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India's Energy-Climate Dilemma: The Pursuit for Renewable Energy Guided by Existing Climate Change Policies

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Abstract

India is confronted with the arduous challenge of supplying accessible and affordable energy to help alleviate poverty and meet energy demands that is necessary for economic growth. This task is exacerbated by a growing global environmental consciousness due to climate change and its impacts in both the environmental and socioeconomic realm. India is striving to meet energy needs while being cognizant about climate change by advocating sustainable energy alternatives to fossil fuels and adopting ambitious targets for reducing greenhouse gas emissions through climate change policies.

This review addresses and exposes the challenges India is faced with in abolishing its energy crisis and increasing its economic growth while being environmentally responsible and judicious. First, an introduction to the problem by explaining India's current situation will offer a basis for understanding the extent to which both socioeconomic and environmental factors have on decision making and finding the appropriate solution. Second, an overview of India's energy and climate policies are provided along with their objectives and targets in meeting both energy demands while reducing greenhouse gas emissions through the adoption of renewable energy sources. Third, financial instruments employed by India to encourage the promotion and innovation of renewable energy and discourage the use of conventional sources is discussed. Lastly, India's renewable energy potential and capacity is explored through various energy sources. The research reveals that India's continued use of conventional energy sources is both unsustainable and environmentally destructive in meeting energy demands, instead, the research suggests the encouragement of the use of renewable energy sources by mandating environmental and energy policies and employing monetary incentives to increase its share in the energy grid and promote its implementation. Despite setting very ambitious goals, India will need to be assertive in promoting renewable energy technologies for a sustainable future, which is possible owing to its generous potential.

Keywords: India; Climate change; Climate change policy; Renewable energy; Energy poverty; Energy policy; Fossil fuels

Introduction and Background

India is experiencing unrelenting economic growth that has aroused concern for the country's current highly energy intensive resource stocks and their contribution towards the salient problem of climate change [1]. The energy-climate issue is challenging for India as it supports approximately 18% of the world's population which is equivalent to 1.2 billion people and is expected to rise to 1.5 billion by 2030 [2]. Despite India being ranked fourth in the world for total energy consumption [3], its per-capita emissions of 1.7 tonnes of carbon dioxide (CO2) falls significantly short compared to the world average of 4.4 tonnes of CO_2 [4]. This trend is likely to persist up until 2031 as energy resources are becoming exhausted in spite of India being one of the largest producers of energy [5]. Electricity is required for sustaining India's social and development growth of more than 8-10% of its gross domestic product (GDP) [6], an increase experienced in the past 5 years [7], but overall important for industrialization, economic growth and improved quality of life [8]. India's electrification rate, defined as the percentage of households that have access to electricity, is only 44%, with an estimated 580 million people having no access to electricity along with a quarter of the 600,000 villages yet to be electrified [9]. Energy poverty and outages exacerbate the energy dilemma, one example of a severe power outage occurred in July 2012 for several hours, preventing 600 million people access to electricity as a result of the collapse of the power grid, highlighted with a supply, demand and shortage of electricity of 6.7%, 6.8% and 7.8% respectively [10], and an energy deficit of 13% [1]. India has relied on coal and oil to meet its energy demands for an increasingly growing economy and population, with coal, oil and natural gas comprising of 55%, 29.9%, 8.5%, and hydro and nuclear energy comprising of 5.6% and 1.0% respectively in 2005 [11]. Today, 64% is dependent on fossil fuels, 22% on hydro, 11% on renewables and 3% on nuclear [1]. It is evident that India depends on fossil fuels to meet its energy demands, however the country lacks sufficient reserves to meet such demands. India already imports 80% of its oil [12], an increase from 72% in 2004-2005 [11], rendering it vulnerable to sustaining and increasing capacity. Oil imports are likely to increase four to five times by 2030, along with a doubling of imported coal in the next decade from 16% to an estimated 30% [6]. However, coal is India's most abundant resource and has the highest electric power capacity of 62% out of the 84% of the thermal power generated electricity in the year ending in March 2015 [13]. India's electricity generated from fossil fuel sources produced 770 kilowatt-hours (kWh) per-capita in 2011-2012, which is a quarter compared to the world average of 3100 kWh [13]. For India to sustain an economic growth rate of 8-10% per year [5], it will require more than the theoretical maximum of 1200 kWh generated per person from the current fossil fuel intensive system [14].

India's energy challenges extend into the domestic realm, with over 600 million people lacking modern cooking fuels, instead, traditional

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fuels like coal, charcoal, wood and dung comprise of 80-90% of the rural energy requirements chiefly because of affordability and accessibility [9]. Three quarters of India's rural and one quarter of its urban households rely on biomass for domestic needs [6], which is utilized inefficiently and releases large amounts of methane gas causing over 2.5 million deaths of women and children per year in developing countries as a result of indoor air pollution [9]. The use of fuelwood for example has other environmental impacts due to the amount of pressure it places on forests and ecosystems. It is estimated that 86 million tonnes of wood is required for forest regeneration, however India's rural population has consumed over 220 million tonnes [15]. It is anticipated that total and per-capita emissions in the future will rise significantly as a response to meeting the demands of a growing population. Currently India's electricity generation division is accountable for 38% of its total greenhouse gas (GHG) emissions [13], and it is projected that over 3000 million tonnes of CO_2 will be released by 2030 [4], as India's use of coal is projected to triple also by 2030 as energy demand doubles [7]. This increase in demand is due to India's population increasing from 1.2 to 1.5 billion people where 40% of the population will live in urban areas compared to the 30% today [2]. The increase in carbon intensive fuels will also impact the health sector of India. The combustion of coal not only contributes to global warming but also to acid rain pollution due to sulphur dioxide emissions, particulate matter and smog that threatens both urban and rural communities [15].

Thus, India is faced with the ongoing challenge of supplying accessible energy to abolish poverty and meet the increasing energy demands as a result of economic growth, urbanization, per-capita consumption and an enhanced livelihood which threaten energy security. It is evident that India's energy situation for rural and urban settings are described as needing more energy due to an insufficient supply and relying on imports and carbon intensive sources that are inefficient and environmentally unsustainable [15]. India's struggle between energy demand and supply is exacerbated by the impacts of climate change, where GDP is expected to decrease by 3-9% by 2100 as a result of a 4 degree increase [7], although both energy security and climate change have been the major driving forces for the implementation of policies, regulations and investments in the renewable energy (RE) sector. RE is not foreign to India and its pursuit can make a significant contribution to each of the challenges mentioned above due to its presence as being part of the solution for both energy security and demand, and environmentally by reducing India's reliance on fossil fuels causing a decrease in GHG emissions and aiding in the fight against climate change. The objective of this paper is to analyze the RE and climate change polices of India and its development towards future strategies for sustainable energy transformations while also briefly mentioning India's potential for RE.

National Strategies that Address the Problem: Policy Framework and their Objectives

India's aim to sustain the environment and establish effective policies are grounded in its Constitution, found in Article 48-A, stating that the country will strive to protect, preserve and enrich the environment while also sustaining its forests and wildlife [2]. This catalyzed India to be one of the first countries to formulate a RE program beginning in the 1970s [6]. India's initial push for RE technologies began with the creation of the Commission for Additional Sources of Energy in 1981 due to their realization that renewables such as sunlight, wind and biomass are able to provide an inexhaustible supply of environmentally friendly energy [15]. Over the next decade the commission began to transform into what was formerly called the Ministry of Non-conventional Energy Sources in 1992, to the newly Ministry of New and Renewable Energy (MNRE) in 2006 which is the only one of its kind in the world [11]. India's RE sector is ranked fifth in the world, with 9% of its energy sector derived from renewables in 2010 [6], to 11% currently [1]. The Indian RE Department Agency was created in 1987 as a means to fund RE initiatives, and today through the MNRE and its state affiliates, encouragement of renewables and active participation in the private sector led to an enrichment in the RE sector [11]. The MNRE has four main objectives that promote the use of RE, the first is promoting its participation in the power grid, second is to meet energy demands for urban and rural areas along with industries, third is to promote the implementation, design and research of new RE technologies, and lastly, to create a vigorous manufacturing industry in the RE division [12]. Since the creation of the MNRE in 2006, India has been showing a 19% cumulative annual growth rate of RE capacity installment with the addition of policies and regulations developed by various government administrations since the early 2000s [10].

India's Electricity Act

India's electricity act became enacted in May 2003 and is said to have accelerated and motivated India's search for alternative energy sources to fossil fuels while replacing all prior legislation related to India's electricity [10]. There are 185 sections within this act, however only those that are relevant will be discussed. Part two section 3 describes the national electricity policy and plan which aims to prepare a National Electricity Policy, a tariff policy and National Electricity Plan that optimizes the use of resources including thermal, nuclear, hydro and mainly renewable [16]. Section 4 promotes a national policy on stand-alone systems for rural areas centered on RE [16], in addition to section 61(h) which uses RE in the generation of electricity through tariff regulations [10,16]. Section 86(1-e) advocates the generation of electricity from renewables in order to connect it with India's grid and permit the sale to any person while also specifying a certain percentage of India's total electricity consumption derived from RE sources [6,16].

National Electricity Policy

India created its National Electricity Policy (NEP) in 2005 under section 3(1) of the Energy Act (2003) with the intention of formulating and enhancing its energy systems to maximize the efficiency and utilization of its resources [17]. The NEP encourages the necessary requirements for an increase in the portion of RE by authorizing the State Electricity Regulatory Commissions (SERCs) to launch a tariff for electricity generated from renewable sources which encourages competitiveness in the energy market [17]. Under section 5.12 labelled the Cogeneration and Non-Conventional Energy Sources, the policy promotes the implementation of cogeneration amenities and provides consent to the SERCs to establish a deal in the sale of a surplus of electricity through a competitive bidding system between co-generators and industry [10,17]. This section also stresses the importance of utilizing RE as a way of preserving and sustaining the environment and aiding in the mitigation of climate change with the benefit of meeting energy demands and empowering both urban and rural communities [17]. India further encouraged the share of electricity coming from renewable sources by creating the Electricity Tariff Policy in 2006 which mandates a specified portion of the total energy consumption coming from renewables through a preferential tariff which is decided by the state [10]. In conclusion, the objectives of the NEP are laid out in section 2.0 and consist of the following; to increase the accessibility of electricity for all citizens by 2010, to secure energy availability by meeting energy demands by 2012, to supply reliable electricity that is efficient and reasonably priced, to increase per-capita electricity

by over 1000 units by 2012, to increase the commercial viability and longevity of the electricity sector, and protect consumer interests [2]. Both the Energy Act of 2003 and National Electricity Policy of 2005 are mechanisms that help increase the share of RE in the total electricity generation in India and have been influential in India's path towards a sustainable future.

National Action Plan on Climate change

India released its National Action Plan on Climate Change (NAPCC) on June 30, 2008 that extends until 2017 with the purpose of achieving a sustainable development path that enhances both economic and environmental aspirations [18]. The vision of the NAPCC is to enable India to be a prosperous and efficient economy that is self-sustaining for both present and future generations while confronting climate change [19]. The NAPCC is governed by a list of principles, with the most relevant being the following: First, deploying a sustainable development strategy that reduces poverty, vulnerability and anthropogenic impacts on climate change, second, attaining India's growth objectives through a shift in energy practices that encourages sustainability while leading to a decline in GHG emissions, third, developing and installing technologies at a rapid pace that aid in the adaptation and mitigation of GHGs and lastly, establishing new markets and regulatory and voluntary mechanisms that stimulate sustainable development [19].

The NAPCCs main objective is to advance both India's economic growth and climate change objectives of adaptation and mitigation through the Eight National Missions that are representative of a multi-faceted, long term and unified approach for achieving the key objectives in the framework of climate change [19]. These objectives are enforced by actions of state governments, non-governmental organizations, the private sector and other stakeholders [2]. First is the National Solar Mission, which takes advantage of India's solar generation capacity by attempting to make solar energy competitive with conventional sources of energy [19]. Projects that promote solar energy include the creation of a solar research institution, increased participation in international initiatives on technological expansion, strengthening domestic participation and production and supporting solar energy through government funding and investments [18]. Second is the National Mission for Enhanced Energy Efficiency, which promotes a decline in energy consumption targeted towards large industries by allowing companies to trade energy-saving certificates, providing tax reduction incentives on energy efficient products, and financing to reduce energy consumption in both the public and private spheres through various management programs [18,19]. The NAPCC aims to derive 15% of India's electricity from renewable sources by 2020 [20]. Third is the National Mission on Sustainable Habitat, which looks to increase energy efficiency through urban planning, improving building codes, promoting the use of efficient vehicles and encouraging citizens to use public transportation through monetary incentives, and stressing the importance of waste management and recycling [18]. Fourth is the National Water Mission, which aims to increase water use efficiency by 20% by setting new prices and alternative means that address the issue of water scarcity and climate change [19]. Fifth is the National Mission for Sustaining the Himalayan Ecosystem, which aims to preserve and protect the health of both mountainous and forest ecosystems while also abating melting of the glaciers [19]. Sixth is the National Mission for a Green India, with the objective of increasing their forest area from 23% to 33% and reforesting 6 million hectares of degraded forest lands [18]. Seventh is the National Mission for Sustainable Agriculture, with the objective of increasing the resiliency of their agricultural sector by investing in climate resilient crops, increasing weather insurance systems and improving agricultural processes [19]. Lastly is the National Mission on Strategic Knowledge for Climate Change, which aims to expand their knowledge on climate change science, research obstacles, modelling techniques, international cooperation and establishing a Climate Science Research Fund [19]. It promotes private sector actions and engagement in developing adaptation and mitigation technologies by using venture capital funds [19].

The NAPCC includes other ongoing objectives such as discontinuing inefficient coal-fired plants while investing in RE, making electricity from renewable sources reach a certain percentage of the total grid's energy consumption under the Electricity Act of 2003 and National Tariff Policy of 2006, and promote energy efficiency under the Energy Conservation Act of 2001 by targeting large industries through energy audits and energy labeling programs [18].

Copenhagen Accord

India announced in 2009 under the Copenhagen Accord that it will commit to reduce its emissions by 20-25% below 2005 levels by 2020, a voluntary goal that is not legally binding under the convention [21,22]. India plans on meeting and exceeding this goal by implementing fuel efficiency standards and building energy regulations, expanding the country's forest cover to sequester 10% of its annual emissions, and increase electricity from renewable sources from 8% to 20% by 2020 [23].

India's Intended Nationally Determined Contribution

The Intergovernmental Panel on Climate Change (IPCC) in its 5th assessment report indicates that irreversible impacts as a result of climate change will occur once we surpass a threshold value of 2°C above pre-industrial levels [24]. This statement has emphasized with grave concern the need for the international community to focus on limiting global mean temperatures to well below 2°C, which led to the recent climate change agreement under the United Nations Framework Convention on Climate Change (UNFCCC) Conference of the parties (COP21) in Paris of December 2015 [25]. Countries participating in COP21 have been submitting their Intended Nationally Determined Contributions (INDCs) which specifies their emission reduction commitments through 2025 or 2030 [26]. India submitted their INDC on the first of October 2015 [27], where the following outlines their 8 major commitments for the period of 2021 to 2030 [2]: First, to promote a sustainable way of life centered on traditions and principles of preservation and moderation. Second, to implement an environmentally sustainable oriented path compared to other nations of equal economic growth. Third, to lower the emissions intensity of GDP by 33% to 35% by 2030 based on 2005 levels. Fourth, to increase the proportion of non-fossil fuel based energy sources to 40% power capacity of the total electricity consumption by 2030, and achieve 175 gigawatts (GW) of RE capacity by 2022. Fifth, to develop supplementary carbon sinks by expanding forest and tree cover area that can absorb 2.5 to 3 billion tonnes of CO_2 equivalent by 2030. Sixth, to increase adaptation strategies by encouraging investments in development programs in susceptible divisions such as agriculture, water resources and disaster management. Seventh, to transfer resources and funds from developed countries in order to implement mitigation and adaptation strategies. Lastly, to build capacities and invest in technology advancements and encourage international collaboration for research and development for future technologies.

It is estimated that India will need a minimum of USD 2.5 trillion for meeting its objectives between now and 2030 [2]. India's INDC is very ambitious considering that it is trying to increase the country's

standard of living while being environmentally sustainable by shifting towards a non-fossil fuel based energy system and development pathway, while meeting the economic and energy demands it is confronted with today.

Financial Instruments to Promote Climate change Action

Coal tax

A popular market instrument used globally to reduce GHG emissions is through a carbon tax. India initiated a nationwide carbon tax as a Clean Energy tax on July 1, 2010 only on coal which was initially set at 50 rupees per tonne of domestic and imported coal [28]. For the tax to be successful people must be willing to pay, although a carbon tax in general is to provide an incentive for people to use transportation methods that are sustainable. Gupta [28] conducted a study to evaluate the citizens of India's willingness to pay by analyzing survey data from three cities and found that citizens were willing to pay largely because of their awareness and interest towards the environment and on other factors such as their education, age and income. In 2015 the tax quadrupled to 200 rupees per tonne of coal, and so far it has been a massive success for financing the National Clean Environment Fund used to invest in clean energy projects and technologies by collecting an equivalent of USD 2.7 billion until 2015, which has supported 46 clean energy initiatives [2]. Recently in 2016, the coal tax doubled from 200 rupees to 400 rupees per tonne, enabling RE to become more competitive in the energy market and help finance more RE projects [29].

Subsidy cuts on fossil fuels

India has cut its subsidies while elevating its taxes on fossil fuels, in particular petrol and diesel, with a carbon tax of USD 140 and USD 64 respectively [2,30]. This tax is considered to exceed what the reasonable value is in terms of an initial carbon tax, and led to a decrease in the petrol subsidy by approximately 25% which is projected to help India reduce 11 million tonnes of CO_2 emissions in under a year [2]. In addition, India has implemented tax free infrastructure bonds valued at USD 800 million for financing RE initiatives through 2015 and 2016 [2].

RE Certificates

RE Certificates (RECs) is a market instrument that endorses RE and its participation in the energy market with the goal of promoting sustainable development in India [10]. The MNRE established the RECs in 2010 and allowed their trading in March 2011 to address the discrepancy between the availability of electricity coming from RE sources and the conditions of the obligated industries to meet their Renewable Purchase Obligation (RPO) under the Electricity Act 2003 [20]. The RPOs require distribution companies, energy producers and certain consumers to obtain a share of their electricity from renewable sources [31]. The REC program is enforced by the Central Electricity Regulatory Commission and offers two choices for RE producers, the first allows them to sell their energy at special prices, and second, offer electricity with environmental attributes that can be tradeable like RECs [31]. So far it has been widely stated that participation in REC markets is short and unsuccessful in enticing large investments because less than 2.5% of certificates out of the anticipated REC demand were issued [20]. The main elements that hinder the programs ability to reach its full potential results from demand uncertainty due to the absence of long term targets, lack of compliance and the absence of future price signals to investors [20].

Perform Achieve and Trade

Perform Achieve and Trade (PAT) aims to improve energy efficiency by 1-2% per year for large energy intensive industries through energy trading mechanisms that runs from 2012 to 2015 [32]. To date, 478 plants in eight energy demanding sectors that make up one third of the total energy consumption in India have participated and have resulted in a 4% to 5% decline in energy consumption at the end of 2015 compared to 2012 [2].

Mitigation Strategies – Promotion of RE

India is blessed with an immense potential of RE resources to achieve its energy demands. Globally, it is considered to have one of the largest RE capacity extension programs, which has shown an increase in the proportion of renewables in the energy grid from 2% (3.9 GW) to 13% (36 GW) between 2002 and 2015 [2]. Currently India aims for a RE capacity of 175 GW by 2022 [19], and therefore it is likely that India's RE sector will significantly increase to meet this target.

Solar power

Initially solar power was not considered to play a significant role in the energy mix due to its high costs, however the emergence of the Jawaharlal Nehru National Solar Mission under the NAPCC has accelerated its growth [1]. India's location between the Tropic of Cancer and the equator is very appealing to solar power because it receives 4-7 kWh of solar radiation per square metre per day for 250-300 sunny days annually [31]. India experiences an average temperature of 25°C to 27°C and has a solar energy potential of 5000 trillion kWh per year [8], which far surpasses its annual energy consumption and can enable India to become a global leader in solar power. India has rapidly increased its solar power capacity from 3.7 MW in 2005 to 4060 MW in 2015 showing a compound annual growth rate exceeding 100% over the past 10 years [2]. The solar sector has grown over 200-fold in the last five years and is expected to expand further under the National Solar Mission to install 22 GW of solar capacity by 2022 [13,31].

Wind energy

Wind energy is the largest growing RE sector in India while simultaneously experiencing an increase in social acceptability [33]. Wind provides India with 24 GW of power which comprises of 65% of the total renewable installed capacity [2], ranking India fifth in the world for wind power consumption [34]. Offshore wind farms do not supply energy to the mix because of the lack of policies to strengthen their development [35], despite their vast coastline of 7500 km^2 which is suggestive of their potential [1]. However, the MNRE has drafted an offshore policy framework that is still in its infancy [36]. The potential of wind power is cited to be 103 GW and 50 GW at a height of 80 metres and 50 meters, respectively at 2% land area [8]. India's wind industry is growing 2.1 GW a year from additional installations and is projected to save 48 million tonnes of CO_2 in 2020 and 105 million tonnes in 2030 [8]. India's current target is to attain 60 GW of wind power installed capacity by 2022 [2].

Biomass energy

Biomass energy accounts for 13% out of the 10.5% of the total RE generation for India [37], and approximately 32% of the total primary energy use comes from biomass [1]. Biomass is an important energy source to India because more than 70% of its population rely on it for energy [2], and globally in 2011 2.4 billion people depended on wood, agricultural residues and dung for energy and is expected to increase to 2.6 billion by 2030 [9]. India has an extensive agricultural and forest

region that contains over 640 million tonnes of biomass that is available annually [1]. India's total biomass power generation capacity is 17.5 GW [37], where presently 4.4 GW is being generated [2]. Biomass however is being used inefficiently and is exposing mainly women and children to high levels of indoor pollution [9], although a number of policies and programs have been established to advocate cleaner and efficient utilization [2]. India aims to increase its biomass installed capacity to 9 GW by 2022 through its Biomass power and Cogeneration program [1].

Hydropower

Next to coal power plants, hydropower is the second largest source of energy consumed in India [38]. The geography of India is advantageous for the development of both large and small hydropower plants [39]. Hydropower has a growing potential of more than 150 GW [1], currently it contributes to 46 GW of installed capacity where 4 GW and 42 GW are derived from small and large scale hydro respectively [2]. As of 2013 hydropower provided 17% of the total electricity generated in India and was ranked fifth in available hydro potential globally [1]. A number of programs and projects are advocating new and efficient schemes for watermill designs which are effective in remote and rural areas because they can be deployed on small rivers, canals and dams [9]. The MNRE provides incentives to encourage these projects and help make hydropower more competitive in the market by subsidizing 75% of the costs, and some states have deployed special tariffs, low interest loans and other financial mechanisms to encourage private sector entrepreneur developments and investments [9]. Currently India is in pursuit of advancing and promoting both large and small scale hydropower because of their widespread potential by launching a number of policy initiatives in the near future [2].

Conclusion

India is a country housing a considerable portion of the world's poor, thus making the issue of sustainable development a pressing concern. The current energy scenario for India is one that is heavily dependent on fossil fuels, specifically coal, to meet their energy needs. India's energy demands are projected to sharply increase as it experiences population growth, rapid industrialization and an increase in per-capita consumption. This places a substantial amount of pressure on unsustainable energy sources and the power grid often leading to power shortages due to the demand outstripping the supply. It is anticipated that their fossil fuel supply will last around 50 years with current consumption patterns, despite how over 50% of the country has yet to be electrified.

In light of climate change, India has developed an extensive policy framework with specific targets and objectives to reduce their emissions by increasing their deployment of RE technologies. This originated with policies regarding electricity in the 2000s promoting the proportion of renewables in the energy mix which catalyzed the formation of the NAPCC and their eight missions to achieve development objectives while tackling GHG mitigation and climate change adaptation. Commitments extending to 2020 and 2030 like the Copenhagen Accord and the recent COP21 followed with the goal of reducing emissions by promoting the use of RE. India has exerted various financial instruments that act as incentives for developing RE through subsidy cuts on fossil fuels, taxing carbon and subsidizing various RE projects. India is endowed with an enormous potential of renewables that include solar, wind, biomass and hydro that are becoming more widespread due to climate change and energy policies. Thus, the pursuit and promotion of RE will provide India with more energy security and independence to meet energy demands and growth in the future while simultaneously reducing their GHG emissions.

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