wind equipment is diverse. Wind sector employment reached a new high of 105,500 full-time workers at the end of 2017. For wind projects recently installed in the United States, domestically manufactured content is highest for nacelle assembly (more than 90%), towers (70% to 90%), and blades and hubs (50% to 70%). It is much lower (less than 20%) for most components internal to the turbine. Although there have been a number of manufacturing plant closures over the last decade, each of the three largest turbine suppliers serving the US market—Vestas, General Electric Co., and Siemens Gamesa—has one or more domestic manufacturing facilities in operation.

https://www.sciencedaily.com/releases/2018/08/180823143922.htm

States boost renewable energy and development when utilities adopt renewable standards

States that require utilities to increase renewable energy see expansion of renewable energy facilities and generation—including wind and other renewable sources, but especially solar—according to new research from Indiana University and two other institutions.

IU's Sanya Carley led a team of researchers including Nikolaos Zirogiannis, an assistant scientist at IU, and law professors Lincoln Davies of the University of Utah and David B Spence of University of Texas at Austin. The group closely examined the history and evolution of state renewable portfolio standards and interviewed more than 40 experts about renewable portfolio standards implementation.

Their findings are newly published in the peer-reviewed journal Nature

Energy, in an article titled "Empirical evaluation of the stringency and design of renewable portfolio standards".

The regulations, which require utilities to increase the percentage of energy they sell from renewable sources by a specified amount and date, have been adopted in varying forms by about 30 states. For example, New York requires 50% of all electricity sold in 2050 to come from solar.

"As the federal government moves away from climate mitigation policy, including abandoning the Paris Agreement, the role of state-level policy tools, such as RPS, take on increasing importance," said Carley, an associate professor in the IU School of Public and Environmental Affairs.

Most states have adopted such standards, except those in the Southeast and parts of the Great Plains and Interior West, where fossil fuel prices are low. Nevada and Massachusetts were the first to adopt a renewable portfolio standard in the 1990s, and Hawaii's is considered the most stringent, a pivotal measuring stick.

Renewable mandates drive renewable energy development across the US, the researchers found. The design of the policy, however, is of fundamental importance. These are key findings:

» When designing a renewable mandate, stringency is critical. The stronger the mandate, the more renewables a state develops.
» Other important design features include frequent planning processes and regulations that are mandatory rather than voluntary.
» States that allow utilities to count non-renewable energy, such as "clean coal" or other fossil fuels, to satisfy renewable mandates will develop significantly less renewables, particularly less solar energy.
» In addition to the renewable portfolio standards, having a conducive economic climate and good resources (e.g., strong winds as in Iowa or abundant sun as in Arizona) is especially important.

Carley said teaming up with researchers from three universities gave the project unique and unusual depth, including through its quantitative analysis and the use of structured expert interviews. The team developed a unique score to measure the stringency of renewable portfolio standard policies, then reaffirmed their findings by interviewing experts from government agencies, including public utility commissions and state energy offices, and renewable energy firms and associations.

"Policymakers face tough trade-offs when designing their RPS policies, such as whether to force in-state renewable energy for local economic development purposes, or to purchase renewables from other states at a potentially lower cost," said Davies of the University of

Utah. "Our research also shows just how critical state energy laws are today, particularly as the Trump administration alters the national energy policy landscape. States are where the action is. They are driving the future of our electric grid."

https://www.sciencedaily.com/releases/2018/07/180723142824.htm

How gold nanoparticles could improve solar energy storage

Star-shaped gold nanoparticles, coated with a semiconductor, can produce hydrogen from water over four times more efficiently than other methods—opening the door to improved storage of solar energy and other advances that could boost renewable energy use and combat climate change, according to Rutgers University-New Brunswick researchers.

"Instead of using ultraviolet light, which is the standard practice, we leveraged the energy of visible and infrared light to excite electrons in gold nanoparticles," said Laura Fabris, associate professor in the Department of Materials Science and Engineering in the School of Engineering who led the work with Fuat Celik, assistant professor in the Department of Chemical and Biochemical Engineering. "Excited electrons in the metal can be transferred more efficiently into the semiconductor, which catalyzes the reaction."

The researchers, whose study was published online today in the journal Chem, focussed on photocatalysis, which typically means harnessing sunlight to make faster or cheaper reactions.

Titanium dioxide illuminated by ultraviolet light is often is used as a catalyst, but using ultraviolet light is inefficient.

In the study, Rutgers researchers tapped visible and infrared light that allowed gold nanoparticles to absorb it more quickly and then transfer some of the electrons generated as a result of the light absorption to nearby materials like titanium dioxide.

The engineers coated gold nanoparticles with titanium dioxide and exposed the material to UV, visible, and infrared light and studied how electrons jump from gold to the material. The researchers found that the electrons, which trigger reactions, produced hydrogen from water over four times more efficiently than previous efforts demonstrated. Hydrogen can be used to store solar energy and then combusted for energy when the sun is not shining.

"Our outstanding results were ever so clear," Fabris said. "We were also able to use very low temperature synthesis to coat these gold particles with crystalline titanium. I think both from the materials perspective and the catalysis perspective, this work was very exciting all along. And we were extremely lucky that our doctoral students, Supriya Atta and Ashley

Pennington, were also as excited about it as we were."

"This was our first foray," she added, "but once we understand the material and how it operates, we can design materials for applications in different fields, such as semiconductors, the solar or chemical industries or converting carbon dioxide into something we can use. In the future, we could greatly broaden the ways we take advantage of sunlight."

https://www.sciencedaily.com/releases/2018/07/180712114514.htm

Bright future for solar cell technology

Harnessing energy from the sun, which emits immensely powerful energy from the center of the solar system, is one of the key targets for achieving a sustainable energy supply.

Light energy can be converted directly into electricity using electrical devices called solar cells. To date, most solar cells are made of silicon, a material that is very good at absorbing light. But silicon panels are expensive to produce.

Scientists have been working on an alternative, made from perovskite structures. True perovskite, a mineral found in the earth, is composed of calcium, titanium, and oxygen in a specific molecular arrangement. Materials with that same crystal structure are called perovskite structures.

Perovskite structures work well as the light-harvesting active layer of a solar cell because they absorb light efficiently but are much cheaper than silicon. They can also be integrated into devices using relatively simple equipment. For instance, they can be dissolved in solvent and spray coated directly onto the substrate.

Materials made from perovskite structures could potentially revolutionize solar cell devices, but they have a severe drawback: they are often very unstable, deteriorating on exposure to heat. This has hindered their commercial potential.

The Energy Materials and Surface Sciences Unit at the Okinawa Institute of Science and Technology Graduate University (OIST), led by Prof. Yabing Qi, has developed devices using a new perovskite material that is stable, efficient, and relatively cheap to produce, paving the way for their use in the solar cells of tomorrow. Their work was recently published in Advanced Energy Materials. Postdoctoral scholars Dr Jia Liang and Dr Zonghao Liu made major contributions to this work.

This material has several key features. First, it is completely inorganic—an important shift, because organic components are usually not thermostable and degrade under heat. Since solar cells can get very hot in the sun, heat stability is crucial. By replacing the organic parts with inorganic materials, the researchers made the perovskite solar cells much more stable.

"The solar cells are almost unchanged after exposure to light for 300 hours," says Dr Zonghao Liu, an author on the paper.

All inorganic perovskite solar cells tend to have lower light absorption than organic-inorganic hybrids, however. This is where the second feature comes in: The OIST researchers doped their new cells with manganese in order to improve their performance. Manganese changes the crystal structure of the material, boosting its light harvesting capacity.

"Just like when you add salt to a dish to change its flavor, when we add manganese, it changes the properties of the solar cell," says Liu.

Thirdly, in these solar cells, the electrodes that transport current between the solar cells and external wires are made of carbon, rather than of the usual gold. Such electrodes are significantly cheaper and easier to produce, in part because they can be printed directly onto the solar cells. Fabricating gold electrodes, on the other hand, requires high temperatures and specialist equipment such as a vacuum chamber.

There are still a number of challenges to overcome before perovskite solar cells become as commercially viable as silicon solar cells. For example, while perovskite solar cells can last for one or two years, silicon solar cells can work for 20 years.

Qi and his colleagues continue to work on these new cells' efficiency and durability, and are also developing the process of fabricating them on a commercial scale. Given how quickly the technology has developed since the first perovskite solar cell was reported in 2009, the future for these new cells looks bright. EF

https://www.sciencedaily.com/releases/2018/04/180427100250.htm

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NATIONAL AND INTERNATIONAL EVENTS

NATIONAL

Envirotech Asia
November 1–3, 2018
Mumbai, Maharashtra
Website: http://www.envirotechasia.com/

REIFF India 2018
Renewable Energy Investment and Finance Forum
November 2, 2018
Mumbai, Maharashtra
Website: http://firstviewgroup.com/reiffindia/index.php

Bengaluru Renewable Energy Expo
November 28–30, 2018
Bengaluru, Karnataka
Website: http://renewableenergyexpo.biz

Electric Vehicles and Renewable Energy Conference & Expo 2018
November 13–14, 2018
Hyderabad, Telangana
Website: https://evrexindia.com/

Energy Expo 2018
November 30–2 December 2018
Surat, Gujarat
Website: https://www.sgcci.in/

Green Power Conference & Exposition
December 4–5, 2018
Chennai, Tamil Nadu
Website: http://www.greenpower-cii.com/

INTERNATIONAL

Asia Clean Energy Summit 2018
31 October–2 November 2018
Marina Bay Sands
Website: https://www.asiacleanenergysummit.com/

International Conference on Renewable Energy Sources & Energy Efficiency
November 1–2, 2018
Nicosia, Cyprus
Website: http://www.mse.com.cy/resee2018/

Directed Energy Systems
30 October–1 November 2018
London, United Kingdom
Website: https://directedenergysystems.iqpc.co.uk/

The Big 5 Solar
November 26–29, 2018
Dubai, United Arab Emirates
Website: https://www.thebig5solar.ae/

5th Mozambique Gas Summit & Exhibition
31 October–2 November 2018
Maputo, Mozambique
Website: https://www.mozambique-gas-summit.com/

AICPA Oil & Gas Conference
November 11–13, 2018
Denver, USA
Website: https://www.aicpastore.com/aicpa-oil---gas-conference/PRDOVR~PC-OIL/PC-OIL.jsp

RENEWABLE ENERGY AT A GLANCE

Ministry of New & Renewable Energy			
Programme/Scheme wise Physical Progress in 2018-19 & Cumulative upto July, 2018			
Sector	**FY- 2018-19**		**Cumulative Achievement (April-July 2018) (as on 31.07.2018)**
	Target	**Achievement (April-July 2018)**	
I. GRID-INTERACTIVE POWER (CAPACITIES IN MW)			
Wind Power	4000.00	257.12	34402.12
Solar Power - Ground Mounted	10000.00	1304.57	21892.42
Solar Power - Roof Top	1000.00	159.02	1222.65
Small Hydro Power	250.00	7.40	4493.20
Biomass (Bagasse) Cogeneration)	250.00	0.00	8700.80
Biomass (non-bagasse) Cogeneration)/ Captive Power	100.00	14.00	676.81
Waste to Power	2.00	0.00	138.30
Total	15602.00	1742.11	71526.30
I. OFF-GRID/ CAPTIVE POWER (CAPACITIES IN MWEQ)			
Waste to Energy	18.00	0.00	172.15
Biomass Gasifiers	1.00	0.00	163.37
SPV Systems	200.00	90.15	761.55
Total	219.0	90.15	1097.07
III. OTHER RENEWABLE ENERGY SYSTEMS			

Tentative State-wise break-up of Renewable Power target to be achieved by the year 2022 (Posted on 30.03.2015)

Source: www.mnre.gov.in

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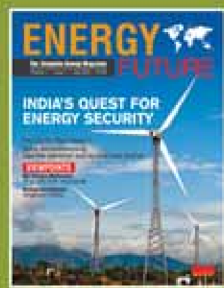

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