ENFUSE

Volume – LXXI Book 1

April - June 2021

Publisher:
Mr. S Ramalingam
Honorary President
Energy & Fuel Users' Assn. of India

Editorial-cum-Admn. Office:
No.4 B1 J P Tower
7/2 Nungambakkam High Road
Chennai 600 034, INDIA
Phone: 091-44-48502133
Email: enfuse2001@yahoo.com
enfuse2001@gmail.com

EDITORIAL

Dear Reader,

In February 2021, severe winter storms crippled almost the entire energy infrastructure in Texas, USA, causing massive blackouts. The cause of blackout turned out to be insufficient weatherization of power generation plants, including wind turbines and gas-based power plants. This blackout highlights two major issues faced by all countries – the frequent and severe weather events caused by climate change, and how we are all prepared for such events. It also raises questions about the importance of preventing such events, given that the Texas blackouts are expected to have led to losses to the tune of $200 Billion.

We deal with this topic in one of the articles of this edition of the Journal. On a related note, we also have included on the power systems transition and some barriers to renewable technology development. An article on Sustainable Energy for all is also part of the curated content.

We cannot talk of energy transition without talking about the evolution of the energy systems, especially the oil and gas industry. And there is no best chronicler of the history of the industry than Daniel Yergin. This edition contains excerpts from his latest book on Energy Transition. We have included another article on the same subject.

Articles from SRMIT students about the role of the variable alternate energy sources in replacing petroleum fuels find space in this journal. These technologies include Solar, Wind and Biomass, among others.

In addition to the above topics, the regular updates on the various activities of ENFUSE are available in this Journal.

We hope that you find the content of this edition informative and useful. Please let us know your comments and feedback.

Happy Reading!!

MADHAVAN NAMPOOTHIRI

FROM THE PRESIDENT'S DESK

ENFUSE, as in the past has successfully conducted the Mass Awareness Campaign for effective utilization of Petroleum Products on behalf of M/s. Chennai Petroleum Corporation Limited as part of their corporate responsibility during 16th January to 15th February 2021. The programs captioned Oil & Gas Conservation Awareness Drive (Saksham 2021) was conducted in 9 Colleges, 1 Polytechnics & 1 School. This year we had the priviledge of penetrating to the interior of Tamil Nadu, to the Engineering Institutions at Tirunelveli & Mayiladuthurai besides to 1 High School in Mayiladuthurai District. In addition an exclusive programme on Energy Saving & Conservation was conducted through zoom platform for the benefit of CPCL family members also. On the whole Saksham 2021 programs were well received by all the participants and ENFUSE can boast to have the benefit of directly interacting with about 1500 budding professionals during the period .

Reverting back to current affairs, the outline of the climate crisis story brought out eloquently by Al Gore's in his book "An Inconvenient Truth" is very much the same now as it was then. As stated by him, The relationship between human civilization and the Earth has been utterly transformed by a combination of factors, including the population explosion, the technological revolution, and a willingness to ignore the future consequences of our present actions. The underlying reality is that we continue to collide with the planet's ecological system, and Earth's most vulnerable components are crumbling as a result.

On every corner of the globe – on land and in water, in melting ice and disappearing snow, during heat waves and droughts, in the eyes of hurricanes and in the tears of refugees – the world is witnessing mounting and undeniable evidence that nature's cycles are profoundly changing.

As rightly observed by Al Gore, there is at least one absolutely indisputable fact: Not only does human-caused global warming exist, but it is also growing more and more dangerous, and at a pace that has now made it a planetary emergency.

We are dumping so much carbon dioxide into the Earth's environment that we have literally changed the relationship between the Earth and the Sun. So much of that CO2 is being absorbed into the oceans that if we continue at the current rate we will increase the saturation of calcium carbonate to levels that will prevent formation of corals and interfere with the making of shells by any sea creature.

Global warming, along with the cutting and burning of forests and other critical habitats, is causing the loss of living species at a level comparable to the extinction event that wiped out the dinosaurs 65 million years ago. The above climate crisis situations are being brought out in some detail in this issue of the journal for the benefit of readers.

Also, ENFUSE is getting geared up to reactivate the student chapters in various academic institutions in the forthcoming academic year 2021 – 22.

Wishing you safe and healthy days ahead, I look forward to addressing you again in the next issue.
S RAMALINGAM

ENFUSE NEWS

Oil & Gas Conservation Awareness Drive – Saksham 2021 on 16th January to 15th February 2021:

ENFUSE, as in the past has successfully conducted the Mass Awareness Campaign for effective utilization of Petroleum Products on behalf of M/s. Chennai Petroleum Corporation Limited as part of their corporate responsibility during 16th January to 15th February 2021. The programs captioned Oil & Gas Conservation Awareness Drive (Saksham 2021) was conducted in 9 Colleges, 1 Polytechnics & 1 School. This year we had the priviledge of penetrating to the interior of Tamil Nadu, to the Engineering Institutions at Tirunelveli & Mayiladuthurai besides to 1 High School in Mayiladuthurai District.

Also, Workshops in 2 Academic Institutions were conducted with lecturers from students from the institutions on the topic of Energy & Environmental Management". Students of SRMIST conducted a workshop on 28th January 2021 under the title "Oil & Gas Conservation Awareness Drive" with the following topics and the excepts of the same of appearing in the other pages of this issue of the journal.

1. Role of bio mass energy in replacing petroleum fuels
2. Role of wind energy in replacing petroleum fuels
3. Role of solar energy in replacing petroleum fuels
4. Different types of alternate fuels used in internal combustion engines

Technical Meeting was conducted through zoom platform for the benefit of Petro Chemical Industries in Manali belt on 8th February 2020.

Two Emission Test Camps for 2 wheelers and 4 wheelers were conducted at CPCL premises on 9th &10th February 2021. 236 vehicles were tested.

In addition an exclusive programme on Energy Saving & Conservation was conducted through zoom platform for the benefit of CPCL family members.

On the whole Saksham 2021 programs were well received by all the participants and ENFUSE can boast to have the benefit of directly interacting with about 1500 budding professionals during the period besides a large number of public.

World Water Day on 22nd March 2021

World Water Day was absorbed on 22nd March 2021 through a virtual event organized by ENFUSE in association with ENFUSE – SRMIST. Theme lecture was delivered by Er. S Jeyaram, Joint Secretary, ENFUSE on the subjects "Valuing Water" - theme declared by United Nations for the year 2021. Also presentation were made by SRMIST student chapter members on the following subjects:

1. Importance of water and basics of hydropower – by Hariharasudhan, Omm Aryan & Paras Sharma
2. Recent developments and research on hydropower – by Amrudha S, Aswin Krishna

CONTENTS

AN INCONVENIENT TRUTH: THE PLANETARY EMERGENCY OF GLOBAL WARMING AND WHAT WE CAN DO ABOUT IT

Excerpts selected by editors of the American Energy Society.

From Al Gore's An Inconvenient Truth

Some experiences are so intense while they are happening that time seems to stop altogether. When it begins again and our lives resume their normal course, those intense experiences remain vivid, refusing to stay in the past, remaining always and forever with us.

Seventeen years ago my youngest child was badly – almost fatally – injured. This is a story I have told before, but its meaning for me continues to change and to deepen.

That is also true of the story I have tried to tell for many years about the global environment. It was during that interlude 17 years ago when I started writing my first book, *Earth in the Balance*. It was because of my son's accident and the way it abruptly interrupted the flow of my days and hours that I began to rethink everything, especially what my priorities had been. Thankfully, my son as long since recovered completely. But it was during that traumatic period that I made at least two enduring changes: I vowed always to put my family first, and I also vowed to make the

climate crisis the top priority of my professional life.

Unfortunately, in the intervening years, time had not stood still for the global environment. The pace of destruction has worsened and the urgent need for a response had grown more acute.

The fundamental outline of the climate crisis story is much the same now as it was then. The relationship between human civilization and the Earth has been utterly transformed by a combination of factors, including the population explosion, the technological revolution, and a willingness to ignore the future consequences of our present actions. The underlying reality is that we are colliding with the planet's ecological system, and its most vulnerable components are crumbling as a result.

On every corner of the globe – on land and in water, in melting ice and disappearing snow, during heat waves and droughts, in the eyes of hurricanes and in the tears of refugees – the world is witnessing mounting and undeniable evidence that nature's cycles are profoundly changing.

I have learned that, beyond death and taxes, there is at least one absolutely indisputable fact: Not only does human-caused global warming exist, but it is also growing more and more dangerous, and at a pace that has now made it a planetary emergency.

After more than thirty years as a student of the climate crisis, I have a lot to share. I have tried to tell this story in a way that will interest all kinds of readers. My hope is that those read the book and see the film will begin to feel, as I have for a long time, that global warming is not just about science and that it is not just a political issue. It is really a moral issue.

The climate crisis is… extremely dangerous. Two thousand scientists, in a hundred countries, working for more than 20 years in the most elaborate and well-organized scientific collaboration in the history of humankind, have forged an exceptionally strong consensus that all the nations on Earth much work together to solve the crisis of global warming.

The voluminous evidence now strongly suggests that unless we act boldly and quickly to deal with the underlying causes of global warming, our world will undergo a string of terrible catastrophes, including more and stronger storms like Hurricane Katrina, in both the Atlantic and the Pacific.

We are melting the North Polar ice cap and virtually all the mountain glaciers in the world. We are destabilizing the massive mound of ice on Greenland and the equally enormous mass of ice propped up on top of islands in West Antarctica, threatening a worldwide increase in sea levels of as much as 20 feet.

The list of what is now endangered due to global warming also includes the continued stable configuration of ocean and wind currents that has been in place since before the first cities were build almost 10,000 years ago.

We are dumping so much carbon dioxide into the Earth's environment that we have literally changed the relationship between the Earth and the Sun. So much of that CO2 is being absorbed into the oceans that if we continue at the current rate we will increase the saturation of calcium carbonate to levels that will prevent formation of corals and interfere with the making of shells by any sea creature.

Global warming, along with the cutting and burning of forests and other critical habitats, is causing the loss of living species at a level comparable to the extinction event that wiped out the dinosaurs 65 million years ago. That event was believed to have been caused by a giant asteroid. This time it is not an asteroid colliding with the Earth and wreaking havoc; it is us.

Last year, the National Academies of Science in the 11 most influential nations came together to jointly call on every nation to "acknowledge that the threat of climate change is clear and increasing" and declare that the "scientific understanding of climate changes is now sufficiently clear to justify nations taking prompt action."

So the message is unmistakably clear. This crisis means "danger!"

Why do our leaders seem not to hear such a clear warning? It is simply that it is inconvenient for them to hear the truth?

If the truth is unwelcome, it may seem easier just to ignore it.

But we know from bitter experience that the consequences of doing so can be dire….

As Martin Luther King Jr. said in a speech not long before his assassination:

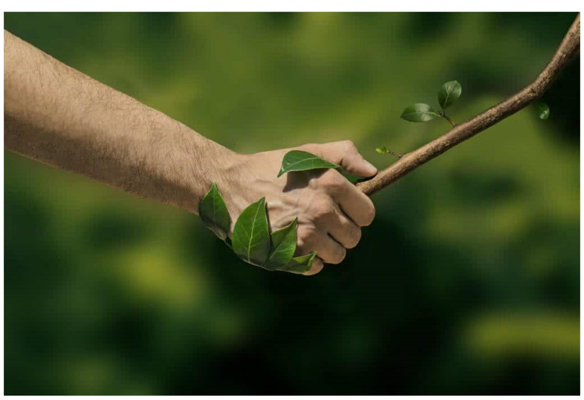
"We are now faced with the fact, my friends, that tomorrow is today. We are confronted with the fierce urgency of now. In this unfolding conundrum of life and history, there is such a thing as being too late."

But along with the danger we face from global warming, this crisis also brings unprecedented opportunities.

What are the opportunities such a crisis also offers? They include not just new jobs and new profits, though there will be plenty of both, we can also build clean engines, we can harness the Sun and the wind; we can stop wasting energy; we can use our planets plentiful coal resources without heating the planet.

The procrastinators and deniers would have us believe this will be expensive. But in recent years, dozens of companies have cut emissions of heat-trapping gases while saving money. Some of the world's largest companies are moving aggressively to capture the enormous economic opportunities offered by a clean energy future.

But there's something even more precious to be gained if we do the right thing.



The climate crisis also offers us the chance to experience what very few generations in history have had the privilege of knowing: a *generational mission*; the exhilaration of a compelling *moral purpose*; a shared and unifying *cause*; the thrill of being forced by circumstances to put aside the pettiness and conflict that so often stifle the restless human need for transcendence; *the opportunity to rise*.

When we do rise, it will fill our spirits and bind us together. Those who are now suffocating in cynicism and despair will be able to breathe freely. Those who are now suffering from a loss of meaning in their lives will find hope.

When we rise, we will experience an epiphany as we discover that this crisis is not really about politics at all. It is a moral and spiritual challenge.

At stake is the survival of our civilization and the habitability of the Earth. Or, as one eminent scientist put it, the pending question is whether the combination of an opposable thumb and a neocortex is a viable combination on this planet.

Courtesy: Excerpts selected by editors of the American Energy Society.

From Al Gore's An Inconvenient Truth

POWERING SUSTAINABLE ENERGY FOR ALL

As a child growing up during the Korean War, I studied by candlelight. Electric conveniences such as refrigerators and fans were largely unknown. Yet within my lifetime, that reality changed utterly. Easy access to energy opened abundant new possibilities for my family and my nation.

Energy transforms lives, businesses and economies. And it transforms our planet — its climate, natural resources and ecosystems. There can be no development without energy. Today we have an opportunity to turn on the heat and lights for every household in the world, however poor, even as we turn down the global thermostat. The key is to provide sustainable energy for all.

To succeed, we need everyone at the table — governments, the private sector and civil society — all working together to accomplish what none can do alone. The United Nations is well-placed to convene this broad swathe of actors and forge common cause between them. That is why I have established our new initiative, Sustainable Energy for All. Our mission: to galvanize immediate action that can deliver real results for people and the planet.

This is the message I will bring to the World Future Energy Summit in Abu Dhabi. As I see it, we face two urgent energy challenges.

The first is that one in five people on the planet lacks access to electricity. Twice as many, almost 3 billion, use wood, coal, charcoal or animal waste to cook meals and heat homes, exposing themselves and their families to harmful smoke and fumes. This energy poverty is devastating to human development.

The second challenge is climate change. Greenhouse gases emitted from burning fossil fuels contribute directly to the warming of the earth's atmosphere, with all the attendant consequences: a rising incidence of extreme weather and natural disasters that jeopardize lives, livelihoods and our children's future.

Sustainable energy for all by 2030 is an enormous challenge. But it is achievable. My vision is for a world with universal energy access coupled with significantly improved rates of energy efficiency and a doubling of renewable energy in our mix of fuel sources. The obstacles are not so much technical as human. We need to raise sustainable energy to the top of the global agenda and focus our attention, ingenuity, resources, and investments to make it a reality.

Consider the precedent of cellular phones. Twenty years ago, universal access to mobile communications seemed preposterous. Yet as governments put proper frameworks in place and the private sector invested resources and pioneered business models, the communications revolution exploded.

A similar paradigm can emerge in sustainable energy. Developing countries can leapfrog conventional options in favor of cleaner energy solutions, just as they leapfrogged land-line based phone technologies in favor of mobile networks. Industrialized countries can and should support this transition to low-emission technologies, not least through their own example.

This is the right thing to do to reduce poverty and protect our planet. It also happens to be the smart thing to do for expanding business opportunities in the world's fastest growing marketplaces. Mobilizing private capital is essential, particularly at a time when public budgets are under strain.

With the right policy frameworks in place, the return on investment can be enormous: increased productivity and growth, job generation, included for grass-roots entrepreneurs, improved public health, enhanced energy security and a more stable climate.

Over the past five years the renewable energy industry has experienced tremendous growth. Capacity is expanding. Performance is improving. Prices are declining. New products are emerging that require less energy. This is a solid foundation upon which to build the next great energy transition.

At least 118 countries have set policy targets or created supportive renewable energy policies. Yet we can, and must, do more. In the lead up to Rio conference on sustainable development, I am urging governments, the private sector and other stakeholders to make concrete commitments that drive action on the ground.

Governments can advance more ambitious national energy plans and targets, provide financial support, and moderate perverse tariffs. Companies can make operations and supply chains more energy-efficient and form public-private partnerships that expand sustainable energy products. Investors can provide seed money for clean technologies. Governments, industry and academia can all contribute new research.

Some argue that in times of economic uncertainty, sustainability is a luxury we cannot afford. I say that we cannot afford to wait. Science and economics reach the same conclusion: advancing economic growth, lifting people out of poverty and protecting our planet are all part of the same agenda: the sustainable development agenda. What connects them is energy. Sustainable energy for all is an idea whose time has come. Turning ideas into action depends on us all.

Courtesy: The New York Times, Ban Ki-moon, Secretary General of the United Nations from 2007 -2016.

REQUEST TO MEMBERS

Keeping in mind that we should start practising what we preach, your Executive Committee is anxious to slowly restrict them printed version of our Quarterly Journal and switch over to e-journals, thereby optimizing the resultant carbon foot prints. All the members (LIFE, INDIVIDUAL) are requested to forward your email ids to our secretariat at your earliest convenience.

Hon. Secretary, ENFUSE

Email: enfuse2001@yahoo.com

POWER SYSTEMS IN TRANSITION

Challenges and opportunities ahead for electricity security

Electricity is an integral part of all modern economies, supporting a range of critical services from healthcare to banking to transportation. The secure supply of electricity is thus of paramount importance. The power sector is going through fundamental changes: decarbonisation with fast growth in variable renewable sources, digitalisation expanding the surface for cyberattacks, and climate change leading to more extreme weather events. In response, governments, industries and other stakeholders will need to improve their frameworks for ensuring electricity security through updated policies, regulations and market designs.

This report surveys the ongoing multiple transformations in the electricity sector, which are leading to a new system in the future. For the first time, three key aspects of electricity security are addressed in one report: energy transitions with more variable renewables, cyber risks, and climate impacts. In addition, the roles of new technologies and demand-side response, and electrification of other sectors are explored. Examples and case studies of all these changes are taken from power systems around the world. Existing frameworks that value and provide electricity security are described, and best practices offered along with recommendations to guide policy makers as they adjust to the various trends underway.

- **Overview**
- **Electricity security matters more than ever**
- **Cyber resilience**
- **Climate resilience**
- **Recommendations**
- **References**
- **Downloads (2)**

Executive Summary

A secure supply of electricity is essential for the prosperity of our societies and indispensable for the 24/7 digital economy. Recent difficulties caused by the Covid-19 pandemic remind us of the critical importance of electricity in all aspects of our lives, from keeping medical equipment working and IT systems available to accommodating teleworking and videoconferencing. Ensuring safe and reliable electricity supply is of paramount importance for all countries.

While electricity only accounts for a fifth of total final energy consumption today, its share is rising. In pathways consistent with the Paris Agreement such as the IEA Sustainable Development Scenario (SDS), the trend will accelerate, and electricity could surpass oil as the main energy source by 2040. Electricity demand increases by roughly 50% in just 20 years in all scenarios of the IEA World Energy Outlook, with growth predominantly concentrated in emerging and developing economies.

Looking ahead, electricity is expected to play a bigger role in heating, cooling, and transport as well as many digitally integrated sectors such as communication, finance and healthcare. The need for robust electricity security measures will become a prerequisite for the proper functioning of modern economies. All this puts electricity security higher than ever on the energy policy agenda.

The power sector landscape has been undergoing dramatic changes, shifting from one characterized by centralized, vertically integrated systems using a relatively small number of large dispatchable thermal power plants to one made up of markets with large numbers of power producers of all sizes, many of which are using variable renewable resources. At the same time, the role of digital technologies is increasing exponentially. New digital technologies provide new opportunities for the economy as well as assisting in the management of these more complex systems, but they also expose the electricity system to cyber threats. While governments and industry are employing measures to mitigate climate change, adapting electricity system infrastructure to the impacts of climate change to preserve its robustness and resilience must become a priority.

These trends call for a broader, widely encompassing approach to electricity security: one that brings together actions taken at the technical, economic and political levels, with the goal of maximising the degree of short- and long-term security in a context that simultaneously comprises energy transitions, cyberthreats and climate impacts. This is the first time that a report considers all three of these aspects together.

Clean energy transitions will bring a major structural change to electricity systems around the world. Variable renewable generation has already surged over the past decade. The trend is set to continue and even accelerate as solar PV and wind become among the cheapest electricity resources and contribute to achieving climate change objectives. In the IEA Sustainable Development Scenario, the average annual share of variable renewables in total generation would reach 45% by 2040.

Such rapid growth in variable renewable resources will help alleviate traditional fuel security concerns, but it will **call for a fast increase of flexibility in power systems**. On the other hand, conventional power plants, which provide the vast majority of flexibility today, are stagnating or declining, notably those using coal and nuclear. On the demand side, electrification will increase demand for electricity, and technology and digitalization are enabling a more active role for consumers as part of more decentralized systems.

Traditional frameworks for ensuring electricity security will not be sufficient in the face of these changes. The challenge for policy makers and system planners is to update policies, regulation and market design features to ensure that power systems remain secure throughout their clean energy transitions.

Experience in a number of countries has shown that variable renewables can be reliably integrated in power systems. Many countries and regions in many parts of the world have succeeded in this task using different approaches and taking advantage of their flexibility resources. They leave to the world a large set of tools and lessons to be integrated into the policy maker toolkit.

Making the best use of existing flexibility assets and ensuring these are kept when needed should be a policy priority. This will require market and regulatory reforms to better reward all forms of flexibility as well as careful adequacy assessments of the impact of decommissioning plans of dispatchable supplies.

However, going forward, new additional flexibility resources need to develop in parallel with expanding solar and wind, especially in emerging and developing economies that are facing strong electricity demand growth. Maintaining reliability in the face of greater supply and demand variability will require greater and more timely investments in networks and flexible resources – including demand side, distributed, and storage resources

– to ensure that power systems are sufficiently flexible and diverse at all times.
Notably, current investment trends do not support such requirements and will need to be upgraded accordingly, sooner rather than later. Grids are a particular concern, as investment has been decreasing by 16.3% since 2015. Grids also require long-term planning, have long construction lead times and often face social acceptance issues.

Building new assets to provide needed adequacy and flexibility will require an update to market design. Increased reliance on renewables will augment the need for technologies that provide flexibility and adequacy to the system. This will include storage, interconnections, natural gas-fired plants in many regions, and demand-side response enabled by digitalisation. Updated approaches to planning will also be necessary, with more advanced probabilistic analyses that account for and enable contributions from all available technologies to adequacy.

Electricity security during energy transitions

Digitalisation offers many benefits for electricity systems and clean energy transitions. At the same time, the rapid growth of connected energy resources and devices is expanding the potential cyberattack surface, while increased connectivity and automation throughout the system is raising risks to cybersecurity.

The threat of cyberattacks on electricity systems is substantial and growing. Threat actors are becoming increasingly sophisticated at carrying out attacks. A successful cyberattack could trigger the loss of control over devices and processes, in turn causing physical damage and widespread service disruption.

While the full prevention of cyberattacks is not possible, electricity systems can become more cyber resilient – to withstand, adapt to and rapidly recover from incidents and attacks while preserving the continuity of critical infrastructure operations. Policy makers, regulators, utilities and equipment providers must play key roles to ensure cyber resilience of the entire electricity value chain.

Governments around the world can enhance cyber resilience through a range of policy and regulatory approaches, ranging from highly prescriptive approaches to framework-oriented, performance-based approaches. Approaches that are more prescriptive have the advantage of allowing for more streamlined compliance monitoring, but they could face challenges in keeping pace with evolving cyber risks. Less prescriptive, framework-based approaches allow for different approaches and implementation speeds across jurisdictions, but they raise questions around how to establish a coherent and robust cross-country approach to cybersecurity with tangible and effective impact. Implementation strategies should be tailored to national contexts while considering the global nature of risks.

Enhancing cyber resilience

The electricity system is witnessing increasing pressure from climate change. Rising global temperatures, more extreme and variable precipitation patterns, rising sea levels and more extreme weather events already pose a significant challenge to electricity security, increasing the likelihood of climate-driven disruption.

While there is a general recognition of these trends and associated risks, **only 17 "IEA family" countries have incorporated concrete actions for climate resilience** of electricity systems into their national adaptation strategies to date. Of those, only six cover the entire electricity value chain.

Enhancing the resilience of electricity systems to climate change brings multiple benefits. More resilient electricity systems reduce damage and loss from climate impacts and bring greater benefits than costs. Moreover, deployment of climate-resilient electricity systems helps developing countries address immediate threats from climate hazards and ensure reliable electricity access. Climate resilience also facilitates clean energy transitions, enabling more electrification solutions and accelerating the transition to renewable energy technologies, which are often sensitive to a changing climate.

Effective policy measures play a significant role in building climate resilience. The benefits of climate resilience and the costs of climate impacts tend to be distributed unevenly across the electricity value chain. This inevitably raises the question of who should be responsible for delivering resilience measures and paying for them. Policy measures for climate resilience can encourage businesses to adopt resilience measures, thus preventing a potential "market failure".

A higher priority should be given to climate resilience in electricity security policies. In many countries, the level of commitment and progress towards climate resilience in the electricity sector still lags behind. Mainstreaming climate resilience in energy and climate policies can send a strong signal to the private sector, inspiring businesses to consider climate resilience in their planning and operation.

Enhancing climate resilience

The three areas above require different security responses. The following overarching principles should be applicable: 1) **Institutionalise**: establish clear responsibilities, incentives and rules; 2) **Identify risks**: undertake regular system-wide risk analyses; 3) **Manage and mitigate risk**: improve preparedness across the electricity supply chain; 4) **Monitor progress**: keep track, record and share experiences ; and 5) **Respond and recover**: cope with outages or attacks and capture the lessons learned.

Framework for action

Electricity security matters more than ever if we are to have successful clean energy transitions. In addition to identifying best practices and innovations already underway around the world, new and updated responses from governments and other stakeholders to ensure security, build off existing frameworks and develop methodologies will enable much needed changes to electricity systems.

Many of us are facing similar challenges. Policy makers, regulators and operators can learn from the experience of other countries and regions. **The IEA will be at the heart of such co-operation.** Co-operation for secure energy transitions

Courtesy: IEA Report

SEVERE POWER CUTS IN TEXAS HIGHLIGHT ENERGY SECURITY RISKS RELATED TO EXTREME WEATHER EVENTS

Exceptionally cold weather hitting the United States has provoked an electricity shortage in Texas, with extensive power cuts affecting over 4 million customers. The crisis was a combination of factors as cold weather drove up demand and hampered supply from the gas system and from power plants. The outages are far larger and much longer lasting than the rotating cuts during the exceptionally hot weather in California last August.

The cold weather had three main impacts on the Texas power system that led to this situation:

Much higher electricity demand: Cold weather is driving electricity demand far higher than normal. High temperatures in Dallas were -9° C on February 15, 25° C cooler than the average temperature in February. As 60% of Texans heat themselves with electricity, winter power demand is very sensitive to temperature changes. The unusually cold temperatures led to new winter peak records rivalling the summer peak. Market prices hit the cap of USD 9 000 per MWh.

Lower natural gas production: Most of Texas' electricity demand is met with natural gas. When demand rises, nearly all the incremental supply comes from gas-fired power generation. But the cold weather hampered gas production, with frozen gas wells contributing to a 20% cut in South Central's gas production. As a result, there wasn't enough to supply the system's gas generators.

Generation equipment outages: The unavailability of natural gas resulted in gas generators declaring their resources unavailable (for a total of up to 31 GW). Some wind turbines were also frozen cutting their potential output (about 2.5 GW to 3 GW on average for 15-16 February) although low wind was a more significant issue. Coal plants are operating 40% below rated capacity, and one of the four nuclear facilities in the state was shut down due to weather-related loss of feed water pumps.

Texas has a power shortage because it has a gas shortage. Given the key role gas-fired generation plays in many power systems today, resilient power systems depend on resilient natural gas systems. For the future, system planners will need to take account of increasingly extreme weather that is both hampering the supply of power and fuel and driving up demand. This should include modern planning criteria to encompass a broad range of threats to the power system. This will be particularly important as electrification of heating grows as part of clean energy transitions, underscoring the importance of efficiency in limiting demand growth.

Extreme temperatures are putting today's power systems in transition to fresh tests. Avoiding major outages in the electricity systems is also crucial to ensure solid societal support for clean energy transitions. Market designs and regulations need to improve to make the best use of existing assets and to encourage new investments both in supply and demand for flexibility and capacity adequacy.

The IEA has been focusing greater attention on electricity security as shown in its first comprehensive electricity security report, "Power Systems in Transition", and stands ready to support its member and partner countries' efforts for building secure, affordable and sustainable electricity systems.

Summary

The Electricity Reliability Council of Texas (ERCOT) called a Stage 3 emergency on 15 February and began rolling power cuts that affected 4 million customers. It shed as much as 27 GW of load, or about 35% of forecasted demand. These conditions continued through 17 February, with a slight easing on 18 February as milder temperatures reduced demand. Demand was projected to reach near all-time records on 15 February, but rotating power cuts and the response of other customers resulted in effective demand that was up to 27 GW below forecast.

ERCOT has stated that 16.5 GW of customer demand was shut off due to energy supply shortages (load shedding) for most of 15 February and remained near this level until midday on 17 February before easing to 6 GW in early 18 February. Using these figures, the amount of load shedding in the system for 15-16 February is conservatively estimated to be around 800 GWh. The difference between forecast and actual load is another rough estimate of shedding and other extreme measures taken by customers. That figure reached 27 GW at 9 pm on 15 February and totaled 500 GWh for the day.

In comparison, the California rolling power cuts lasted about two hours and resulted in about 1.5 GWh of lost load. Using these figures as rough estimates, the level of outage in Texas on 15-16 February was over 500 times higher than in California during last summer's load shed event.

Neighboring systems are also suffering rolling power cuts, as the Southwest Power Pool (SPP), whose system includes parts of Texas, Oklahoma, Arkansas, Missouri, Kansas, Nebraska and South Dakota, called for 15 00 MW of load cuts at 10 am, and Midcontinent ISO (MISO), whose system includes parts of Texas, Louisiana, Arkansas, Missouri, Illinois, Indiana, Michigan, Wisconsin, Minnesota, Iowa and North Dakota, was forced to call rotating power outages for a short period on the morning of 15 February. Power outages in northern Mexico reached nearly 5 million customers as well.

Current demand levels are wildly above even the most extreme forecasts. The day-ahead forecast peak for 15 February stood at 74.5 GW, which is almost 10 GW above the previous all-time winter peak of 65.9 GW on 17 January 2018 and 7 GW above the extreme weather forecast load in the most recent seasonal assessment. The all-time peak in any season was 74.8 GW on 19 August 2019. Market prices hit the USD 9 000 per MWh cap and have remained there.

Temperature sensitivity to demand is high in Texas, especially at very cold temperatures due to the use of electricity for space heating. As this is a region that is not regularly exposed to extreme cold but usually extreme heat, buildings are designed with systems to reflect this, including lower efficiency heating systems and lack of passive solar heating.

Generator performance of all types have suffered in the low temperatures. Generation from coal-fired power plants was 60% of rated capacity on 15 February, a shortfall of 6 GW. One of the four nuclear units in the state went out of service in the morning of 15 February. Gas-fired generation has a rated winter capacity of 55 GW but output dropped to 31 GW on 15 February due to issues throughout the supply chain – freezing wellheads, pipeline derates and generator equipment failures all contributed. Wind generation was about half of its 6.1 GW seasonal rating. This is both a demand and supply story – record loads and unavailable generation.

Texas has 25 GW of installed wind capacity and expected average output of 6.1 GW in February. Output on 15 February averaged 3 GW – or about half of that expected and fell as low as 0.65 GW in the early evening – 2.6% of maximum output. Wind performance improved on 16 February to an average of 3.8 GW but still fell short of expectations. Wind generation was affected by low wind speeds and freezing components. Wind generation came up short of expected output, but was not the main driver of the shortfall.

As a consequence of cold temperatures, natural gas demand in the continental United States increased by over 15% between 6 February and 15 February, with gas deliveries reaching a two-day record on 14-15 February. Residential and commercial sectors and the power sector accounted for over 70% of total gas demand.

In Texas the power sector was the most important driver of demand. Natural gas accounts for 53% of the generating capacity in ERCOT. It is mainly gas generation that meets the majority of the increase during periods of high demand, and demand for gas for power in ERCOT more than tripled – between 6 and 15 February – a demand increase close to 4 billion cubic feet (bcfd) (or 110 million cubic meters). Unfortunately, while the cold weather drove up the demand for natural gas in the power sector, it also reduced the production of natural gas so that there was not enough gas to supply the increased needs of power generators. It was the shortfall in gas supply that led over half of the natural gas capacity in Texas (31 GW) to be unavailable, leading to rotating cuts. This insatiable demand drove natural gas prices to unprecedented highs. Prices at key hubs in Texas such as Katy and Waha settled above USD 200/MBtu, whilst intraday prices at the OGT hub in Oklahoma soared to an historical record of USD 999/MBtu on 16 February 2021. Henry Hub prices rose to USD 16.95/MBtu –the highest level since February 2003.

Dry gas production in continental United States fell by over 15% between 5 February and 15 February, primarily due to wellhead freeze-offs, reported across key producing regions. Freeze-offs typically occur when water produced alongside raw natural gas crystalizes due to low temperatures and blocks off the producing well. The drop in production was particularly dramatic in the South Central region, including Texas, and especially impacting the gas output from the Permian basin, the Haynesville and Fayetteville plays, where freeze protection of wells is uncommon. It is estimated that as a result of wellhead freeze-offs, net pipeline receipts in the South Central region dropped by 20% between 6 February and 16 February.

Upstream underperformance had a direct impact on regional pipeline systems, as lower supplies resulted in a thinner linepack which reduced short-term balancing capabilities of pipeline operators. It has been reported that several gas pipelines and processing plants in Texas had to shut down and/or limit their operations due to freezing. In addition, certain pipeline companies experienced horsepower issues at their compressor stations, further reducing the physical deliverability and operational flexibility of the gas system. Over thirty gas pipelines have declared force majeure and/or issued operational flow orders, which effectively restricted upward nominations of shippers and, as such, limited incremental gas supplies to customers.

In addition to pipelines, certain storage sites experienced a rapid drawdown that significantly reduced the volumes of working gas and, consequently, pressure levels, leading to curtailed operations at some. For example, the Keystone Gas Storage facility in the Permian issued a force majeure notice in the morning of the 15 February for an 8-hour-long outage that reduced its withdrawal rate to just 35% of the technical capacity. The force majeure was lifted in the afternoon, however, withdrawal rates remained subdued, just above 50% of the technical withdrawal capacity due to low cavern pressures.

The decline in natural gas supplies to the ERCOT market area effectively led to the shut-in of an estimated 31 GW gas-fired power generation capacity on 15 February and was the main reason for the capacity shortfall.

Gas deliveries to Mexico have also fallen. Since 12 February, the Federal Electricity Commission of Mexico requested the declaration of operational state of alert in the wake of lower gas supplies. On 15 February, pipeline imports from the United States were 1.2 bcf/d (over 33 mcm/d) lower than expected, affecting 6.9 GW of gas-fired power generation capacity. This resulted in power cuts affecting 4.7 million customers in northern Mexico.

Feedgas flows to US LNG terminals practically halved between 8 and 15 February, falling to their lowest levels since Hurricane Sally in September 2020. Freeport LNG has reportedly shut Train 1 on 15 February due to sever weather conditions. On 16 February, the governor of Texas requested Freeport LNG to curb LNG exports from Train 2 and 3 amid natural gas feed shortages in the state. LNG producer Cheniere Energy has reportedly also curbed operations at the Corpus Christi LNG terminal to reduce demand for feedgas.

ERCOT lacks strong interconnections with its neighbors, with DC connections of only 820 MW with SPP and 430 MW with Mexico. This increases the burden on in-state resources to be able to cope with unforeseen events like the current cold snap. There is no connection with MISO South to the east or to the utilities in the west, which would diversify load and resource balancing. MISO includes significant coal-fired generation capacity, which makes up 50% of its generation mix.

ERCOT also relies on its energy-only market design to ensure resource adequacy, as opposed to formal capacity markets. The high price cap of 9 000 USD/MWh is expected to attract sufficient resources to achieve its reliability standard, but there are no other mechanisms that incentivise resource adequacy. As a result, ERCOT has the lowest reserve margin of any region in North America.

Reliability standards attempt to balance the costs of reserving capacity that is mostly idle against the benefits of enhanced electricity security. The low reserve margin dictated by the market design in ERCOT has kept wholesale energy prices lower than other regions, and it is close to optimal, according to their calculations. In addition, the presence of capacity mechanisms has not removed the risk of costly outages in other systems such as PJM. But additional resource adequacy mechanisms, like capacity markets or strategic reserve payments that keep firm supplies from exiting the market, might be justified for security of supply reasons. Regional interconnections are limited, and reserve margins are small.

The experience in Texas and the US Midwest follows on challenges recently faced by the power systems in Japan and last summer's rotating outages in California. It is clear that extreme temperatures are putting today's power systems in transition to fresh tests. Policy makers should attempt to build resilient systems that increasingly take into account extreme weather events by examining their systems from end to end. This should include modern planning criteria to encompass a broad range of threats to the power system.

While the situation is not resolved in Texas, there are already three clear lessons for electricity security related to the reliability of the natural gas system, the challenge of more extreme weather, and the increasing role of electricity for space heating.

- In Texas and in many power systems today, **a resilient electricity system requires a resilient natural gas system**. This is particularly so for Texas, which has an energy system with a high penetration of electricity in space heating and a large share of gas-fired generation despite an increasing share of variable renewables in the power generation mix. As more power systems become reliant exclusively on natural gas to provide incremental supply in extreme temperatures, the reliability of the gas system becomes critical for electricity security. The resilience of those energy systems will depend to a great extent on the robustness of the physical deliverability of the gas network – which should become a key parameter for electricity security assessments in the coming years.

- **System planners need to ensure that power systems are resilient to increasing weather extremes.** The past is increasingly less predictive of the future. Power systems are facing new weather extremes that are challenging the performance of all types of generating resources and networks. In Texas, while the shortfall in the gas system was critical, coal and nuclear plants also experienced outages, and wind generators significantly underperformed expectations. In other events, damage to grid has hampered electricity security. Increasingly, planners should examine the best data and modeling in order to anticipate the potential for stressed conditions that may occur outside of historical peak periods.

- Energy systems with heavy dependence on electricity for space heating will be challenged by exceptionally cold temperatures. High dependence on electricity in space heating can result in strong market volatility when the energy system faces exceptionally cold temperatures. This will become more important as electric space heating becomes more widespread as part of decarbonisation strategies. Electrification of end uses should go hand in hand with energy efficiency, including weatherisation of buildings, passive solar heating, and other measures. This will help to moderate peak demand as systems become more reliant on electricity.

The rolling cuts in Texas are a reminder that electricity security cannot be taken for granted. It must remain a top priority for policy makers, especially as electricity becomes more important for the entire energy system with increased electrification of many sectors and threats to energy security evolve and multiply and as clean energy transitions accelerate. Avoiding major outages in the electricity systems is also crucial to ensure solid societal support for clean energy transitions. Market designs and regulations need to improve to make best use of existing assets and to encourage new investments both in supply and demand for flexibility and capacity adequacy. The IEA has been focusing more on electricity security as shown in its first comprehensive electricity security report "Power Systems in Transition", and stands ready to support its member and partner countries' efforts for building secure, affordable and sustainable electricity systems.

Courtesy: Natural Gas Commentary
Keith Everhart, Energy Analyst – Renewables Integration and Secure Electricity
Gergely Molnar, Energy Analyst –

THE EPIC QUEST FOR OIL, MONEY & POWER

Winston Churchill changed his mind almost overnight. Until the summer of 1911, the young Churchill, Home Secretary, was one of the leaders of the "economists," the members of the British Cabinet critical of the increased military spending that was being promoted by some to keep ahead in the Anglo—German naval race. That competition had become the most rancorous element in the growing antagonism between the two nations. But Churchill argued emphatically that war with Germany was not inevitable, that Germany's intentions were not necessarily aggressive. The money would be better spent, he insisted, on domestic social programs than on extra battleships.

Then on July 1, 1911, Kaiser Wilhelm sent a German naval vessel, the Panther, steaming into the harbor at Agadir, on the Atlantic coast of Morocco. His aim was to check French influence in Africa and carve out a position for Germany. While the *Panther* was only a gunboat and Agadir was a port city of only secondary importance, the arrival of the ship ignited a severe international crisis. The buildup of the German Army was already causing unease among its European neighbors; now Germany, in its drive for its "place in the sun," seemed to be directly challenging France and Britain's global positions. For several weeks, war fear gripped Europe. By the end of July, however, the tension had eased—as Churchill declared, "the bully is climbing down." But the crisis had transformed Churchill's outlook. Contrary to his earlier assessment of German intentions, he was now convinced that Germany sought hegemony and would exert its military muscle to gain it. War, he now concluded, was virtually inevitable, only a matter of time.

Appointed First Lord of the Admiralty immediately after Agadir, Churchill vowed to do everything he could to prepare Britain militarily for the inescapable day of reckoning. His charge was to ensure that the Royal Navy, the symbol and very embodiment of Britain's imperial power, was ready to meet the German challenge on the high seas. One of the most important and contentious questions he faced was seemingly technical in nature, but would in fact have vast implications for the twentieth century. The issue was whether to convert the British Navy to oil for its power source, in place of coal, which was the traditional fuel. Many thought that such a conversion was pure folly, for it meant that the Navy could no longer rely on safe, secure Welsh coal, but rather would have to depend on distant and insecure oil supplies from Persia, as Iran was then known. "To commit the Navy irrevocably to oil was indeed 'to take arms against a sea of troubles,' " said Churchill. But the strategic benefits—greater speed and more efficient use of manpower—were so obvious to him that he did not dally. He decided that Britain would have to base its "naval supremacy upon oil" and, thereupon, committed himself, with all his driving energy and enthusiasm, to achieving that objective.

There was no choice—in Churchill's words, "Mastery itself was the prize of the venture."

With that, Churchill, on the eve of World War I, had captured a fundamental truth, and one applicable not only to the conflagration that followed, but to the many decades ahead. For oil has meant mastery through the years since. And that quest for mastery is what this book is about.

Though the modern history of oil begins in the latter half of the nineteenth century, it was the twentieth century that was completely transformed by the advent of petroleum. In particular, three great themes underlie the story of oil.

The first is the rise and development of capitalism and modern business. Oil is the world's biggest and most pervasive business, the greatest of the great industries that arose in the last decades of the nineteenth century. Standard Oil, which thoroughly dominated the American petroleum industry by the end of that century, was among the world's very first and largest multinational enterprises. The expansion of the business in the twentieth century—encompassing everything from wildcat drillers, smooth-talking promoters, and domineering entrepreneurs to highly trained scientists and engineers, great corporate bureaucracies, and state-owned companies—embodies the evolution of business, of corporate strategy, of technological change and market development, and indeed of both national and international economies. Throughout the history of oil, deals have been done and momentous decisions have been made— among men, companies, and nations—sometimes with great calculation and sometimes almost by accident. No other business so starkly and extremely defines the meaning of risk and reward—and the profound impact of chance and fate.

The second theme is that of oil as a commodity intimately intertwined with national strategies and global politics and power. The battlefields of World War I established the importance of petroleum as an element of national power when the internal combustion machine overtook the horse and the coal- powered locomotive. Petroleum was central to the course and outcome of World War II in both the Far East and Europe. The Japanese attacked Pearl Harbor to protect their flank as they grabbed for the petroleum resources of the East Indies. Among Hitler's most important strategic objectives in the invasion of the Soviet Union was the capture of the oil fields in the Caucasus. But America's predominance in oil proved decisive, and by the end of the war German and Japanese fuel tanks were empty. In the Cold War years, the battle for control of oil between international companies and developing countries was a major part of the great drama of decolonization and emergent nationalism. The Suez Crisis of 1956, which truly marked the end of the road for the old European imperial powers, was as much about oil as about anything else. "Oil power" loomed very large in the 1970s, catapulting states heretofore peripheral to international politics into positions of great wealth and influence, and creating a deep crisis of confidence in the industrial nations that had based their economic growth upon oil. Oil was at the heart of the first post–Cold War crisis—Iraq's 1990 invasion of Kuwait.

A third theme in the history of oil illuminates how ours has become a "Hydrocarbon Society" and we, in the language of anthropologists, "Hydrocarbon Man." In its first decades, the oil business provided an industrializing world with a product called by the made-up name of "kerosene" and known as the "new light," which pushed back the night and extended the working day. At the end of the nineteenth century, John D. Rockefeller had become the richest man in the United States, mostly from the sale of kerosene. Gasoline was then only an almost useless by-product, which sometimes managed to be sold for as much as two cents a gallon, and, when it could not be sold at all, was run out into rivers at night. But just as the invention of the incandescent light bulb seemed to signal the obsolescence of the oil industry, a new era opened with the development of the internal combustion engine powered by gasoline. The oil industry had a new market, and a new civilization was born.

For most of this century, growing reliance on petroleum was almost universally celebrated as a good, a symbol of human progress. But no longer. With the rise of the environmental movement, the basic tenets of industrial society are being challenged; and the oil industry in all its dimensions is at the top of the list to be scrutinized, criticized, and opposed. Efforts are mounting around the world to curtail the combustion of all fossil fuels – oil, coal, and natural gas – because the resultant smog and air pollution, acid rain, and ozone depletion, and because of the specter of climate change. Oil, which is so central a feature of the world as we know it, is now accused of fueling environmental degradation; and the oil industry, proud of its technological prowess, and its contribution to shaping the modern world, finds itself on the defensive, charged with being a threat to present and future generations.

Yet Hydrocarbon Man shows little inclination to give up his cars, his suburban home, and what he takes to be not only the conveniences but the essentials of his way of life. The peoples of the developing world give no indication that they want to deny themselves the benefits of an oil-powered economy, whatever the environmental questions. And any notion of scaling back the world's consumption of oil will be influenced by the extraordinary population growth ahead…. The global environmental agendas of the industrial world will be measured against the magnitude of that growth. In the meantime, the stage has been set for one of the great and intractable clashes of the 1990s between, on the one hand, the powerful and increasing support for greater environmental protection and, on the other, a commitment to economic growth and the benefits of Hydrocarbon Society, and apprehension is about energy security.

Daniel Yergin is a leading authority on energy, geopolitics, and the global economy, bestselling author, and a winner of the Pulitzer Prize. He is Vice Chairman of IHS and founder of IHS Cambridge Energy Research Associates. Dr. Yergin is known around the world for his book The Prize: the Epic Quest for Oil Money and Power, which was awarded the Pulitzer Prize. It became a number one New York Times best seller and has been translated into 20 languages.

Courtesy: Excerpts from 1991 and 2011 prologues of "The Prize," selected by editors of the American Energy Society.

REQUEST TO STUDENT MEMBERS

You may kindly note that you are receiving the soft copy of the ENFUSE Journal individually addressed to your email. You are requested to interact with ENFUSE Secretariat with your comments / observations / suggestions for improvements. Also, you are requested to forward your articles for publication in the journal.

Student members who have not notified their email ids are requested to act immediately.

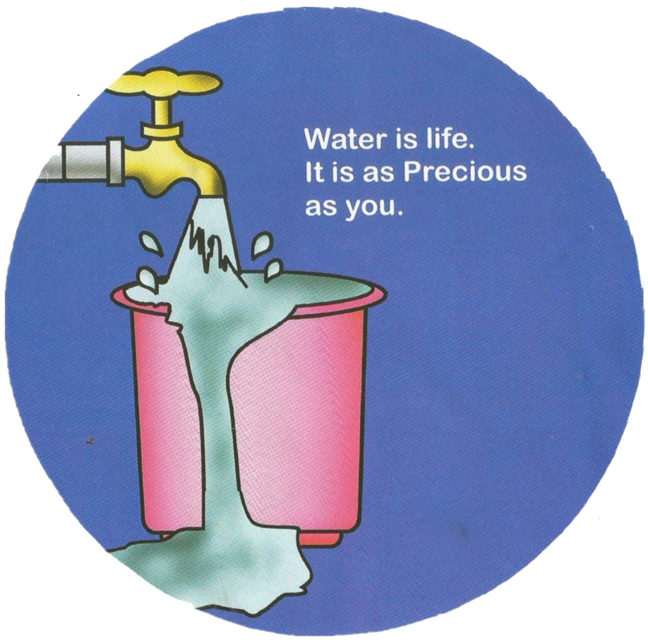
S RAMALINGAM
President

FUEL CONSERVATION DRIVE - JANUARY – FEBRUARY 2021

SAKSHAM 2021

SWACHH INDHAN, SWASTH VATAVARAN

GREEN & CLEAN ENERGY



Unfortunately, a lot of fuel is wasted.

The saddest thing is that after paying so much, a lot of people carelessly waste this precious liquid

- *In kitchens, gas and kerosene stoves many times burn unnecessarily*
- *The black smoke you see coming out of automobiles means a big waste of oil*
- *In factories and firms, lot of precious oil is wasted through bad working machines/ methods*

ONLINE ESSAY WRITING COMPETITION

THEME: "ENERGY TRANSITION – GREEN & CLEAN ENERGY"

The CPCL Essay writing competition aims to raise awareness among youth about energy conservation and environment management in industrial, transport, agriculture and domestic sector.

PARTICIPANTS

STUDENT MEMBERS OF ENERGY & FUEL USERS' ASSOCIATION OF INDIA FROM ENGINEERING INSTITUTIONS

SEND ENTRIES

enfuse2001@yahoo.com

Last date for submission of entries: 1st June 2021

The top 3 essays will be awarded prizes and will be published in the subsequent issues of the ENFUSE journal. All participants will be given e-certificate.

The result will be published in the journal

Instruction:

1. ***One essay per participant***
2. ***The essay can be written in English***
3. ***Students should write their Name, Institution, Academic Year, Email ID and Mobile number***

THE SEVEN SISTERS: THE GREAT OIL COMPANIES AND THE WORLD THEY SHAPED

1. Anglo-Iranian Oil Company (now BP)
2. Gulf Oil (later part of Chevron)
3. Royal Dutch Shell
4. Standard Oil Company of California (now Chevron)
5. Standard Oil Company of New Jersey (Esso, later Exxon, now ExxonMobil)
6. Standard Oil Company of New York (Socony, later Mobil, also now part of ExxonMobil)
7. Texaco (later merged into Chevron)

These seven companies – five American, one British, one Anglo-Dutch – had all become major powers in the oil industry before the 'twenties. There were many others, including the other offspring of the Rockefeller's Standard Oil, that were to play important roles. But it was the seven 'majors' who were to dominate the world oil business in the following decades, and to become new kinds of industrial organization – in some respects the forerunners of the modern multinational corporation. Each of them soon developed into an 'integrated oil company' controlling not only its own production, but also transportation, distribution and marketing. With their own fleets of tankers, they could soon operate across the world in every sector of the industry, from the 'upstream' business of drilling and producing at the oilfields, to the 'downstream' activity of distributing and selling at the pumps or the factories. And each company strove, with varying success, to be self-sufficient at both ends, so that their oil could flow into their tankers through their refineries to their filling-stations.

There were plenty of signs that the seven companies were competing, often ferociously, to sell their precious fuel: and nowhere was the competition more evident than in the promotion of the new product gasoline for the new automobiles. The names Standard, Gulf or Texaco, first on cans, then on filling-stations, then on the bright signs sticking up from the landscape were visible symbols of choice facing the consumer. Yet the competition also had striking limitations. It was not just that the product, as far as any consumer could detect, was identical – much more identical than cars or soaps. Nor that the new garages and filling-stations seemed to huddle in clusters on the roadside as if they dreaded to stick their tall necks out alone. More seriously disturbing for the advocates of free enterprise was the tendency of the giant companies, as they ventured further abroad, to cling together in consortia and to reach hidden understandings with each other in their attempts to bring order to the volatile market. The name the Seven Sisters, that came to be applied to them and which they so much resented, was not altogether inappropriate. Like the classical sisters, who were translated by Zeus into stars, they seemed to have acquired immortality. But also like mortal sisters, they fought and competed with each other, while still preserving a family likeness and closing ranks when challenged by outsiders.

In the words of Calouste Gulbenkian "Oilmen are like cats; you can never tell from the sound of them whether they are fighting or making love"

The American companies had begun with their production safely based in their own home country, and their government was more concerned with protecting the consumer than with national security. But as the future of American oil became more uncertain, the companies began to look abroad for their supplies and thus to become much more deeply involved with diplomacy. The relationships between the company headquarters and Washington thus became both closer and more barbed.

The First World War made all Western governments painfully aware of the importance of oil for survival, and led to the development of what was called 'oleaginous diplomacy.' The dependence on oil for survival became obvious as the war extended – fought with planes, cars, and tanks – and the oil tankers were critical for supplies. 'Oil,' said Clemenceau, 'is as necessary as blood.' 'We must have oil,' said Foch, 'or we shall lose the war.' 'The allies,' said Lord Curzon in a phrase much quoted by oilmen, 'floated to victory on a wave of oil.' The Germans were desperately short of oil, while Britain had access to the Persian oil from BP at Abadan, and to Shell oil from Mexico and the East Indies. But still by far the biggest source of supply was America and 80 percent of all Allied oil supplies came from the United States. A quarter of all the allies' oil came from a single company: Exxon.

After the war the United States was still easily the leading oil producer in the world and far the biggest consumer. In the post-war years there was a new rush of consumption, with the multiplication of automobiles and the building of a new lifestyle based on cheap oil. The right to travel cheaply, to have cheap electricity and cheap heating, became regarded as part of American democracy and the whole landscape was already being transformed by the product. As the two English authors Davenport and Cooke described it in 1923:

Travel but a little in the country and you will gain the impression that the modernism of the United States flowed from its oil wells. Outwardly, oil occupies there the place which coal occupies in Great Britain. The oilfield derrick is as familiar a landmark to the American as the pithead wheels to the workers in our 'black country'. The oil-tank car is as ubiquitous on his railroads as the coal-truck on ours. The oil-tin litters his waste places. His wayside is dotted with the petrol pump and at night illuminated oil 'filling stations' make his streets beautiful. A network of oil pile-lines underlies his country, more extensive than the network or railways overlying ours… Does not the American partly live in oil? Certainly, he cannot move without it. Every tenth man owns an automobile, and the rest are saving up to buy one.

But now there was once again the nightmare of a world shortage. The American Secretary for War, Josephus Daniels, who had confronted Socal over the Californian naval reserves, was appalled by the rapid depletion; and in 1920 the Director of the U.S. Geological Survey pronounced that the American oil situation 'can best be characterized as precarious.'

Both Americans and Europeans began a new scramble for oil, with new bitterness between the haves and the have-nots. The British and French tried ruthlessly to establish their own sources of oil in the Middle East, which they regarded as their own equivalent of Texas. They were determined to exclude America, which had its own oil anyway. But the Americans argued that it was quite wrong that they should provide the world our of their dwindling reserves, while they were shut out of foreign oil. They had helped to win the war, and were entitled to its spoils. In the post-war years, both companies and governments came into sharper conflict. The State Department supported more closely the interests of oil companies abroad, and the new intimacy was further encouraged by the administration of President Harding (whose benign attitude to oilmen eventually extended into the Teapot Dome Scandal). The relationships were often confusing. Ostensibly the companies were the boxers in the big fights, and the governments were the seconds, providing encouragement or reproof. This meant that when the fight was most critical, the governments were out of the ring. The companies – as we shall see – usually had their own way in the end. But it was never quite clear who was using whom.

To radical critics, it looked as if the State Department had simply abdicated the whole process of oil diplomacy to the oilmen. The government, however much they might distrust the oilmen, were not prepared to set up their own organization. They preferred to use the oil companies, at a discreet distance, as the instruments of national security and foreign policy. The British government, being totally dependent on imported oil, had closer relationships, as we have seen, with the two oil companies. But they preferred not to be closely involved with such a controversial commodity, and, in Britain, too, the heads of the companies began to play important roles in forming foreign policy.

Courtesy: Excerpt from Antoy Sampsons award winning book The Seven Sisters

Global CO2 emissions have rebounded strongly after their Covid slump

The Covid-19 crisis in 2020 triggered the largest annual drop in global energy-related carbon dioxide emissions since the Second World War, according to **recent IEA data**, but the overall decline of about 6% masks wide variations depending on the region and the time of year.

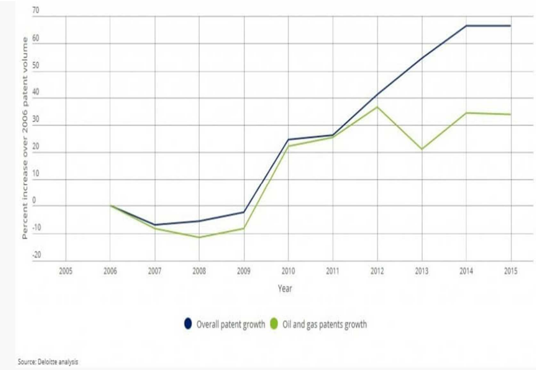
After hitting a low in April, global emissions rebounded strongly and rose above 2019 levels in December. The latest data show that global emissions were 2%, or 60 million tonnes, higher in December 2020 than they were in the same month a year earlier. Major economies led the resurgence as a pick-up in economic activity pushed energy demand higher and significant policies measures to boost clean energy were lacking. Many economies are now seeing emissions climbing above pre-crisis levels.

Courtesy: I E A

THE ARC OF INNOVATION IN THE OIL AND GAS INDUSTRY USING US PATENT DATABASES TO TRACK TRENDS

The oil and gas business has a rich history of continuous innovative and technological advances, across the value chain, that have enabled the development of new and challenging resource types and given the ability to respond to customer needs, all while continually improving safety and environmental performance. This research series uses the US patent database to tell the story of oil and gas innovation.

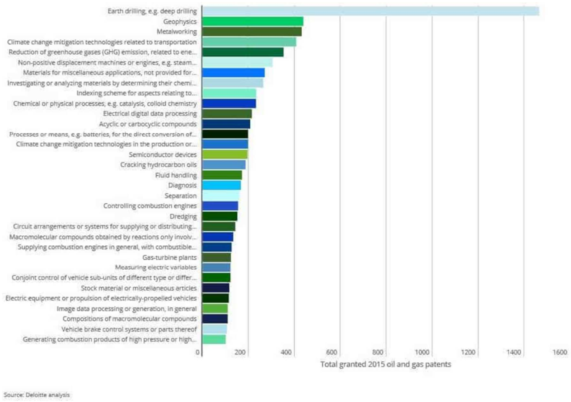
In both O&G patents and the entire patent universe, filings dipped going into the Great Recession in 2008. This decline was followed by a period of rapid intellectual property acquisition in both segments that lasted until 2012. However, after 2012, while the oil and gas industry continued to produce a significant number of patents, it did not generate the same rates of increase as the rest of the patent universe. While the absolute number of oil and gas patents was considerably higher than a decade earlier, the five-year compound annual growth rate for oil and gas patents was 1.3 percent compared to 5.7 percent for the overall patent universe.



Increase in patent activity over time

In spite of general steady growth, some O&G technologies showed an uptick in growth rate over the defined period. Earth drilling, the single largest O&G technology area has grown at a rate higher than the rest of the patent universe. In addition, metalworking, dredging, and gas turbine technologies have all grown substantially faster than the rest of the patent universe (as shown in the figure below). The same data shows that other categories of patents, specifically those related to cracking hydrocarbon oils, acyclic or carbocyclic compounds, and chemical or physical processes used in O&G applications (patents can have multiple classifications), have had markedly lower rates of growth than the rest of the patent universe.

While these changes in the volume of original filings allow us to identify the dominant new technology areas for oil and gas and determine how their relative importance is changing, a look at trends in patent citations can help in understanding how knowledge flows between different O&G technologies.



Linking for Innovation: The Changing O&G Knowledge Network

Granted patents from the USPTO reveal a great deal about the oil and gas knowledge network.[1] By measuring how knowledge flows to and from technologies within the oil and gas industry, we can learn how the structure of knowledge in the industry is evolving. In Deloitte's patent knowledge maps, circles represent technology categories while connections between them appear when patents from one technology draw on innovations from patents in other technology areas. In 2006, almost all major innovation links in oil and gas, except for a few stragglers, directly related to earth drilling.

How Knowledge has Grown in the Oil and Gas Space Over Time

This pattern of dominance by earth drilling technology continued mostly unchanged until 2012. By this point, distinct other technology clusters had emerged, and while earth drilling was still dominant, it was not as uniformly dominant as in prior years.

By 2012, lesser-cited categories such as metalworking (patents comprising of new processes, tools, machines, and apparatus made from metal) had emerged as a key linking technology, or a bridge, between earth drilling and other O&G-related technologies. Combined with its high growth rate of 192 percent from 2006–2015, metalworking has become a technology area that has not only grown in volume but seemingly also in its significance within the oil and gas knowledge network.

Deloitte's analysis also identified individual patents that were frequently cited by oil and gas patents. Surprisingly, a significant focus of quite recent metalworking patents remains in the field of kerogen, which is extensively leveraging the work done in 2008–2009 around low-temperature barriers for in situ processing of the immature hydrocarbon deposits of oil shale fields. Sample metalworking O&G patents produced between 2006 and 2015 that have received a large number of citations by other oil and gas patents are:

Patents most frequently cited in O&G patents	Year
Double barrier system for an in situ conversion process	2009
Low temperature barriers with heat interceptor wells for in situ processes	2008
Low temperature barrier wellbores formed using water flushing	2009
In situ conversion process utilizing a closed loop heating system	2009
Low temperature monitoring system for subsurface barriers	2009

Patents most frequently cited in O&G patents

This important position for metalworking remained consistent in 2015 as it provided the link between earth drilling and other technologies including gas turbine plants, non-positive displacement machines, and non-positive displacement pumps.

Metalworking and other bridging technologies (like chemistry, shown in a smaller network in the bottom right of the above diagram) should not be regarded simply as sideshows in the growth of knowledge at oil and gas firms. They represent key strategic "bridges" of intellectual property that connect back to the singularly important task of earth drilling.

Companies seeking flexibility in their development path should consider additional investment in these bridge technologies—which we refer to "technological pressure points"—as areas with the potential to have disproportionate impact. These changes in the shape of the O&G technology network indicate vibrancy and dynamism within the O&G patent universe.

Measuring Innovation: The Energy Innovation Index

While noting historical trends in O&G patent filings, the question remains whether innovation is fundamentally changing how O&G relates to the broader non-O&G patent universe.

A unique way to measure the impact of innovation is to consider the extent to which oil and gas patents are being leveraged over time by non-O&G patents. Just as technologies combine in unique ways over time within the O&G patent universe, technologies developed by O&G companies are also cited outside of the O&G universe. Higher synergies between disparate technologies move them into stronger and more central locations within the broader patent universe.

Location in the knowledge network is important, because the more centrally located technologies have a greater chance of quickly incorporating innovations from neighboring technology areas. By way of contrast, technologies that are at the fringe of the knowledge network have fewer chances of bridging into totally new knowledge areas and creating genuinely disruptive innovations.

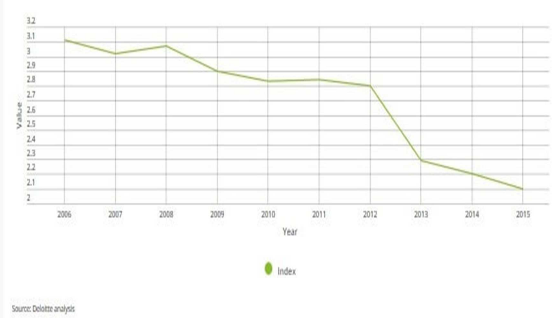
In the 2015, semiconductor devices, which were among the fastest growing patent area in the oil and gas industry at the time (Growth and volume by technology), connect widely within the patent universe because of their cross-sectional applications across industries.

In contrast, earth drilling, O&G's highest volume area of patenting, has some connections but is not as deeply connected to as many other technologies. Also, some of the technologies it links to are not centrally located in their own right (such as oilfield technology, which only connects to two other technologies). This makes it less likely that the oil and gas industry's current stock of granted earth drilling patents will result in advances based on bridging technologies from genuinely different fields of science.

While the movement of individual O&G technologies is of interest, we can measure the drift in aggregate of innovation within the O&G industry as a whole by producing a weighted average across all technologies to produce what Deloitte refers to as the "Energy Innovation Index."[3] Technologies with high O&G contributions and a commanding location in the patent network contribute positively towards the O&G aggregate score. When a core technology in the oil and gas industry drifts away from the center of the patent universe, or has a decreasing contribution from the O&G industry, it causes a decline in the Energy Innovation Index.

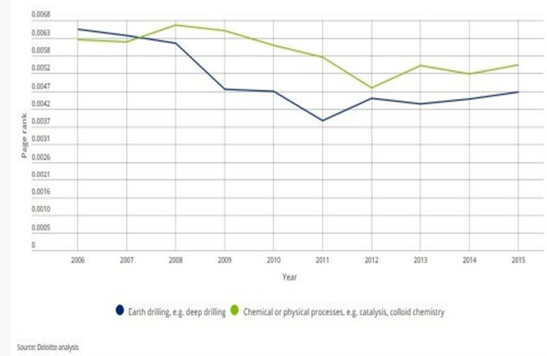
Higher values on the Energy Innovation Index reflect a trend toward highly connected technologies that, many times, might lie outside of the O&G industry's traditional areas. Lower values on the Index indicate may be technology areas with a narrow focus within O&G, located toward the fringe of the overall knowledge network. As such, the Energy Innovation Index helps us understand whether the industry is trying to expand into highly connected technologies or is focusing on innovation from within.

When we compute the Energy Innovation Index it shows a slight decline over time. This means that the overall O&G industry seems to be moving toward the edge of the overall patent universe. This should not be interpreted as a slowdown in the pace of innovation within oil and gas, but rather that other industries have likely accelerated their intensity and interconnectedness of innovation faster over the past decade or so—a decade in which advances in IT and communications technologies have become pervasive. It also reflects the fact that many of the meaningful innovations in the oil and gas industry have come from combining existing O&G technologies rather than "moon shot" innovations combining more distant technologies.



Energy Innovation Index

What explains the move of O&G technologies toward more inner-focused innovation, and away from the center of the patent universe? One explanation might be the decline of patent network page rank (which measures how much a technology area gives and takes knowledge from areas outside of itself via patent citations) for two traditionally important O&G technologies: earth drilling and Chemistry: colloid chemistry.



Page rank over time

The concept that O&G innovation is looking increasingly inward might seem at odds with the success reported by O&G firms in many areas of operation through new and better technology. An explanation might be that oil and gas firms are succeeding by increasing innovation within focused technology areas like earth drilling—and not from more connected areas (like semiconductors). These new technologies may yield headlines and genuinely drive profits in the future but are not currently a major source of patent-protected innovation within O&G firms. Bottom line: firms that can buck this inward-looking trend and successfully adopt distant, patentable technologies have the chance of leapfrogging competition and experiencing greater upside.

No matter which way the industry leans, past evidence suggests that there will be substantial and meaningful innovation in oil and gas related to expanding relatively new technologies like hydraulic fracturing. In the next section, we examine the progress of innovation in hydraulic fracturing and its related technologies to provide a detailed, specific and impactful example of how innovation continues in a key technology underpinning a period of extraordinary success in developing and producing unconventional oil and gas, particularly in North America.

Hydraulic Fracturing: A Case Study in Innovation

Studying Growth: A look at Patent Filing Trends

Hydraulic fracturing is a stimulation process in which water, chemicals, and proppants are injected at high pressure to fracture impermeable tight rock formations, leading to an increased flow of hydrocarbons to the wellbore. This technology, along with horizontal drilling and related technologies, has enabled the extraction of large oil and gas reserves trapped in shale and other source rock formations, leading to the shale revolution in the United States. “Shales” now account for over 40 percent of US crude oil and natural gas production, up from a mere two percent in 2001.

Patents related to hydraulic fracturing have gained prominence in the oil and natural gas industry throughout the past decade. O&G companies (primarily oilfield service majors, followed by equipment manufacturers, niche suppliers of proppants and compositions, supermajors, and a few large E&P independents) have filed nearly 1,000 hydraulic fracturing related patents since 2006, with the pace of filing increasing year over year. In 2015, for example, these companies filed over 150 patents, more than double the number in 2006.

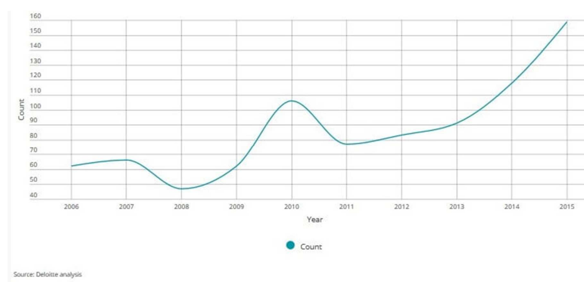
The majority of the fracturing-related patents lie in the (a) earth drilling category (E21B43, patent classification code), followed by (b) drilling compositions and related aspects (C09K8, C09K2208) and (c) well treatment and oilfield chemistry (Y10S507,Y10T428). A deep dive into these three groups reveals where fracking-related innovation specifically is taking place, and helps determine if the industry's technology focus has changed over the last few years.

Within the (a) earth drilling category of patents, our research shows that there are two dominant areas of fracking-related patenting activity:

(i) Tools and methods to create effective fractures (increasing penetration, isolating zones, seismic monitoring, well treating, etc.), and

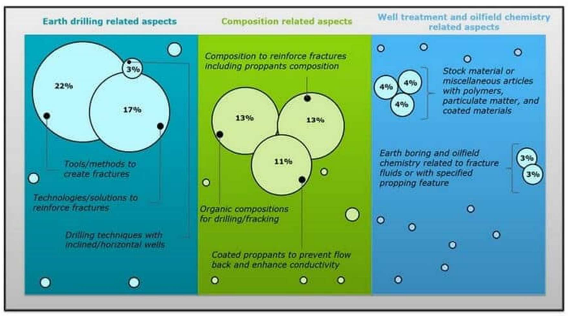
(ii) Technologies and solutions that reinforce the already created fractures (different materials, shapes, and sizes of proppants; preventing flowback of particles, etc.).

About 40 percent of the hydraulic fracturing related patents we researched fell in one of these two areas of innovation. For example, the “Multi-stage fracture injection process for enhanced resource production from shales” patent, US8978764B2, filed by Maurice B. Dusseault and Roman Bilak, is an invention that generates “a network of fractures and induces it by injecting a plurality of slurries comprising a carrying fluid and sequentially larger-grained granular proppants in a series of injection episode.”



Hydraulic fracturing related patents

The second largest hydraulic fracturing-related group in terms of patents, seems to (b) drilling compositions and related aspects, has seen a boost in attention among O&G innovators, especially over the last few years. A large part of the innovation in this group is centered on fracture fluids composition containing organic compounds (fluid loss control agents, system stabilizers, viscosity reduction, etc.), composition of proppants and related fluids used to keep fractures open, and use of coated proppants to enhance conductivity. The ongoing learning and innovation in drilling fluid composition, along with new methods to create and reinforce fractures, are a major factor in explaining the rising productivity in shale plays [In the Eagle Ford play in Texas, for example, new well oil production per rig has increased from less than 40 barrels per day in 2007 to more than 1,400 barrels per day by early 2017].



Notes:
1. The percentage of patents filed in various categories are not mutually exclusive, same patent can have multiple group tagging.
2. Smaller bubbles are for indicative purpose that there are several other patent groups that are not specified.
Source: Deloitte analysis

Major patents categories

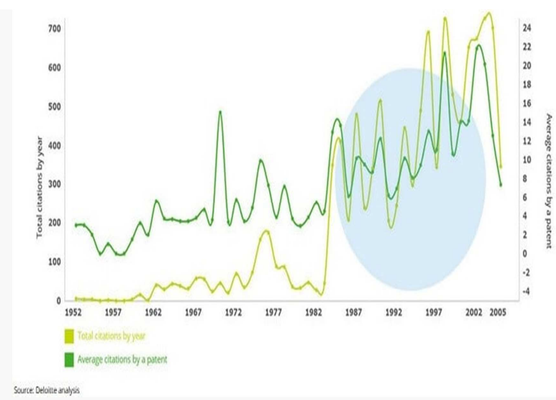
Within (c) well treatment and oilfield chemistry patents, the invention focus appears to have changed over the years and remains highly fragmented. From 2006 to 2009, much of the innovation within the group focused on reducing the viscosity of fracturing fluids by including new additives and particulates. However, since then, the focus appears to have shifted toward fluid treatment systems and increasing fracture complexity. This patent group, which primarily consists of cross-sectional technical subjects, is likely to gain prominence and draw inspiration from increasing innovation in other industries.

Inspiring Innovation: Past Patents Show the Way for Future Innovation

Prior patents often act as a source of innovation for future research. Specific to recent fracking patents, their source of innovation goes as far back as the 1860s and comes from both within and outside the O&G industry. An O&G patent, "Improvement in revolving ordnance," published in 1862, and a non-O&G patent, "Improvement in rock-drills," published in 1865, were among the first patents to inspire more recent breakthroughs in the hydraulic fracturing processes.

Deloitte's research of the top five patent technologies suggests that the mid-1980s–2000 period was, and continues to remain, a "golden age" for shaping innovation in fracturing. Approximately 60 percent of the total citations by recently filed fracking-related patents belong to the 1985–2000 period.

Furthermore, each patent in the 1985–2000 period was cited up to 20 times by the recently filed patents, highlighting the strength and impact of innovation patented during the years from 1985–2000.



Yearly citations by recent hydraulic fracturing patents

The prime source of innovation for all of the recent fracking-related patents is the earth drilling category (E21B43). In other words, earth drilling is not only the top area of O&G patent filing but also the top source of innovation for other fracking patents. Specifically within this group, E21B43/267, which consists of methods or apparatus for reinforcing fractures by propping, has been the most cited subgroup since the 1860s.

Within this propping sub-group, however, citation trends for recently filed hydraulic fracturing patents have changed from decade to decade. For instance, the majority of the innovations cited in this subgroup during 1981–1990 concerned developing sintered proppants with low density, high strength, and increased conductivity. Over the period from 1991–2000, innovation centered around new methods and/or techniques to prevent the flowback of proppants or other fine particles from the formation to the wellbore. During the 2000s, the trend shifted again, showing more patent filing citations involving the use of new materials, especially composites, as proppants.

Simply put, a solid history and timely evolution explain the large-scale commercialization and success of hydraulic fracturing technologies. The role of past innovations on future research may become more important as the industry targets new subsurface challenges to improve well productivity without compromising safety and environmental performance.

Branching Out: Hydraulic Fracturing Looking Outward for Inspiration

The focus of research in the field of hydraulic fracturing continues to evolve, rapidly. With shale technology starting to mature toward full-scale commercialization, and the growing need to increase shale well productivity and improve recovery, the industry seems to have shifted its research focus over the past 12–18 months toward:

- Monitoring of proppants, fractures, and fracturing fluids by using advanced tracking tools and techniques like opticoanalytical devices, hybrid transponder systems, real-time seismic monitoring, and DNA sequencing, and by employing conductive proppants containing dispersed piezoelectric or magnetostrictive fillers.
- Treating flowback water/fluids through electrocoagulation, chemical co-precipitation, and even employing microwave separation technology ("MST") and ultraviolet light remediation ("UVLR") units. Some research is also underway on treating and mixing oil-based drilling fluids, fracking fluids, and produced waters with mature compost, organic fertilizer, hydrocarbon-digesting microbes, etc. so as to produce fertile topsoil.
- Controlling the viscosity and heat resistance of fracking fluids by using more and more nanoparticles. Over the past few years, research has increased on the usage of nanoparticles like cellulose nanowhiskers, nano-sized phyllosilicate minerals, nano-encapsulated fluids viscosity breakers, and thermoset-nanocomposite particles for improving heat and environment resistance.
- Enhancing field development plans through optimal positioning of horizontal laterals and drilling pads and even exploiting significant portions of a reservoir through a "horizontal well line-drive oil recovery" process. In this new in situ combustion process, adjacent horizontal wells are continually drilled in a direction along the reservoir and the penultimate lower production wells are converted into injection wells to drive hydrocarbons to an adjacent parallel production well for recovery to surface.

Summing up, hydraulic fracturing and related technologies have come a long way in sourcing and extending innovation from the parent O&G patent group of earth drilling and related aspects. More recent filings and ongoing research in the field of nanoparticles, monitoring and sensing, etc. suggest that hydraulic fracturing innovations are quickly building connections or borrowing from neighboring technologies outside the O&G industry, and will most probably be a source of inspiration for other industries, especially in the aspect of waste fluid management and treatment.

Looking Forward: The Future Lies in Building Networks of Innovation

Innovation in the oil and gas industry continues to center around traditional core applications such as earth drilling. However, the rapidly evolving networks and ongoing innovation in oil and gas are giving rise to several new bridging technologies that connect disparate technologies to the core. These connections are emerging both within O&G and outside O&G, and thus starting a new network of knowledge in the industry.

O&G companies contributing to and sourcing knowledge from these new networks of technologies could have an improved chance of leapfrogging their competition in a new world of energy where incremental innovation focused on improving an existing product's development efficiency and productivity may not be enough.

The networks and innovation indices presented in this paper could help companies track their standing and influence within their own specific innovation ecosystems. A deep dive into technology networks, and investigating the specifics and trails of newer technologies like hydraulic fracturing, could help companies identify new research themes and partners earlier, thus giving new direction to ongoing and future research pursuits.

Notes:

1. Each patent has a bibliography of other patents. When a patent in one area (say earth drilling) cites another (such as geophysics), we infer that innovations in geophysics led to innovations in new earth drilling technology. In this way, prior patents are a resource to future patents. When enough patents demonstrate the same link between two technologies, we can infer that they are connected and meaningfully contribute to each other.
2. within our study, In order to form a 'link' between two technologies, we set a threshold that 75 patents from one area had to cite another area. This was kept consistent across all years. As a result, part of the increasing complexity of charts from later years is that there were simply more patents. However, more patent activity can genuinely reflect greater levels of innovation, and so the benchmark of 75 was kept consistent.
3. In network theory, nodes and links are measured by several variables. The ratio of oil and gas patents within the universe is applied to one of these values (called page rank) and summed up to quantify the centrality of oil and gas patents to the network. This is the foundation of the Energy Innovation Index. It is computed annually across the entirety of the patent space. For more details on the calculation of the index, please see our computational methods paper.

Courtesy: Andrew Slaughter is an executive director for the Deloitte Center for Energy Solutions, Deloitte Services LP. John England serves as the vice chairman, US Energy & Resources leader for Deloitte LLP.

The complete article with interactive graphs can be found at Deloitte – Energy and Resources.

BARRIERS TO RENEWABLE ENERGY TECHNOLOGIES DEVELOPMENT

Since the beginning of the 21st Century, renewable energy has been a significant area of research amongst scientists. However, despite scientists coming up with practical and convincing technologies on renewable energy, the process of getting people to switch from their use of non-renewable energy sources has been quite slow and uncertain especially in the developing nations. This essay aims to identify and explain why many countries have stuck to the use of non-renewable energy resources, specifically coal, and the challenges facing renewable energy technologies adoption which, consequently, affects the potential of the technologies in many countries. In the essay, these barriers to renewable energy adoption have been discussed under the following seven categories: over-reliance on fossil fuels (coal), political and regulatory barriers, technical barriers, market-related barriers, social-cultural barriers, financial and economic barriers, and geographical and ecological barriers. The paper will be useful to renewable energy researchers, students, policymakers and individuals or organisations who may be concerned with promoting renewable energy technologies, as it highlights gaps in renewable energy development which they may need to address in their research and decision-making processes.

Introduction

Use of energy is a necessity for physical and socio-economic development in rural and urban settings. However, despite being the major contributor of energy in the global energy mix, fossil fuels are also the main contributor to the high levels of carbon dioxide emissions in the atmosphere, hence an increase in global warming. Access to sustainable energy is, therefore, one of the leading factors that contribute to the difference between thedeveloped and the developing countries. Due to the increased use of conventional sources of energy such as fossil fuels (coal, gas, oil and radioactive ore) all over the world and the associated environmental impacts, efforts have been directed towards minimizing dependence on these resources by increasing renewable energy supply, with little impact to date.

Many studies indicate that most countries have an enormous potential for renewable energy production. However, for some reasons, the current renewable energy application in these countries is negligible compared to their potential. For example, though India is rich in both renewable and conventional energy resources, coal has continued to be the dominant source of electricity due to its availability, suitability to the needs and relatively low cost .

Similarly, Africa experiences a slow development rate as a result of little access to renewable energy; this is because of the high levels of limitations from underprivileged energy policies, inadequate funds, lack of technological advances, as well as lack of adequate infrastructures. Additionally, rapid growth in population and subsequent increase in energy demand in the developing countries has led to emerging energy crisis which in effect increases people's dependence on non-renewable energy sources.

The following sections of this essay discuss the use of coal as a barrier to renewable energy development, as well as six other categories of barriers to renewable energy technologies which in turn favours people's over-reliance on coal. These categories of barriers are political and regulatory, technical (technology and infrastructure), market-related, social-cultural, financial and economic, and geographical and ecological.

Why are people still using coal?

According to International Energy Agency (2017), coal contributes one-third of global energy supply, making up about 40% of electricity generation; as well as playing a very significant industrial role. This means that it will be hard to replace coal as a source of energy, especially in our industries. The kind of infrastructural changes that are required in changing from coal to other renewable sources of energy is prohibitive—in terms of cost and time.

Also, industries require a lot of energy. Coal has a high net energy yield compared to other sources of energy. This means that for a unit of coal a lot of energy is produced compared to other sources of energy. Therefore, coal is very efficient for producing the high amounts of energy required in the industries, which makes it very hard to replace it with other energy sources.

Additionally, coal is an abundant source of energy. In most countries, coal is readily available and is in ample supplies. Therefore, it can hardly be replaced by other forms of energy, because people usually prefer to use what is readily available to them. For example, about half of electricity in the United States of America is generated via coal plants: mainly because they have abundant coal deposits. This is because when something is in abundance, it becomes cheaper compared to something that is in limited supply.

With the advent of technology, burning of coal has been made cleaner and efficient than it used to be. Therefore, there might be no need to replace it with other cleaner energy sources such as solar and wind power. In this regard, the technological advancements have made it more efficient to mine and burn coal to produce high amounts of energy. Therefore, it is challenging to convince people to abandon coal power for other sources of energy.

Further, the cost of infrastructural development required to develop and set-up renewable energy plants is prohibitive. Aside from its abundance, most countries find coal a cheaper alternative to natural gas and is therefore favourable. In most cases, countries prefer a cheaper option that is more economical, because the main goal of any economy is to reduce the cost of production and increase its profits. Since coal power plants have already been established, there is no need to set up other power plants that are very expensive to the economy. Therefore, most countries will be reluctant to change from the existing power plants and establish new clean energy power plants (such as solar and wind energy).

Another factor that discourages use of renewable energy is that coal power requires fewer workers to produce high amounts of energy compared to renewable energy sources. For example, in the USA, solar energy industries employ more workers compared to coal industries; (337807 and 160119 respectively). However, even with a more substantial workforce in the solar industries compared to coal industries (almost twice), coal produces more power than solar energy and wind energy combined. Therefore, since coal requires fewer men to produce more power, it is seen as an economical energy production method, and that is why most countries (both developed and developing) still want to use it. Why would people want to employ more workers in an industry that produces less power while there is another industry that can produce more power with fewer workers?

The continued use of coal is a barrier to renewable energy development, and people need to be sensitised on the negative effects of coal. These effects include environmental pollution; emission of carbon dioxide and methane which are greenhouse gasses leading to global warming; and other toxic gasses released when coal is burnt which can be detrimental to the health of people when inhaled.

However, according to, despite being associated with high levels of emissions, coal-fired energy production will remain a significant energy source for decades to come. But International Energy Agency on their part trusts that renewable energy technologies are the only solution to the reduction of over-reliance on fossil fuels globally.

Other Barriers to Renewable Energy Development

Apart from over-reliance on fossil fuels, most people can also attribute their reluctance to adopt renewable energy technologies to several other categories of barriers as described in the following sections.

Political and regulatory barriers

Lack of policies and regulations favouring the development of renewable energy technologies can hinder adoption of these technologies. Due to the nature of renewable energy structures, renewable energy market needs clear policies and legal procedures to increase the interest of investors. This is because "enabling policies create stable and predictable investment environments, help overcome barriers and ensure predictable project revenue streams". Additionally, regulatory measures such as standards and codes enhance the adoption of renewable energy technologies by minimising the technological and regulatory risk that comes along with investments in these projects.

However, in some countries like India, there are no complete renewable energy policy declarations simply because most renewable energy technologies in the country remain in the advancement stage. Similarly, Mohammed et al., (2013, p.461) in his study on renewable energy adoption in Sub-Saharan Africa noted that many countries in the region have distinctive national renewable energy policies whereas regional policies are not fully formed because of unsuitable implementation approach. This means that, despite the many renewable energy policies developed in most of these countries, it has been difficult to implement them mainly because they are immature.

Additionally, private sector participation in renewable energy projects in some countries is hindered by the lack of well-defined policies on private investment and delays in the authorisation of private sector projects . Therefore, because large-scale renewable energy projects require large amounts of capital to run, many countries' progress toward renewable energy is held back by policymakers' failure to implement measures to attract private investors.

Technical barriers

Technical barriers to renewable energy development include inadequate technology and lack of infrastructure necessary to support the technologies. From a study conducted by, in Saskatchewan, Canada, technology was identified as one of the main barriers to the willingness to invest in wind-generated electricity. This is particularly true in cases where core renewable energy technologies are not provided in many places or are not sustained well in some areas where present in the developing countries, especially Sub-Saharan Africa. Because of lack of trained personnel to train, demonstrate, maintain and operate renewable energy structures, especially in regions with low education levels, people are unwilling to import the technologies for fear of failure.

Additionally, currently, in some countries, renewable energy technologies are costdisadvantaged compared to commonly used non-renewable technologies, such as coal-fired production. maybe because most renewable energy technologies are imported. The high costs of the technologies, therefore, means that most people are more likely to go for coal-generated energy because it is readily available hence reliable and affordable compared to renewable energy.

On the other hand, lack of physical facilities for transmission and distribution networks, as well as equipment and services necessary for power companies, is a major infrastructural challenge for renewable energy development in most developing countries. Most of these equipment are usually not readily available in those countries and are therefore imported from the industrialised nations. Because imported equipment are expensive compared to locally made, the production of renewable energy becomes expensive and even unaffordable in most countries.

Another significant infrastructural barrier to renewable energy technologies expansion is inadequate connectivity to the grid, more so in wind power sector. In such cases, energy (whether electrical or mechanical) is transported from the production points to consumption points; during which high levels of transmission loss are experienced. As a result, many investors lose their confidence in renewable energy technologies and are not willing to invest in them for fear of losing.

Additionally, inadequate servicing and maintenance of equipment, together with low reliability in a technology lowers customer confidence in some renewable energy technologies and hence hinder their adoption . This is because most renewable energy equipment in developing countries are imported from the developed nations, and therefore, lack of spare parts and adequate skills to repair/service the equipment leads to equipment failure which in effect halts the supply of energy. Many consumers, therefore, opt for fossil fuels because they are reliable and readily available.

Social-cultural barriers

Socio-cultural barriers, for example, households' unwillingness to adopt renewable energy for fear of unreliability, form one of the bases for failure to adopt renewable energy technologies in some countries. For example, general public disinterest and disengagement in wind energy development were identified as the main social issues hindering renewable energy development in Saskatchewan, Canada.
Further, lack of knowledge and awareness of renewable energy technologies and systems amongst rural communities is another challenge encountered in renewable energy development. For example, a majority of people in Sub-Saharan Africa are uneducated and, therefore, they do not understand the concept of renewable energy. These uneducated people in the region are also hardly oriented to technical and environmental impacts associated with over-use of combustible renewables. These factors coupled together have slowed down the rate of development, circulation and usage of renewable infrastructure and technological knowledge. Therefore, the creation of awareness of renewable energy among communities and a critical focus on their socio-cultural practices is required .

Financial and economic barriers

Initial capital, transaction costs, economic status, and availability of incentives and subsidies are important factors that determine the rate of renewable energy technologies adoption. Initial capital cost of renewable energy is relatively high when compared to conventional sources of energy, which in turn raises the cost of renewable energy generation. Because many producers prefer to keep initial investment costs low while maximizing profits, high costs of investment remain a significant barrier to implementation of sustainable renewable energy solutions. For example, many developing countries lack adequate renewable energy technologies and therefore, rely on imports from industrialized nations. Initial investment costs are, therefore, high and discouraging to potential investors because imported technologies from technologically innovative and highly developed countries are more expensive compared to technologies made locally.

Many transaction costs are involved in the generation of renewable energy which in return raises the total production costs. Transaction costs refer to costs of resources and time needed to come up with an establishment and to identify problems that this establishment aims at solving. Naturally, renewable energy projects are multifaceted in their formation when compared to establishing an individual fossil fuel plant. This means that more transaction costs are required in renewable energy projects because whether small or large, the activities, procedures and products/by-products involved are the same. For example, many parties need to come to an agreement, multiple products or by-products fuel the projects and the fact that most of these projects are broadly connected with other socio-economic and community aspects as well as affairs of development. This makes renewable energy technologies unaffordable to producers and even to consumers.

Additionally, a country's economic status determines the level of renewable energy adoption. For instance, due to poor economic conditions in the developing countries in Sub-Saharan Africa and South Asia, a great distortion of renewable energy market has been experienced. One example is Tanzania where the rural communities earn very minimal incomes while the prices of solar power systems remain too high, and are, therefore, unaffordable to most households . Therefore, although some renewable energy uses low levels of technology, they are less commercially competitive compared to fossil fuels . It is, therefore, only wise for governments to support investment in renewable energy development to speed up commercialization of the technologies.

Inadequate or lack of credit facilities to purchase sustainable energy technologies and high-interest rates on credit facilities is also a significant barrier to renewable energy development. Most conventional power plants were built with substantial subsidies, and their capital costs are also covered . However, in most countries where renewable energy technologies are not well established, very few financial institutions (both public and private) are willing to offer considerable loans for execution of renewable energy projects. For example, in some countries such as China, "from the perspective of promoting renewable energy development, in the long run, China's existing economy regulatory policies in terms of tariff and subsidy incentives are relatively weak".

Further, the high levels of subsidies on fossil fuels in some countries raise unfair competition to renewable energy technologies. For example, Malaysia is one of the countries with the highest level of subsidies on fossil fuels, and as a result, renewable energy technologies are economically weak to compete in the markets . This means that because there are many incentives to acquire fossil fuels than renewable energy in most countries, many people still stick to the use of what most favours them, fossil fuels.

Market-related barriers

Initial investment costs for renewable energy systems are usually high. Consequently, market prices for these systems remain high and unaffordable to many potential customers, especially in the developing countries . This is because the total production cost of renewable energy also become relatively high compared to fossil fuels, and therefore, market prices for renewable energy remain relatively high. Consequently, because in most cases many people prefer to go for cheaper options, renewable energy technologies, therefore, suffer unfair market competition from fossil fuel technologies whose establishment and operational costs are usually subsidised.

In connection, other factors that make renewable energy technologies less competitive or unavailable in the markets include: lack of successful and replicable renewable energy business models to help turn small-scale projects into commercial businesses; inconsistent biomass supply in some areas like Europe; lack of market for renewable energy; and the high and fluctuating prices of renewable energy in some countries like China. Therefore, most people cannot afford renewable energy technologies because their initial installation costs and operation costs are usually high which raises their market prices, ultimately limiting their marketability. Since the market for renewable energy sources is limited, its development is also limited. This is because, when something is not marketable people do not invest so much in its development. In this case of renewable energy technologies, it is clear that most people are not motivated to acquire or develop them.

Geographical and ecological barriers

The geographical location and natural conditions in a region can be a form of barrier to renewable energy development. For example, the incidence of solar energy on the surface of the earth is dependent on geographic location, therefore, in some countries like India where solar and wind energy are sporadic, solar power is sporadic too . This, therefore, limits the people of such regions from the use of solar energy as it will not be reliable.

Additionally, as human population increases, natural resources and renewable energy resources have continued to get scarce. Consequently, renewable energy resources have become expensive to obtain and therefore expensive to produce renewable energy which then becomes unaffordable to the consumers. This in effect hinders renewable energy technology development in some countries.

Conclusion

The discussion above has made it clear that there are so many factors that hinder the adoption and development of renewable energy technologies. Starting with the continued use of coal as an energy source, which means that people are reluctant to use alternative renewable energy sources. Other factors are politics and governance, technical, social-cultural, financial and economic, market-related, geographical and ecological. All these factors work in tandem to restrict the development and use of renewable energy sources. For instance, most countries are not able to adapt and develop renewable energy due to the high initial cost required to set up. And since there is a cheaper alternative (coal), most people prefer not to use renewable energy sources; despite their immense benefits not only to the environment but also to the economy in the long run. However, this is not to mean that all countries have not embraced renewable energy technologies, some have; and the question that should linger in every person's mind is, why have others been able to do it despite the challenges? If others have, we all ought to follow suit.

Author: *Dorcas Kariuki, Postgraduate Student of the Department of Geography, Geology and the Environment at Keele University in the UK.*
For further information:
email at kariuki.dorcas55@gmail.com

OIL & GAS CONSERVATION AWARENESS DRIVE BY STUDENTS OF SRMIST

DIFFERENT TYPES OF ALTERNATE FUELS USED IN INTERNAL COMBUSTION ENGINES

By
Shiva Srenivasan and Lakshanasri N. R. S.

As the technology around the world is improving day by day, the need for transportation is increasing dramatically. But at the same time the pollution due to automobile industry is also increasing. This has become a great concern today in all over the world. The main reason for increase in pollution is due the fuel that is used in the internal combustion engine. There are different types of alternate fuels that are used for internal combustion engine to get desired efficiency.

Gasoline generally known as petrol is a which is popularly known fuel to everyone. It is a flammable liquid which is a by-product from petroleum. This is mostly used in spark type ignition internal combustion engine. It is mostly used with some other chemicals to improve the combustion. These chemicals are mostly oxygen carrying chemicals such as ether, ethanol. Gasoline fueled engine gets its energy by the combustion of hydrocarbons in gasoline fuel which combines with oxygen and releases carbon dioxide and water as its exhaust product.

$$2C_8H_8 + 25O_2 \longrightarrow 16CO_2 + 13H_2O$$

This reaction clearly tells us that it is harmful to environment. The gasoline fuelled engine produces a large amount of pollution during combustion. This increases the air pollution in environment. Gasoline directly releases greenhouse gas in environment which badly increases the global warming.

Diesel fuel is a type of fuel in which ignition is done without spark. This a liquid fuel with greater fuel efficiency and also has good thermodynamic efficiency. Similar to gasoline, diesel is also obtained from petroleum as its by product. It is also obtained from coal liquefaction, biomass, natural gas. Diesel-fuelled engine under combustion produce nitrogen as its exhaust product. The efficiency of diesel fuelled engine is 20% to 35% higher compared to gasoline fuelled engine. The released nitrogen combines with combines with oxygen which is turn produces mono nitrogen oxide, nitrous oxides. As we all know that these nitrogen oxides are harmful, this increases the global warming.

Compressed natural gas is one of the best types of fuel that can be used as replacement for gasoline and diesel fuelled engine. The compressed natural gas has a great advantage as it is very much lighter than air. Hence this produce less amount of pollution to environment. Compressed natural gas is generally used in modified internal combustion engine. The cost of this type engine is more compared to other types of alternate fuelled engine. This is considered to be a major disadvantage in using compressed natural gas.
Tetraethyllead is a petrol fuel additive used with gasoline to increase the engine compression. This made a good fuel economy and also increased the efficiency in the performance of the vehicle. This is the structural formula of tetraethyllead. As we all know that lead is a hazardous chemical for environment. Hence this rises the greenhouse gas in environment. Hence this is not considered as a good alternate fuel to use.

ROLE OF BIOMASS ENERGY IN REPLACING PETROLEUM FUELS

By
Aswin Krishna

Developing countries like India and China are heavily dependent on fossil fuels for their growth, and India imports 87% of its total petroleum crude requirement from oil-producing countries. In order to ensure energy security, majority of the countries are now looking for alternative sources of renewable liquid transportation fuels. Biomass fuels are derived from carbon-based materials contained in living organisms, which can be gasified. Current biomasses of interest for gasification include microalgae, crop residues, animal waste, food processing waste, municipal solid waste, sludge waste, and wood–wood waste. Currently, microalgae are of significant interest and are considered a versatile biomass source because of their higher photosynthetic efficiency and biomass productivities. Even though algae have been studied for ~70 years, it is especially important now due to global warming, fluctuation in oil prices, and energy dependence on foreign nations. The first interest occurred during World War II when these organisms were investigated as a potential source of a number of products such as antibiotics and a good source of protein. In the late 1940s and early 1950s, the Carnegie Institution of Washington sponsored the construction of a pilot plant and supplemental laboratory studies. This work is summarized in a report which serves as a valuable source of information even today for algae cultivation.

Commercial systems designed to produce algae for human consumption were developed in Japan in the 1960s. Microalgae are one of the most effective sources of renewable energy production. It can grow at high rates and capable of producing oil throughout the year. Microalgae biomass was first suggested as a feedstock for biofuel production and received early attention for commercial application.

The algal lipids would be an ideal feedstock for high energy density transportation fuels such as biodiesel, green jet fuel, and green gasoline. Since it does not complete with food price, agricultural land and that it has the ability to sequester large quantities of carbon dioxide. Biofuels are expected to be one of the major sources of renewable energy which mainly comprises biodiesel, bioethanol, and biogas

i. Lipids from the algae biomass could be extracted and refined to fatty acids; the fatty acids can be further processed to produce biodiesel by transesterification;
ii. Gasification of the algal biomass by anaerobic digestion or thermal cracking can produce biogas;
iii. Carbohydrate fraction can be used for bioethanol production by direct fermentation;
iv. pyrolysis or thermal degradation of biomass produces solid, liquid, and gaseous products;
v. anaerobic fermentation of biomass to produce methane gas;
vi. direct combustion of biomass to generate power or syngas.

Thus a comprehensive and gradual shift from fossil to algal-based energy economy is a must needed switch to prolong humanities venture into the unknown future

THE ROLE OF SOLAR ENERGY IN REPLACING PETROLEUM FUELS

By
Sahana M Setty & Piyush Dubey

Solar panels convert the sun's light into usable solar energy using N-type and P-type semiconductor material. When sunlight is absorbed by these materials, the solar energy knocks electrons loose from their atoms, allowing the electrons to flow through the material to produce electricity. In short, we can conclude, Solar energy and it's technologies use the sun's energy and light to provide heat, light, hot water, electricity, and even cooling, for homes, businesses, and industry.

As global temperatures and energy demand rise simultaneously, the search for sustainable fuel sources is more urgent than ever. Dramatic fall in costs of renewable energy in the last 24 months has not only accelerated the replacement of fossil fuels by renewable energy in electricity generation, but The low cost renewable electricity is now starting to replace fossil fuels in other sectors.

One reason is that renewable electricity is now cheaper per unit energy than oil, about the same price as fossil methane but, still, more expensive than coal. Another reason is that electricity often offers other opportunities, such as cheaper transport, better control, higher energy efficiency in final production of energy services and lower local environmental costs.

Why solar energy is better preferred over Fossil fuels?

- **Long-term Availability**

Fossil fuels are a limited resource – at current consumption rates, they will eventually be depleted. Some of the least favorable predictions state that the decline of fossil fuels will occur within the first half of this century and once they're consumed, they'll take millions of years to replenish themselves. By that time, it will be too late to use them. Solar power, on the other hand, works with a reliable and predictable energy source. According to astronomers, the sun will last for five billion years more

- **Emissions**

Solar energy has a substantially reduced impact on the environment compared to fossil fuels. Its greenhouse gas emissions are inconsequential as the technology does not require any fuel combustion. Also, although concentrating solar thermal plants (CSP) are comparatively inefficient in their water usage depending on the type of technology being used, the right technology significantly increases efficiency while photovoltaic (PV) solar cells do not require any water when generating electricity.

So, if we want to reduce our carbon footprint by reducing our emissions, one of the best ways to do it is by making the switch to solar energy.

- **Costs**

Sunlight is free and the only costs involved if you own a solar PV system are the initial investment and periodic maintenance. Installing a residential PV system allows homeowners to reduce the impact of any electric energy price variation induced by the ups and downs of the fossil fuel market. The energy output of solar PV systems is guaranteed to be available for an investment that is known since the beginning.

The energy output of solar photovoltaic systems remains stable year after year. However, the actual monetary savings gradually increase. The reason is because electric utility rates are constantly on the rise, and every kilowatt-hour produced by a solar PV system is one kilowatt-hour that wasn't paid to the utility company. If energy is 10% more expensive in 5 years, your solar PV system will also save 10% more money

Vital Statistics related to Solar Energy

- India is emerging as one of the major solar energy markets in the world and in the process of catching up with the two leading countries like China and the US. India currently ranks as the third-largest solar market in the world.
- Over the past decade, a lot of things have changed in the Indian solar market. After a significant policy reshuffling by the current government, and increasing adaptation of solar energy throughout the country, it has been proved to be the right move towards achieving renewable energy solutions.
- The Indian government has set a target to reach 100 GW of solar capacity by 2022.
- India is set to add up nearly 16GW of clean energy capacity in 2019, which is mostly driven by large scale solar projects. The goal is to make renewable sources account for 40% of the total power-generation capacity by 2030.

ROLE OF WIND ENERGY IN REPLACING PETROLEUM FOSSILS

By

Amrutha S & Swathik Sajeesh

There is a good reason for big fossil fuel companies to be nervous. Time is not on their side. People know that they need fossil fuel but most of us wish we had alternatives to this earth damaging source of energy. The market for alternatives is there and it will displace fossil fuels when (not if) renewable energy technology becomes cheaper and more convenient. Our economy is built on energy and assumes energy will be reliable, accessible, and relatively inexpensive. Transitioning away from fossil fuels will be a long process. But it is a transition that the next generation will strongly support. People raised in a world of constant technological change have a different attitude toward technology than those raised in an era of gradual technological change. Young people are constantly learning how to use new software programs and how to make the technologies they use function correctly.

The expectation that climate change, toxins, and pollution are simply the price of modern life and can't be changed makes no sense to people whose life experience has been constant change. Global warming, sea-level rise, massive floods, fires, and storms are a way of life; from Fukushima to Hurricane Sandy. Since we talked about all the reasons as to why we should replace fossil fuels let's see what we can use to replace them. renewable resources. These are natural resource which will replenish to replace the portion depleted by usage and consumption. Compared to fossil fuels they do not give out any harmful toxic substances into the environment. They in turn help in reducing global warming and keeping the environment clean.

We've used the wind as an energy source for a long time. The Babylonians and Chinese were using wind power to pump water for irrigating crops 4,000 years ago, and sailing boats were around long before that. Wind power was used in the Middle Ages, in Europe, to grind corn, which is where the term "windmill" comes from.

All power plants, including renewables, result in some environmental impacts during siting, development and operation. Over the past two decades, siting practices for wind projects have become more sophisticated and effective at minimizing impacts. As a result, wind projects have fewer impacts than other types of projects, falling near the bottom on lists of developments that can have negative effects on the environment and wildlife What's more, these projects often provide co-benefits. Wind farms sited in rural areas benefit land owners by providing annual revenues while allowing landowners to continue to use the sites for grazing Or other purpose.

All power plants and their components have a "useful life" before they need replacement or repair. The useful lifespan of renewable facilities can exceed two decades. Wind turbines, for example, are estimated to last for about 20 years. In some instances, as large wind turbines become more efficient and economic, equipment turnover has been accelerated. In these cases, smaller turbines have been replaced earlier than they might otherwise have been by larger, more efficient turbines, to substantially increase electricity production at existing sites. Furthermore, renewable energy facilities can typically be deployed more rapidly than fossil fuel plants. While onshore wind farms normally take less than two years to build, gas-fired power plants usually take as many as four years to become operational, and can also require construction of gas pipeline infrastructure.

While all sources of electricity result in some GHG emissions over their lifetime, renewable energy sources have substantially fewer emissions than fossil fuel-fired power plants. One study estimates that renewable energy sources typically emit about 50g or less of CO2 emissions per kWh over their lifetime, compared to about 1000 g CO2/kWh for coal and 475 g CO2/kWh for natural gas. Most of the lifecycle emissions from fossil generators occur from fuel combustion but also come from raw materials extraction, construction, fuel processing, plant operation, and decommissioning of facilities.

We need to use more and more of these renewable resources as the need for energy is never ending and fossil fuels are coming to an end and the harm that they cause to the earth is life threatening.

Respectful Homages to Er. R Raju Pandi

We regret to intimate the sad demise of Mr. R Rajupandi, Co-ordinator Power Generation Sector, ENFUSE on 14th January 2021. Mr. Raju Pandi was the Former Member of the Regulatory Commission and actively contributed do the activities of ENFUSE. The Executive Committee passed the Condolence Resolution on 26TH February 2021 with prayers for His Soul to Rest in Peace.

ENERGY & FUEL USERS' ASSOCIATION OF INDIA

OFFICE-BEARERS ADDRESS 2021 – 22

1.	**Mr. S RAMALINGAM**, CMD, CPCL (Retd.), Anand Apartments, 262/11 Poonamallee High Road, Kilpauk, CHENNAI 600 010 Email: ramaling37@yahoo.co.in/ramaling37@gmail.com	National President	96770 11766
2.	**Mr. B PANNEERSELVAM,**Chief General Manager(Manufacturing) Chennai Petroleum Corporation Ltd, Manali, CHENNAI 600 068 **Email:** pselvam@cpcl.co.in	Vice President – HQ	9444397937
3.	**Mr. RAMNATH S MANI,** Managing Director Automation Excellence Pvt. Ltd.New 27, Old 14, Josier Street,2nd. Floor, Nungambakkam,CHENNAI – 600034 Email: rsmani@automationexcellence.com	Vice President – Southern Region	044-28266227 98400 62118
4.	**Mr. A RAJENTHRAN,** Block No.C1, Pranavam Apartments, Plot No.3, Kamadhenu 2nd St. Mogappair East, CHENNAI 600 037 Email: arajenthran@yahoo.in	Secretary	044-26564181 94441 45833
5.	**Mr. K SADASIVA CHETTY**, E D, (Corporate Planning) CPCL (Retd) G-4,Ground Floor, Kala Flats, New No.15 Kamatchipuram 2nd St, W.Mambalam, CHENNAI 600 033 Email: sada1339@yahoo.co.in / ksada1339@gmail.com	Treasurer	98410 46289
6.	**Er. S JEYARAM**, No: 18/19, Putherikarai Street, Velachery, Chennai - 600 042 Email: sjeyaram@hotmail.com	Joint Secretary	97910 20132
7.	**Mr. S SENTHILMURUGAN,** Asst. Professor/EEE, SRM Institute of Science & Technology, Kattankulathur, Chennai 603 203 Email: senthilmurugan.s@ktr.srmuniv.ac.in	Joint Secretary – Academic Domain	98942 96319
8.	**Mr. MADHAVAN NAMPOOTHIRI**, No.7 MalleeswararKoilSt.,Mylapore, CHENNAI 600 004 Email: madhavan@re-solve.in	ENFUSE Journal Editor	8939724520
9.	**Dr. A. PEERFATHIMA,** Professor & Dean, School of Ele, Engg (SELECT), VIT- Chennai, Vandalur-Kelambakkam Road, CHENNAI – 600 127. Email: peerfathima.a@vit.ac.in / fniraj@yahoo.co.in	Coordinator – Academic Interface	9444022777 / 9551399340
10.	**Mr. G THANGARAJ, Asst. V P, Shaw Wallace & Co. Ltd (Retd)** 81 South West Boag Road, T Nagar CHENNAI 600 017 Email: lionthangaraj@yahoo.com	Past President Coordinator – Rural Energy	98402 61978
11.	**Mr. S VISVESWARAN,** 2A, Santosa Flats, 197 RamasamiSalai, K K Nagar, CHENNAI . 600 078 svis2361@gmail.com	Coordinator – New Renewable Energy	94443 90030
12.	**Mr. V SRIRAM VISHWANATHAN**, Deputy General Manager – (O) C P CL, Manali, Chennai 600 068 vsriram@cpcl.co.in	Coordinator – Sustainability Initiatives	98843 81171 / 25944306
13.	**Dr. D. ANANTHANARAYANAN,Chief** Manager (P&A),CPCL, (Retd.), 2/105 Bharathiar Street, Srinivasapuram, Mayiladuthurai 609 001 danacpcl@gmail.com	Coordinator – Narimanam Region	04365 - 256403 94430 71432

14.	**Mr. G L SRINIVASAN, G M (Corporate Planning), CPCL (Retd)** 3rd Floor, Trinity House, No.18/11, 4th Street Thirumurthy Nagar, Nungambakkam, CHENNAI 600034 Email: geeyeles@yahoo.com	Immediate Past President – Member	94449 07738 2827 7738
15.	**Dr. S BASKARA SETHUPATHY**, HOD / Automobile Velammal Engineering CollegeChennai - 66. Email: energysethu@gmail.com / drbaskarasethupathy@velammal.edu.in	Member	94456 33381
16.	**Mr. T DORAIVEL** No.5 First St., East Abhiramapuram, CHENNAI 600 004 Email: doraivel_@hotmail.com	Member	94441 85424
17	**CAPT. DINESH T S R,** No.4 NSK St., Eswaran Nagar, Pammal, CHENNAI 600 075 Email:tsrdinesh82@gmail.com	Member	98842 03213
18.	**Mr. K R GOVINDAN** No.22 Janakiram St., West Mambalam, CHENNAI 600 033 Email: govindan435@gmail.com	Member	94443 82649
19.	**Dr. K MAMALLAN, Senior** Manager (SHEQ), Environment Protection & Safety Department, CPCL, Manali, CHENNAI 600 068 Email: mamallank@cpcl.co.in	Member	044-25944181 96291 06918
20.	**Mr. S PANDARINATHAN,** G M (Dev), CPCL (Retd), #7, Nathamuni 2nd Cross Street Naduvankarai, Anna Nagar CHENNAI 600 040 Email: nathanpandari@gmail.com	Member	94443 90012
21.	**MR. S R PRADHISH KUMAAR** No.4 NSK St., Eswaran Nagar, Pammal, CHENNAI 600 075 Email: pradhishkumar@yahoo.com	Member	99401 50530
22.	**CAPT M SINGARAJA** Ratnabala Designs & Consultants, New No.90 Rama Naicken St., Nungambakkam, CHENNAI 600 034. Email: singaraja@gmail.com	Member	94441 27704
23.	**Mr. J SIVA,** Managing Director**,** Jegan Research Associates Pvt Ltd, No.1 Valluvarkottam High Road, Rashmi Towers, 3rd Floor, Nungambakkam, Chennai 600 034 Email:jsiva68@yahoo.com	Member	044–4211 1932 94431 38523
24.	**Mr. SAKTHIVEL**, Director of Boilers,(Retd) Email: shasvgl@yahoo.com / sakthigandhi@gmail.com	Member	94431 49993
25.	**Mrs. S SUJATHA MUKUNDAN,** Director, Servals Automation (P) Ltd 51/1 Justice Ramaswamy Street ,Venkatarathinam Nagar Adyar, CHENNAI 600 020 sujatha@servals.in	Member	044 - 42629399 9600109777