CLIMATE SMART GOVERNANCE

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सत्यमेव जयते

SECTOR - 7

CLIMATE CHANGE AND ENERGY

TRAINING MODULE

(2017-2020)

CLIMATE CHANGE AND ENERGY

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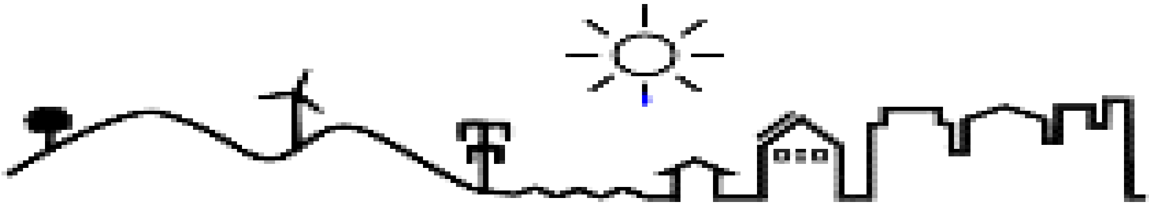


1. CLIMATE CHANGE AND ENERGY

Energy plays a vital role in many aspects of our lives, for example, we use electricity for lighting and cooling, we use fuel for transportation, heating, and cooking. The energy production and its use is interconnected with many other aspects of modern life, such as water consumption, use of goods and services, transportation, economic growth, land use, and population growth.

Climate change is likely to both increase electricity demand for cooling in the summer and decrease electricity, natural gas, heating oil, and wood demand for heating in the winter. New infrastructure investments may be necessary to meet increased energy demand, especially peak demand during heat waves. Climate change could affect the amount of water available to produce electricity or extract fuel. In areas where water is already scarce, competition for water between energy production and other uses could increase. Sea level rise and more frequent intense storms could disrupt energy production and delivery by damaging electricity infrastructure, fuel delivery infrastructure and equipment, power plants, or storage facilities (United States Environmental Protection Agency [EPA], 2016).

Fossil fuels like coal, petroleum, and natural gas are the main sources of energy, producing the vast majority of fuel, electricity, and heat used by people across the globe. They have high content of carbon which results in emission of CO_2 in large amount, which leads to global warming and adds to climate change.

2. NATIONAL AND INTERNATIONAL SCENARIO

World energy consumption will grow by 56% between 2010 and 2040, from 524 quadrillion British thermal units (Btu) to 820 quadrillion Btu. Most of this growth will come from non-OECD (non-Organization for Economic Cooperation and Development) countries, where demand is driven by strong economic growth (U.S. Energy Information of Administration (EIA], (2013).

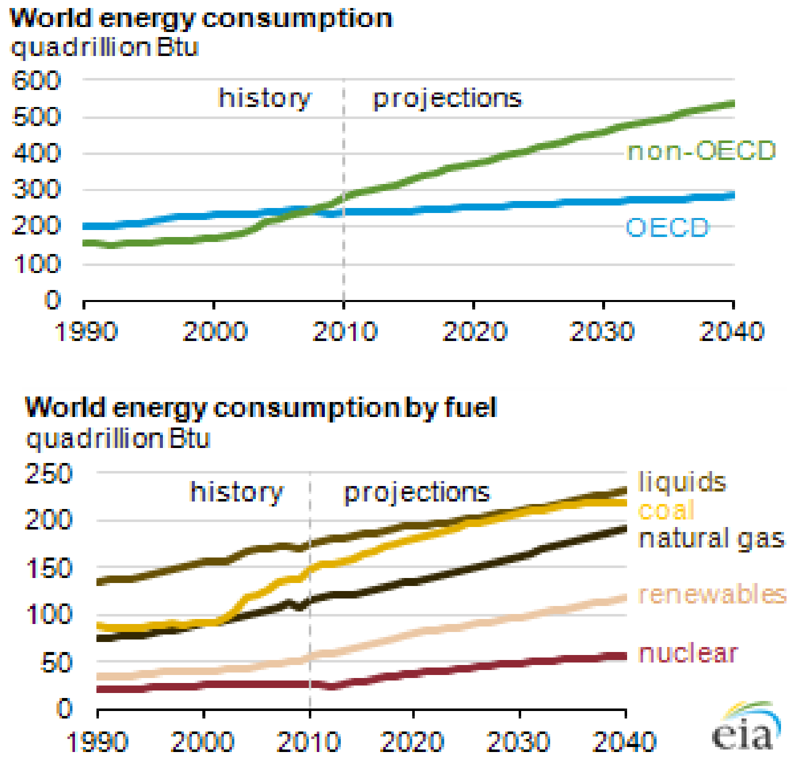


Figure7.1: World Energy Consumption

In India the energy sector has brought electricity to hundreds of millions of people who were previously without electricity supply, but the task remains far from done, with about 300 million people still have no access and many more living with poor quality supply. In some ways, this situation reflects a more general challenge to expand and improve India's underlying infrastructure. Fossil fuels particularly coal, are playing a major role in powering India's economic development, making India the world's fourth-largest source of energy-related CO_2 emissions. India's large (and growing) population, its low (but increasing) levels of energy consumption per capita and the high level of projected economic growth are powerful trends that, in the absence of concerted action, will commit India to a high-carbon development path (International Energy Agency [IEA], 2015).

India is home to 18% of the world's population but uses only 6% of the world's primary energy. Since 2000, India's energy consumption has almost doubled and the potential for further rapid growth is enormous. Per capita final energy consumption in India is very low and there is wide disparity between urban and rural areas. In 2015-16, India's per capita energy and electricity consumption stood at 1075 KWh/year, which was just one third of the world average. Nearly 25% of the population does not have access to electricity and a large proportion of the population especially in rural areas rely on non-commercial biomass like firewood for their cooking needs, exacerbating health concerns due to poor air quality.

In future, India is set to be at the center of the world's energy stage. It is set to contribute more than any other country to the projected rise in global energy demand, around one-quarter of the total. Urbanization will be a key diver of this trend as an additional 315 million people, almost the population of the United States today, are expected to live in India's cities by 2040. This will push up the demand from energy intensive sectors.

In addition, climate change will be a major challenge. Few countries in the world are as vulnerable to the effects of climate change as India is with its vast population that is dependent on the growth of its agrarian economy, its expansive coastal areas and the Himalayan region and islands. The Government of India is taking significant steps towards adopting clean energy. As a part of its international commitment, India put forward eight Nationally Determined Contributions (NDCs) under the Paris Agreement of UNFCCC. Three of the eight NDCs set quantifiable targets to be met by 2030: Goal 3, aims to reduce the emissions intensity of its GDP by 33%-35% from 2005 level, Goal 4, is to have 40% of cumulative electric power installed capacity from non-fossil, and Goal 5, aims to create an additional carbon sink of 2.5 to 3 billion tonnes of CO_2 equivalent (NitiAayog, n.d.).

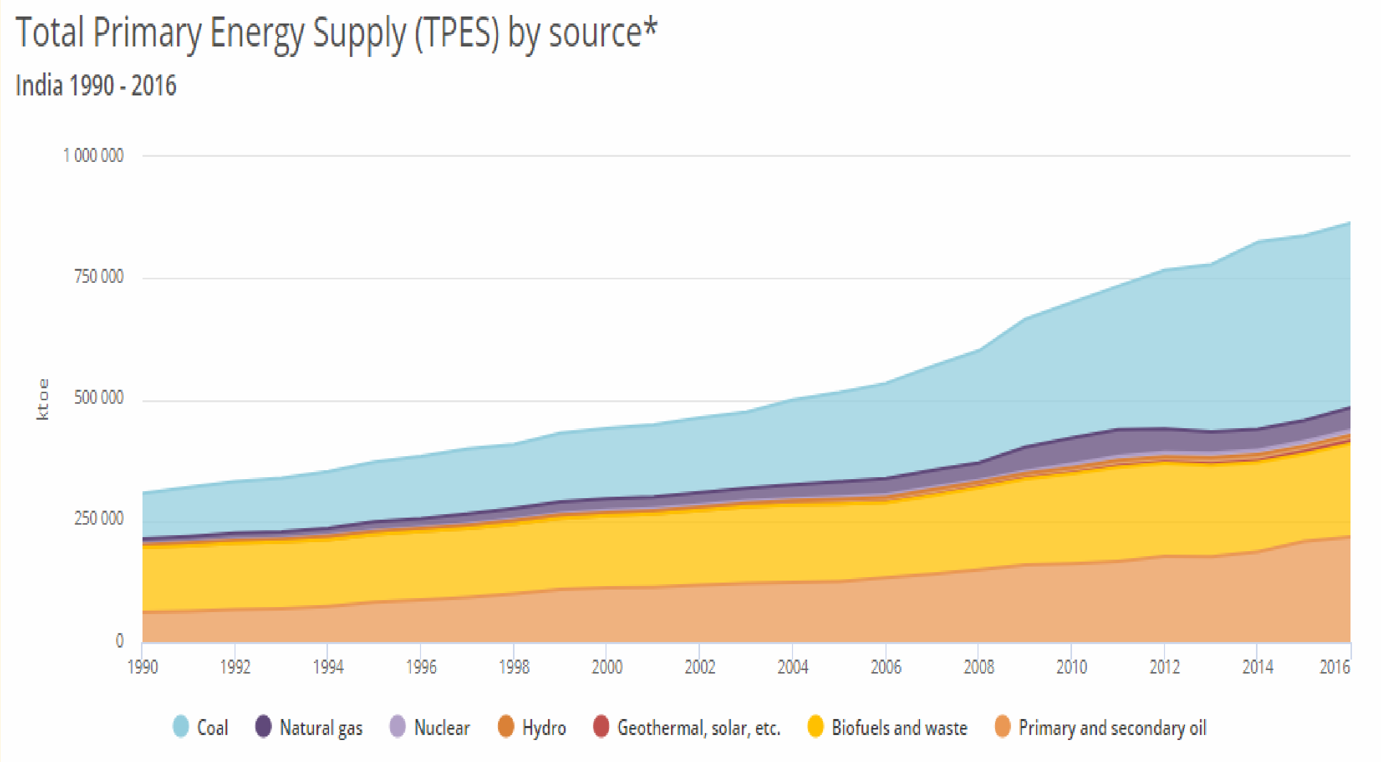


Figure 7.2: Total Primary Energy Supply by Source in India (1990-2016)

Source:https://www.iea.org/statistics/?country=INDIA&year=2016&category=Key%20indicators&indicator=TPESbySource&mode=chart&categoryBrowse=false&dataTable=BALANCES&showDataTable=false

Human activity is overloading our atmosphere with carbon dioxide and other global warming emissions. These gases act like a blanket, trapping heat. The result is a web of significant and harmful impacts, from stronger, more frequent storms, to drought, sea level rise, and extinction. In contrast, most renewable energy sources produce little to no global warming emissions. Even when including "life cycle" emissions of clean energy (i.e. the emissions from each stage of a technology's life—manufacturing, installation, operation, decommissioning), the global warming emissions associated with renewable energy are minimal (Union of Concerned Scientist [UCS], (2017).

Renewable energy is one of the most effective tools we have in the fight against climate change, and there is every reason to believe it will succeed. Renewable energy offers an immediate means to decarbonize the global energy mix. In addition to the climate benefits that they will help deliver, renewables already provide a wide range of market and public health benefits that far outweigh their costs (Long & Steinberger, 2016).

3. GREEN CLEAN: SUTAINABLE ENERGY SOURCES: RENEWABLE ENERGY

Renewable energy sources are found in sunlight, in the air, deep underground and in our oceans. They are part of the planet's physical structure, which means they are constantly being renewed by natural means. They simply cannot run out. These sustainable energy sources are often called "alternative energy" because they're considered to be an alternative to traditional fossil fuels such as oil and coal. The alternative energy resources pack a much lighter environmental footprint than fossil fuels. This is why renewable energy sources are so important. Even if we did not face the threat of climate change, minimizing pollution is basic for good health.

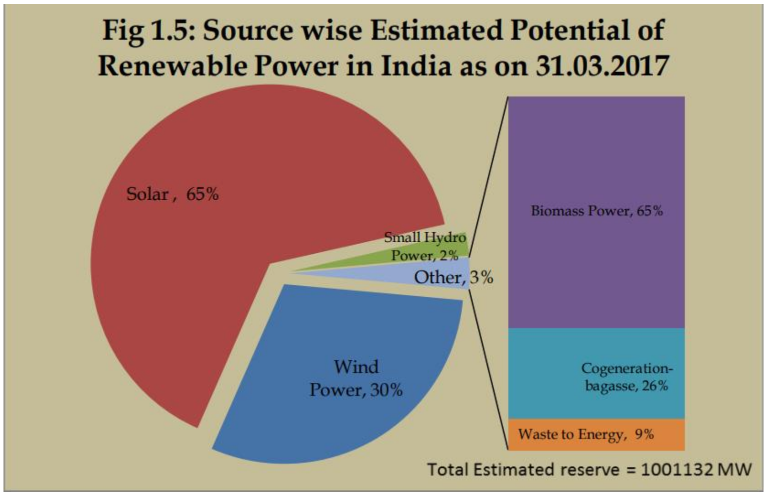


Figure 7.3: Source wise Estimated Potential of Renewable Power in India

Source:http://mospi.nic.in/sites/default/files/publication_reports/Energy_Statistics_2018.pdf

Five types of alternative energy are generated by harnessing a natural process, like sunlight or waves. They are generally the most sustainable forms of energy.

- **Solar Energy**- Sunlight is a renewable resource, and its most direct use is achieved by capturing the sun's energy. A variety of solar energy technologies are used to convert the sun's energy and light into heat: illumination, hot water, electricity and (paradoxically) cooling systems for businesses and industry. Solar hot water systems can be used to heat buildings by circulating water through flat-plate solar collectors. Commercial and industrial buildings can also leverage the sun's energy for larger scale needs such as ventilation, heating and cooling. Finally, thoughtful architectural designs can passively take advantage of the sun as a source of light for heating and cooling.

Technology type	System	Application
PV (solar electric)	Grid connected	• Supplementing mains supply
PV (solar electric)	Stand-alone	• Small home systems for lighting, radio, TV, etc. • Small commercial/community systems, including health care, schools, etc. • Telecommunications and navigation aids • Water pumping • Commercial systems • Remote settlements • Mini-grid systems
Solar thermal	Connected to existing water and/or space heating system	• Supplementing supply of hot water and/or space heating provided by the electricity grid or gas network
Solar thermal	Stand-alone	• Water heating, i.e. for rural clinics • Drying (often grain or other agricultural products) • Cooking • Distillation • Cooling

Figure7.4: Solar technologies & applications

Source: http://slideplayer.com/slide/5868051/

- **Capturing the Wind**- Wind can be considered a form of solar energy because the uneven heating and cooling of the atmosphere cause winds (as well as the rotation of the earth and other topographical factors). Wind flow can be captured by wind turbines and converted into electricity. On a smaller scale, windmills are still used today to pump water on farms. Commercial grade wind-powered generating systems are available to meet the renewable energy needs of many organizations. Single-wind turbines can generate electricity to supplement an existing electrical supply. When the wind blows, power generated by the system goes to offset the need for utility supplied electricity.

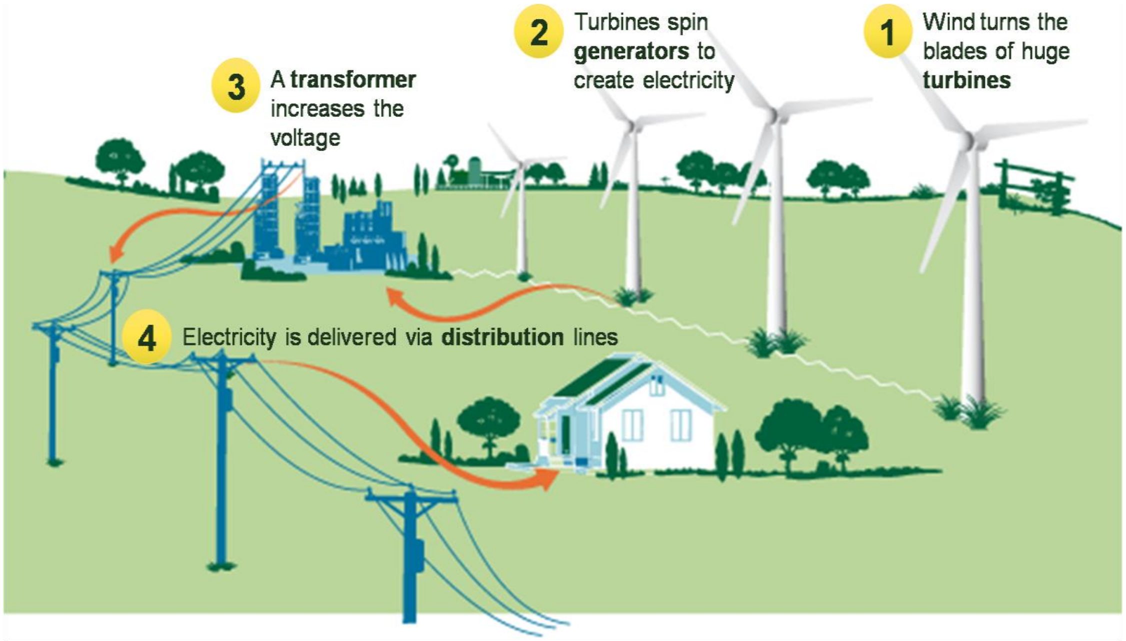


Figure 7.5: Wind Power Plant

Source: http://www.advancedenergycap.com/faq/

- **Geothermal (Power from the Earth)** - Geothermal energy is derived from the heat of the earth. This heat can be sourced close to the surface or from heated rock and reservoirs of hot water miles beneath our feet. Geothermal power plants harness these heat sources to generate electricity. On a much smaller scale, a geothermal heat pump system can leverage the constant temperature of the ground found just 10 feet under the surface to help supply heat to a nearby building in the winter, or to help cool it in the summer.

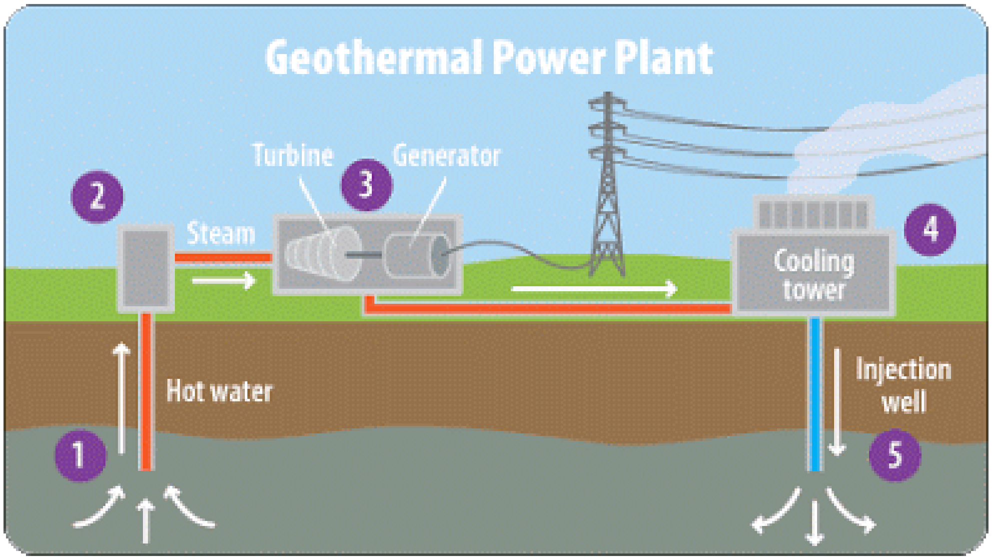


Figure 7.6: Geothermal Power Plant

Source: http://reezafumy.blogspot.com/2015/07/geothermal-powerplant-energy.html

- **From Waterwheels to Hydroelectricity**- Hydropower isn't a new invention, though the waterwheels once used to operate the gristmills and sawmills of early America are now largely functioning as historic sites and museums. The kinetic energy of flowing rivers is captured in a much different way and converted into hydroelectricity. Probably the most familiar type of hydroelectric power is generated by a system where dams are constructed to store water in a reservoir which, when released, flows through turbines to produce electricity. This is known as "pumped-storage hydropower," where water is cycled between lower and upper reservoirs to control electricity generation between times of low and peak demand.

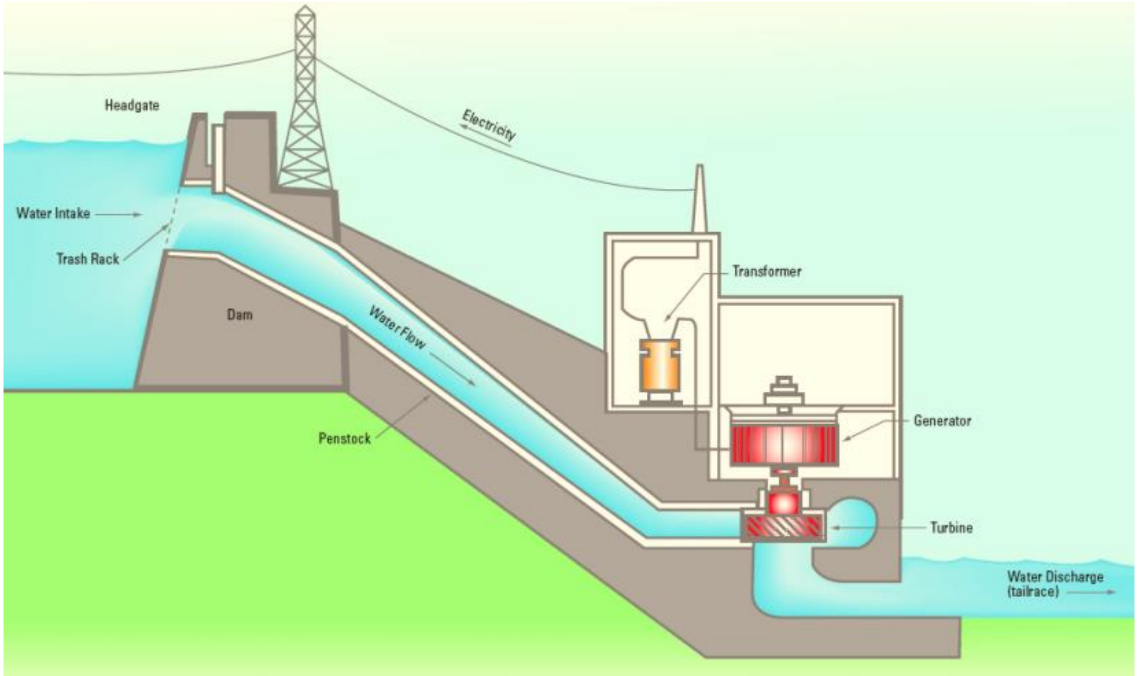


Figure 7.7: Hydrological Power Plant

Source: https://eurasia-news-online.com/2016/10/18/nine-of-the-10-biggest-power-plants-in-the-world-are-hydro-power/

- **Power from the Ocean**- There are two types of energy that can be produced by the ocean: thermal energy from the sun's heat and mechanical energy from the motion of tides and waves. Ocean thermal energy can be converted into electricity using a few different systems that rely on warm surface water temperatures. "Ocean mechanical energy" harnesses the ebbs and flows of tides caused by the rotation of the earth and the gravitational influence of the moon. Energy from wind-driven waves can also be converted and used to help reduce one's electricity costs.

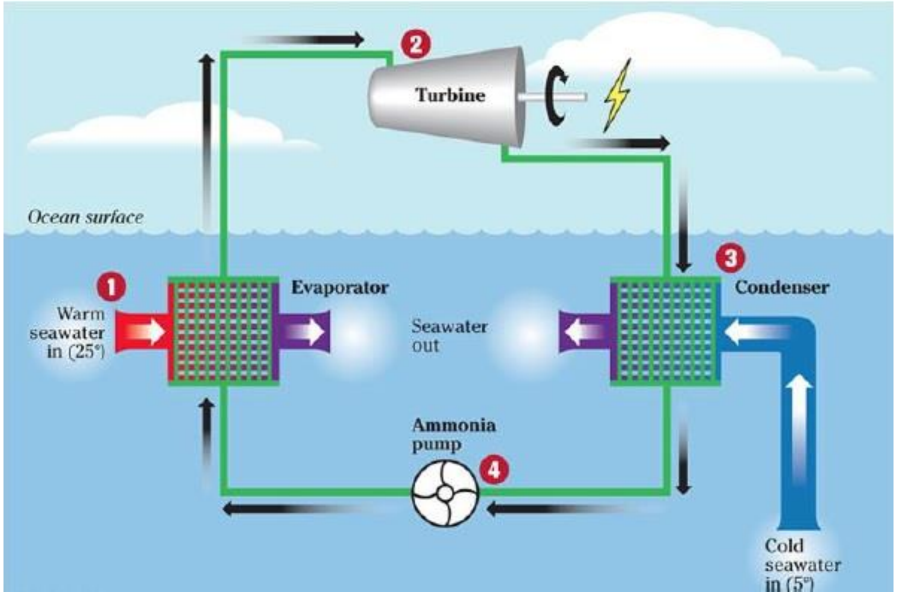


Figure7.8: Ocean Thermal Plant

Source: http://razak.utm.my/noorirza/2016/08/05/utm-ocean-thermal-energy-centre-utm-otec/

- **Other Alternative Energy Sources**- These two types of renewable energy to be produced using mechanical means, rather than by harnessing a natural process. Bioenergy is a type of renewable energy derived from biomass to create heat and electricity or to produce liquid fuels such as ethanol and biodiesel used for transportation. Biomass refers to any organic matter coming from recently living plants or animals. Even though bioenergy generates about the same amount of carbon dioxide as fossil fuels, the replacement plants grown as biomass remove an equal amount of CO_2 from the atmosphere, keeping the environmental impact relatively neutral.

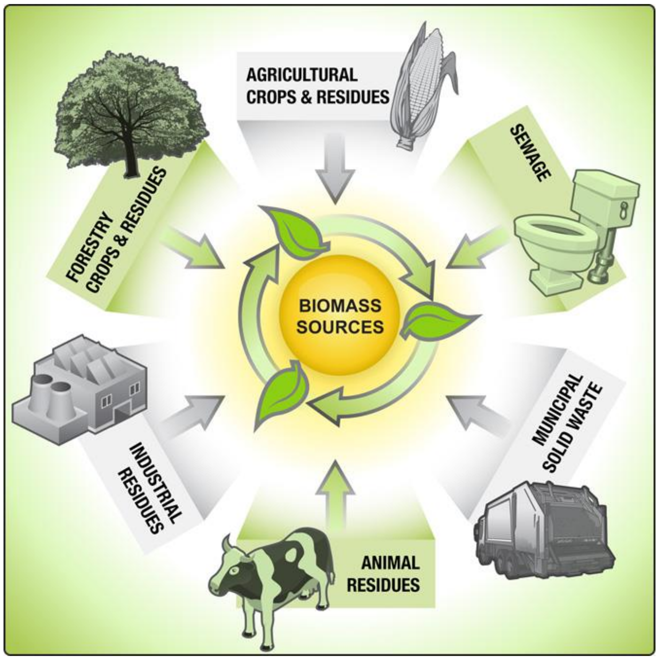


Figure 7.9: Source of Biomass energy

Source: https://theearthproject.com/biomass/

- **Hydrogen (High Energy/Low Pollution) -** Hydrogen is the simplest (comprised of one proton and one electron) and most abundant element in the universe, yet it does not occur naturally as a gas on earth. Instead, it is found in organic compounds (hydrocarbons such as gasoline, natural gas, methanol and propane) and water (H_2O). Hydrogen can also be produced under certain conditions by some algae and bacteria using sunlight as an energy source. Hydrogen is high in energy yet produces little or no pollution when burned. Liquid hydrogen has been used to launch space shuttles and other rockets into orbit since the 1950s. Hydrogen fuel cells convert the potential chemical energy of hydrogen into electricity, with pure water and heat as the only byproducts SunPower, 2018.

The second edition of REthinking Energy – the flagship report from the International Renewable Energy Agency (IRENA) – looks at how the transition to renewables could help limit global warming. As the report points out, renewable energy is at the core of any strategy for countries to meet climate goals while supporting economic growth, employment and domestic value creation.

Doubling the share of renewables by 2030 could deliver around half of the emissions reductions needed and, in combination with energy efficiency, keep the rise in average global temperatures within 2 degrees Celsius, the widely recognized target to prevent catastrophic climate change.

The share of renewables needs to grow not only in power generation but also in transport, heating and cooling. To avoid a lock-in with unsustainable energy systems, investments must grow immediately and must almost double to USD 500 billion annually between now and 2020, IRENA's analysis shows.

Five clear actions are needed to support the renewable energy transition:

- Strengthening the policy commitment to renewable energy;
- Mobilizing investment in renewable energy;
- Building institutional, technical and human capacity;
- Harnessing the cross-cutting impact of renewables on sustainable development;
- Enhancing regional engagement and international cooperation (International Renewable Energy Agency [IRENA], (2015).

Also, many GHG emission-reduction policies undertaken to date aim to achieve multiple objectives. These include market and subsidy reform, particularly in the energy sector are as follows:-

Policy objectives \ Policy options	Economic instruments	Regulatory instruments	Policy processes: Voluntary agreements	Policy processes: Dissemination of information and strategic planning	Policy processes: Technological RD&D and deployment
Energy efficiency	• Higher energy taxes • Lower energy subsidies • Power plant GHG taxes • Fiscal incentives • Tradable emissions permits	• Power plant minimum efficient standards • Best available technologies prescriptions	• Voluntary commitments to improve power plant efficiency	• Information and education campaigns.	• Cleaner power generation from fossil fuels
Energy source switching	• GHG taxes • Tradable emissions permits • Fiscal incentives	• Power plant fuel portfolio standards	• Voluntary commitments to fuel portfolio changes	• Information and education campaigns.	• Increased power generation from renewable, nuclear, and hydrogen as an energy carrier
Renewable energy	• Capital grants • Feed-in tariffs • Quota obligation and permit trading • GHG taxes • radable emissions permits	• Targets • Supportive transmission tariffs and transmission access	• Voluntary agreements to install renewable energy capacity	• Information and education campaigns • Green electricity validation	• Increased power generation from renewable energy sources
Carbon capture and storage	• GHG taxes • Tradable emissions permits	• Emissions restrictions for major point source emitters	• Voluntary agreements to develop and deploy CCS	• Information campaigns	• Chemical and biological sequestration • Sequestration in underground geological formations

Figure 7.10: Examples of policy measures given general policy objectives and options to reduce GHG emissions from the energy-supply sector.
Source: https://www.ipcc.ch/pdf/assessment-report/ar4/wg3/ar4-wg3-chapter4.pdf

4. CASE STUDIES

Study 1: Abellon Clean Energy, India

Pollution is rampant in Gujarat, one of India's most industrialised states. Factories rely mainly on lignite as fuel and the state's agricultural base suffers from high salinity and erratic rainfall. Farmers traditionally burn their crop waste to clear the land, thus further polluting the air.

Abellon, based in Ahmedabad, India, with offices in the U.S., Italy and Ghana, got its start in 2008 when the founders saw the opportunity to tackle both of these problems by replacing the coal and lignite used in factories with a fuel made from the farmers' crop waste. Abellon now pays 8,500 local farmers a small income for crop residues such as cotton stalks and cumin stems. Along with sawdust from nearby saw-mills, these residues are made into pellets and sold to local industries. This year the two pellet plants currently in operation produced 65,000 tonnes of pellets, mostly for large industrial customers. The company, which reported US$3.2 million in income in 2010 aims to open two additional pellet plants in Gujarat and to treble sales in India over the next five years. It also plans to expand into international markets. In addition to its biomass work, Abellon is working in solar energy, setting up pilot solar power projects combining multiple solar technologies

Study 2: Husk Power Systems in Bihar, India

Bihar is one of India's most poorly served states in terms of electricity, and even grid-connected homes and companies have an unreliable supply. Husk Power was established in 2008 to connect remote villages to a clean, reliable electricity supply based on rice husks as the feedstock. As of

March 2011, Husk Power, founded in 2008, was operating 65 plants to gasify rice husks – a plentiful local resource – and other biomass waste to supply electricity to around 180,000 people. Each plant contains a rice husk gasifier, a series of filters to clean the gas, a gas engine, a 35 KW generator and a 240 V AC electricity distribution system to connect customers within a two kilometer range.

New plants are opened when 400 or more households commit to paying a monthly fee. The fees start at US$2.20 per month for a basic connection. Husk's "value proposition" is to keep the plant design simple to encourage local employment. Locals with high school education are trained in management, operation and maintenance. Three of the company's founders come from Bihar and the fourth from the U.S. Based in New York, Husk is growing rapidly and aims to have more than 2,000 plants in operation by the end of 2014. Ten are under construction and carbon finance is being sought (Block, 2011).

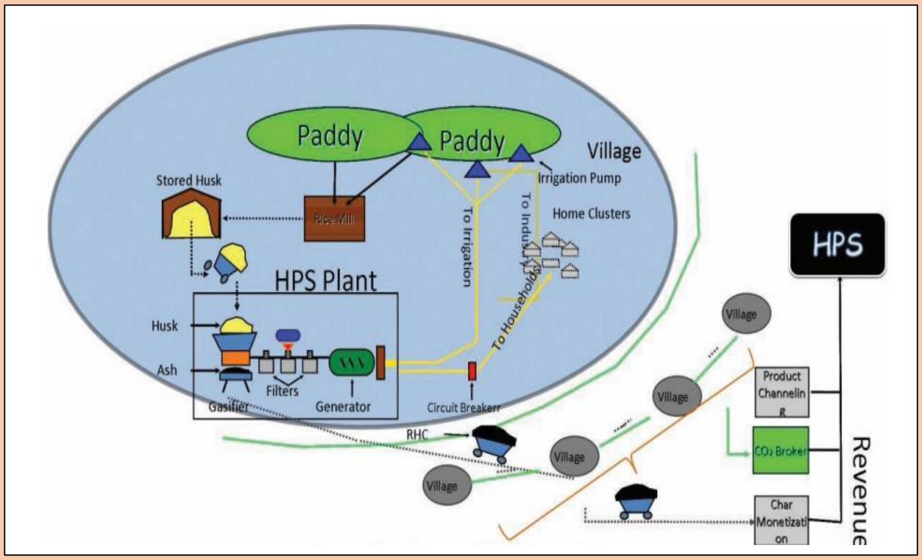


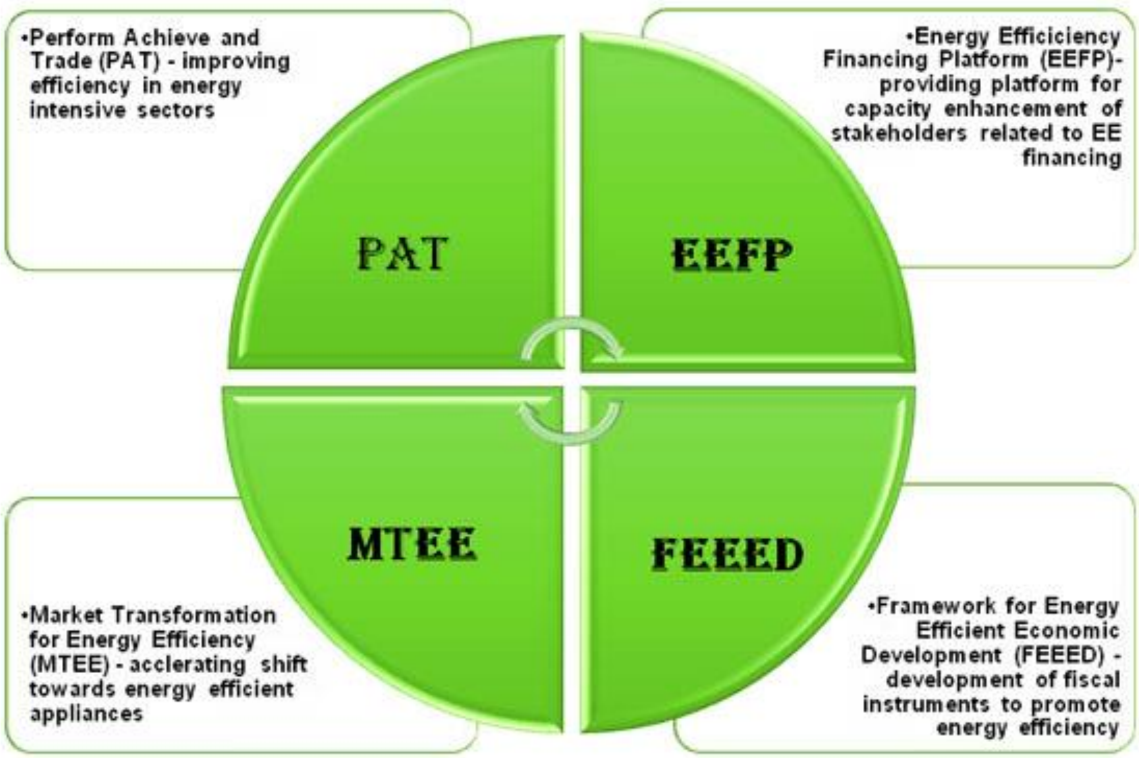
Figure 7.11: Husk Power System (HPS) Plant

Source: http://www.beyondjugaad.com/lighting-lives-husk-power-system-makes-affordable-electricity-reality-rural-india/

5. GOVERNMENT POLICIES

i. Nation Mission for Enhanced Energy Efficiency, 2010

The National Mission for Enhanced Energy Efficiency (NMEEE) is one of the eight national missions under the National Action Plan on Climate Change (NAPCC). NMEEE aims to strengthen the market for energy efficiency through implementation of innovative business models in the energy efficiency sector. NMEEE consist of four initiatives to enhance energy efficiency in energy intensive industries which are as follows (Bureau of Energy Efficiency [BEE], 2015):



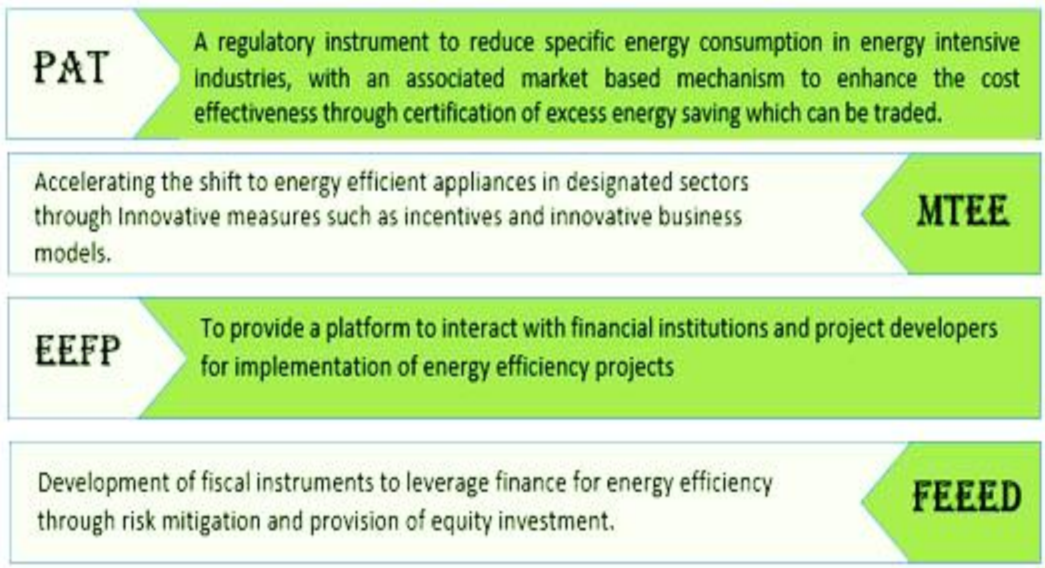


Figure 7.12: Components & Initiatives of NMEEE

ii. National Solar Mission, 2010

The National Solar Mission was launched on the 11th January, 2010 by the Prime Minister. The Mission has set the ambitious target of deploying 20,000 MW of grid connected solar power by 2022 is aimed at reducing the cost of solar power generation in the country through (i) long term policy; (ii) large scale deployment goals; (iii) aggressive R&D; and (iv) domestic production of critical raw materials, components and products, as a result to achieve grid tariff parity by 2022. Mission will create an enabling policy framework to achieve this objective and make India a global leader in solar energy.

Further, Government has revised the target of Grid Connected Solar Power Projects from 20,000 MW by the year 2021-22 to 100,000 MW by the year 2021-22 under the National Solar Mission and it was approved by Cabinet on 17th June 2015 (MNRE, 2018).

iii. National Energy Policy (Draft), 2017

The National Energy Policy (NEP) aims to chart the way forward to meet the Government's recent bold announcements in the energy domain. There are four key objectives of our energy policy: access at affordable prices, improved security and independence, greater sustainability and economic growth.

The policy aims to ensure that electricity reaches every household by 2022 as promised in the Budget 2015-16 and proposes to provide clean cooking fuel to all within a reasonable time. While it is envisaged that financial support will be extended to ensure merit consumption to the vulnerable sections, competitive prices will drive affordability to meet the above aims. Improved energy security, normally associated with reduced import dependence, is also an important goal of the policy The areas of supply and demand intervention considering under NEP are as follows (NitiAayog, 2017):-

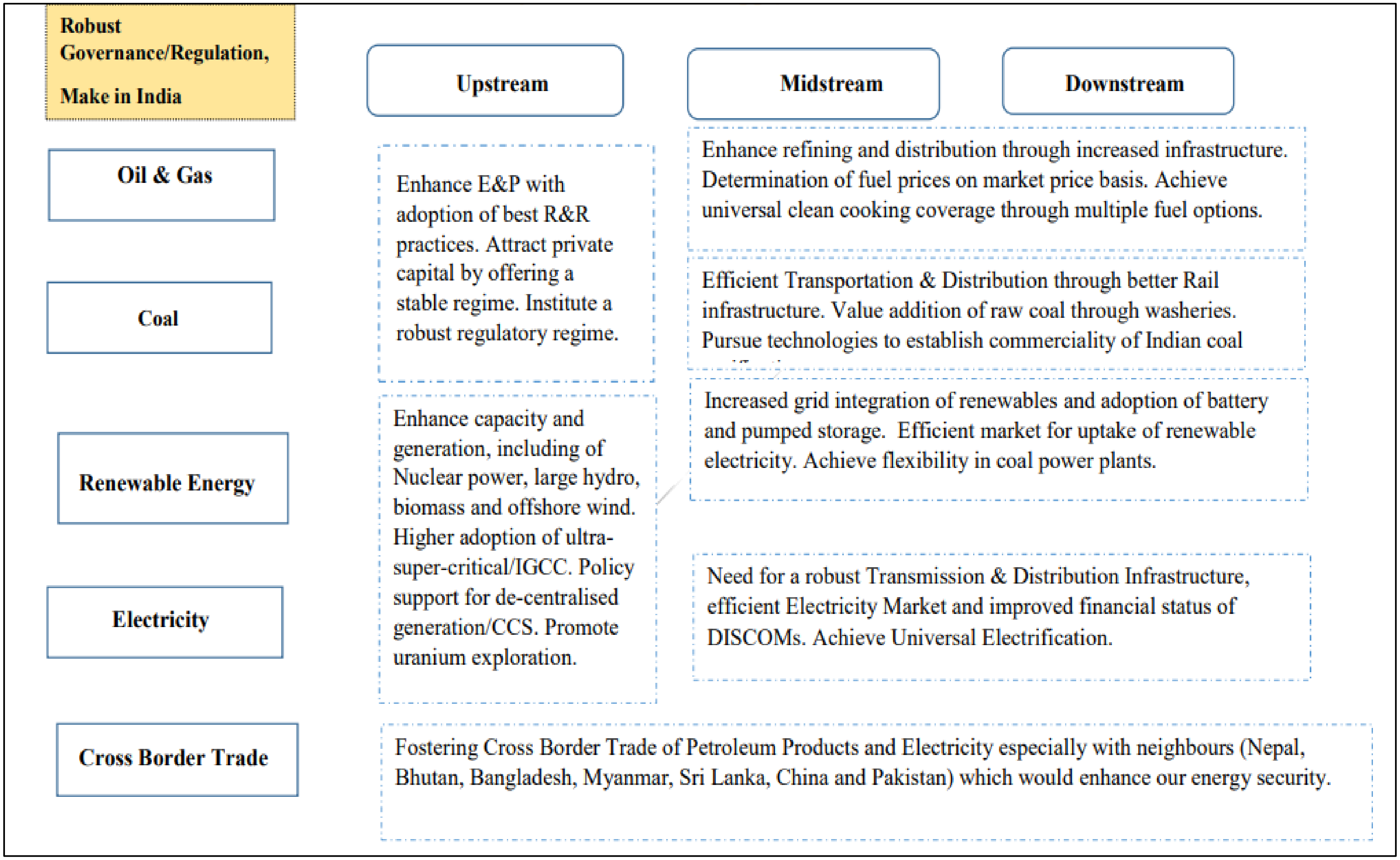


Figure 7.13: Areas of Supply Sector Intervention

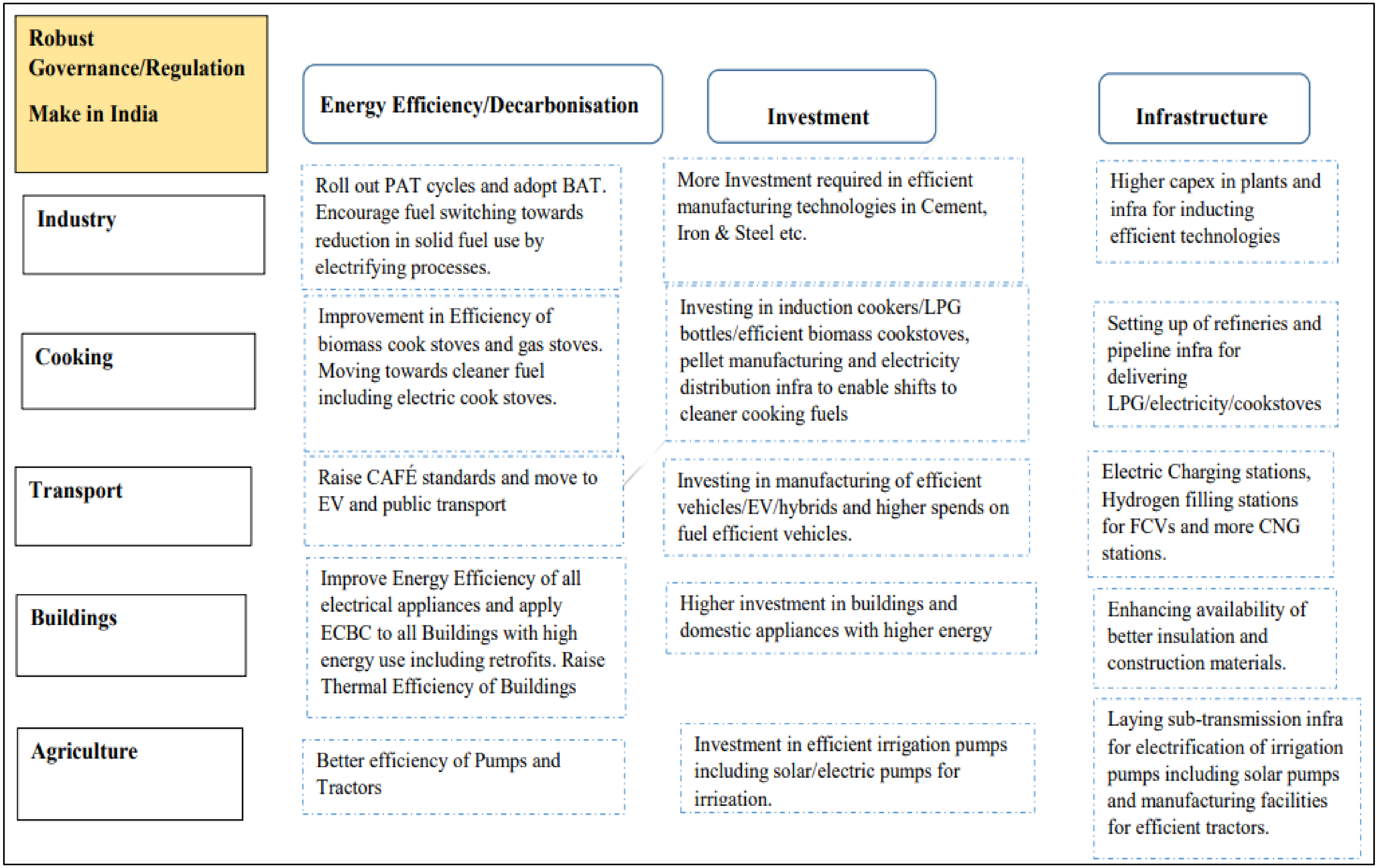


Figure 7.14: Areas of Demand Sector Intervention

6. WAY FORWARD

No energy source is free of some type of environmental impact, though energy efficiency practices properly implemented are the most environmentally friendly. While renewable energy sources such as wind and solar have clear environmental benefits compared to conventional sources, they are not free of consequences. Policy makers must incorporate the cost of some of these negative environmental consequences of energy production and use into prices.

A preponderance of evidence suggests that pricing energy more accurately will greatly improve the efficiency of the electricity industry, provide customers with proper price signals, reduce wasteful energy use, and most importantly, improve household incomes since they no longer have to waste as much time and money dealing with debilitating health issues caused by pollution. If policy makers desire to truly promote cleaner forms of energy, feed-in tariffs seem the best method to rapidly accelerate their adoption (Sovacool, 2014).

7. FURTHER READINGS

- http://niti.gov.in/writereaddata/files/document_publication/India%E2%80%99s-Energy-and-Emissions-Outlook_0.pdf
- https://www.ucsusa.org/clean-energy/renewable-energy/public-benefits-of-renewable-power#.WyYPblUzbcc\
- https://www.ipcc.ch/pdf/assessment-report/ar4/wg3/ar4-wg3-chapter4.pdf

- https://www.iea.org/publications/freepublications/publication/WEO2015SpecialReportonEnergyandClimateChange.pdf
- https://www.iea.org/publications/freepublications/publication/IndiaEnergyOutlook_WEO2015.pdf

8. REFERENCES

Bureau of Energy Efficiency [BEE], 2015. *National Mission for Enhanced Energy Efficiency*, Retrieved from https://www.beeindia.gov.in/content/nmeee-1

International Energy Agency [IEA], 2015. *Energy and Climate Change.* Retrieved from https://www.iea.org/publications/freepublications/publication/WEO2015SpecialReportonEnergyandClimateChange.pdf

International Renewable Energy Agency [IRENA], 2015. *REthinking Energy: Renewable Energy and Climate Change.* Retrieved from http://www.irena.org/publications/2015/Nov/REthinking-Energy-Renewable-Energy-and-Climate-Change

Block (2011). *Renewable energy in the developing world: case studies.* Retrieved from http://www.renewableenergyfocus.com/view/22511/renewable-energy-in-the-developing-world-case-studies/

MNRE, (2018). *Scheme / Documents*. Retrieved from https://mnre.gov.in/scheme-documents

NitiAayog, (2017). *Draft National Energy Policy.* Retrieved from http://niti.gov.in/writereaddata/files/new_initiatives/NEP-ID_27.06.2017.pdf

Long & Steinberger, (2016). Retrieved from https://www.nrdc.org/experts/noah-long/renewable-energy-key-fighting-climate-change

NtitAyog (n.d.). *Energy and Emissions Outlook*. Retrieved from http://niti.gov.in/writereaddata/files/document_publicatIndia%E2%80%99s-Energy-and-Emissions-Outlook_0.pdf

Sovacool, (2014). *Environmental Issues, Climate Changes, And Energy Security In Developing Asia.* Retrieved from https://www.adb.org/sites/default/files/publication/42604/ewp-399.pdf

SunPower, (2018). *A Complete Guide to 7 Renewable Energy Sources.* Retrieved from https://us.sunpower.com/blog/2018/02/23/learn-about-seven-types-renewable-energy/

U.S. Energy Information of Administration [EIA], (2013). *EIA projects world energy consumption will increase 56% by 2040.* Retrieved from https://www.eia.gov/todayinenergy/detail.php?id=12251

Union of Concerned Scientist [UCS], (2017). *Benefits of Renewable Energy Use.* Retrieved from https://www.ucsusa.org/clean-energy/renewable-energy/public-benefits-of-renewable-power#.WyYPblUzbcc\

United States Environmental Protection Agency [EPA], (2016). *Climate Impacts on Energy.* Retrieved from https://19january2017snapshot.epa.gov/climate-impacts/climate-impacts-energy_.html