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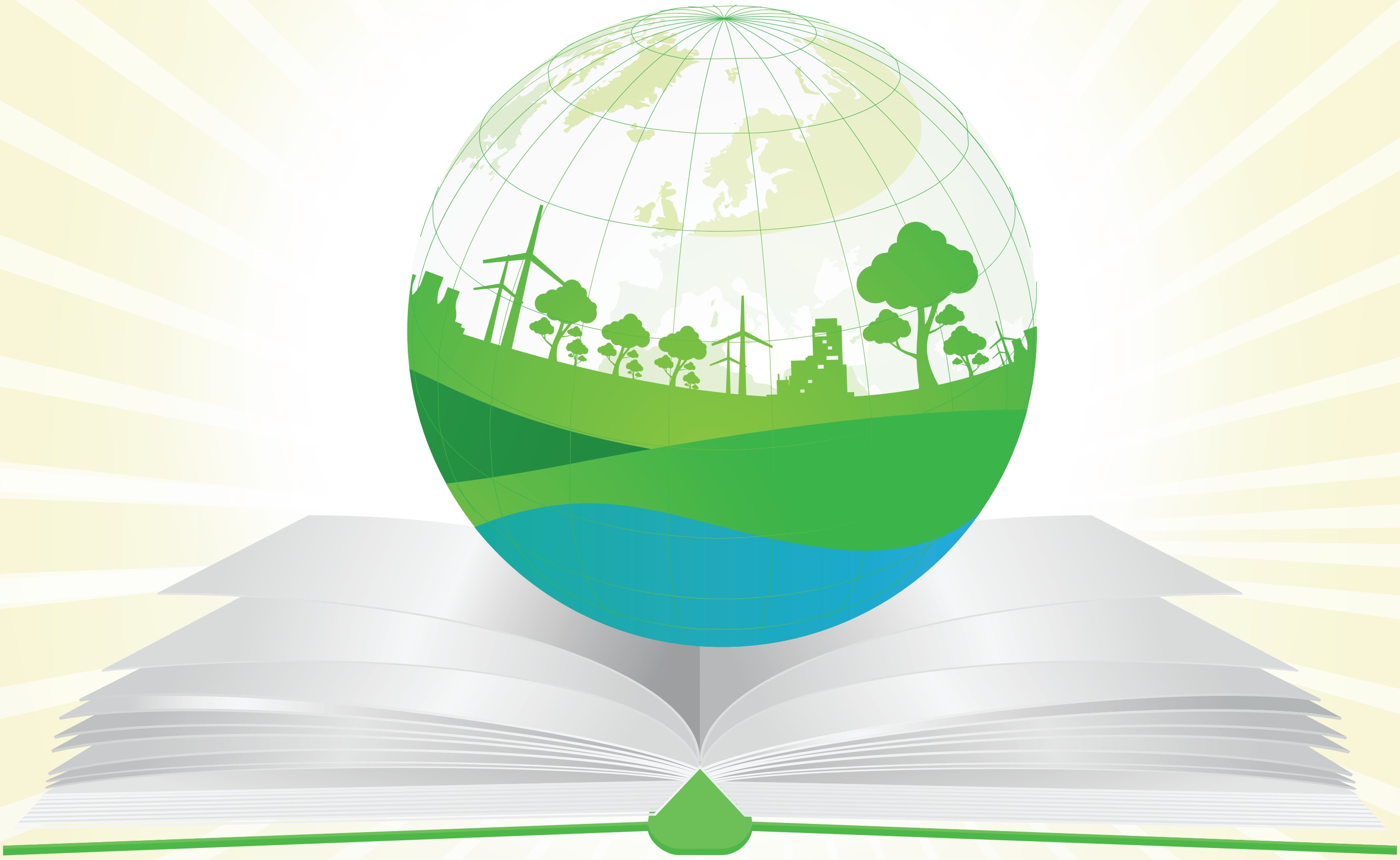

ACHIEVING ENERGY EFFICIENCY UNDER THE MONTREAL PROTOCOL WHILE COMBATING THE FUNDING PARADOX

TERRE Policy Centre

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INKING INNOVATIONS

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Abstract:

A In this paper we will be discussing the economics of energy efficiency in India and the leap from HFCs to non-ozone depleting energy efficient alternatives. While discussing this shift we will outline the current and future energy requirements that may be needed to run the currently existing refrigerant and cooling sectors, and the energy savings we may achieve upon using higher energy efficient and less polluting alternatives. We will also throw light on the current energy efficient alternatives and their applications by different countries around the world. Another aspect of this paper is that these energy efficient alternatives are to be covered under the Montreal Protocol phase out of HFCs. Such replacements provide for multi-faceted advantages like compulsory funding from developed nations, direct movement from the current HCFCs to energy efficient alternatives rather than transiting from the soon to become mandatory use of HFCs and then to energy efficient alternatives. There is however, the question of funding from the developed nations. This is a distressing issue as the developed nations are reluctant in providing funding for such projects even though they are mandated by the Montreal Protocol. The paradox pointed in this paper is that the developed nations fail to acknowledge that the major technologies purchased by the developing countries for energy efficient alternatives are from the developed countries itself. Therefore, the funding they provide for are indirectly reimbursed into their own economies. The conclusion we therefore draw is that there is an instantaneous need for India to adopt energy efficient alternatives that, contrary to popular belief, are present and advantageous; and that the developed nations should provide more funding acknowledging the funding paradox.

Keywords:

Montreal Protocol; Energy Efficiency; Energy Efficient Alternatives; HFCs; Energy Security; Refrigerants.

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Since 2009, proposals have been submitted annually for amending the Montreal Protocol to phase-down production and use of hydrofluorocarbons (HFCs). The proposed amendments, seek a gradual twenty-year phase-down and transition to HFC alternatives which possess a low-global warming potential (GWP), and typically superior energy efficiency.

Prevented direct (HFC) emissions of greenhouse gases (GHGs) resulting from an HFC phase-down would be within the range of 87-146 gigatonnes of CO2 equivalent (GtCO2e) emissions by 2050,[1] representing as much as or more than three years of total global GHG emissions from fossil fuel use. Prevented indirect emissions from increases in energy efficiency would likely be two to three times this amount based on historic reductions associated with past chemical phase-downs within the same usage sectors , and projected increases in energy efficiency associated with an HFC phase-down (primarily in the refrigeration and air conditioning sectors). [2]

India is already suffering from a 4.2% (4.5% peak) national energy deficit [3] *and cooling demand during summer months in major cities represents 50% or more of regional power demand.* [4] *Projected growth in cooling demand is potentially beyond what could be supplied through new generating capacity. Much of this additional capacity will need to be fulfilled by increasing fossil fuel imports that cost India US $150 billion in 2014 and 6.3% of GDP, projected to increase to 50% at a cost of US $300 billion by 2030.* [5]

Transitions to super efficient domestic air conditioning alone could preclude the need for India to add 60-72 gigawatts of new generating capacity (120-144 medium-sized 500-megawatt coal fired power plants) by 2030 [6] *as well as the costs of construction (US $120-144 billion)* [7] *and operation (US $1.3-1.56 billion annually for coal).* [8]

India as a developing nation is also duty bound to receive funding and technology transfer from developed states as mandated under the Montreal Protocol. This however is a paradoxical situation as it is these developed nations that fund the energy efficient technology that is purchased by developing countries from the developed countries themselves. This forms a vicious circle, but may act as an incentive perhaps for the developed nations to fund such projects. The gain in the long run however is to developing countries like India with the beneficial use of energy efficient technology.

1 Dr. Guus Velders, Velders G. J. M., & (2009) The large contribution of projected HFC emissions to future climate forcing, PROC. NAT'L. ACAD. SCI. U.S.A. 106:10949-10954;

2 De Larminat P. (2013) Development of Climate Friendly Alternatives for Chillers (presentation at Bangkok Technology Conference, 29 June 2013). Speech, Shende R. 2009 U.S.EPA's Stratospheric Ozone Protection and Climate Protection Awards (21 April 2009; U.S. Envtl. Prot. Agency (2002) BUILDING OWNERS SAVE MONEY, SAVE THE EARTH: REPLACE YOUR CFC AIR- CONDITIONING CHILLER, 6-7.

3 Indian Energy Sector, http://www.indianenergysector.com/power/peak-and-energy-deficit-in-india.

4 Clean Energy Ministerial (2014) Energy Efficient Cooling and Demand Response, Presentation before the Clean Energy Ministerial, Seoul, Korea, 12 May 2014; citing Delhi State Load Dispatch Center (2012) HOURLY DEMAND DATA FROM THE STATE LOAD DISPATCH CENTER.

5 Report of the Committee on Roadmap for Reduction in Import Dependency in Hydrocarbon Sector by 2030, Part I, December, 2013.

6 Avoiding 100 New Power Plants by Increasing Efficiency of Room Air Conditioners in India: Opportunities and Challenges, Phadke, Abhyankar, and Shah Lawrence Berkeley National Laboratory, Berkeley.

7 US Institute for Energy Economics and Financial Analysis (2014) BRIEFING NOTE INDIAN POWER PRICES, (the key assumptions for the coal- fired power lant, i.e., 400 MW at a cost of Rs242bn (US $4.0 bn or US$1m/MW capacity).").

Economics of Energy Efficiency for India:

India will spend US $150 billion on imported fossil fuels in 2014 – approx. US $125 billion on petroleum and US $25 billion on coal and natural gas. Shipping, transport, storage, refining, and development and maintenance of infrastructure additionally add billions to the total annual cost of providing domestic energy/fuel supplies, as do state and national subsidies to lower electrical costs to consumers.

A 2013 study By Lawrence Berkeley National Labs estimated that even with scheduled improvements in appliance standards, India will need to add the equivalent of 300 new 500 MW coal-fired power plants by 2030 just to maintain pace with increasing demand for domestic air-conditioning, without factoring additional increases in demand from all usage sectors.

In 2011, India became the fourth-largest energy consumer in the world (after China, U.S., and Russia).[9] India and China are projected to account for about half of global energy demand growth through 2040.[10] The U.S. Energy Information Administration projects that India's energy demand will continue to outstrip growth in domestic energy supply, requiring India to import as much as 50% of its primary energy by 2030.[11]

The consequences of India's primary energy shortfall are far-reaching with current energy imports estimated at US $150 billion annually.[12] According to analysis by Goldman Sachs, in FY2014 India's net energy imports were 6.3% of its GDP.[13] India's Report of the Committee on Roadmap for Reduction in Import Dependency in Hydrocarbon Sector by 2030 (section 1.2.4) estimates the cost of importing enough energy to fill the growing energy gap to be nearly US $300 billion annually by 2030, with a cumulative cost from 2013-2030 of US $3.6 trillion – more than twice India's current annual GDP.

Blackouts are becoming increasingly common in India, disrupting transportation, communication, and medical services and the shutdown of factories. Temperature spikes in June of this year created an energy demand nearly 40% higher than available generating capacity causing blackouts in numerous Indian states, especially Uttar Pradesh.

Four of the top five cities globally (Chennai, Bangkok, Mumbai, Calcutta and Delhi) having the highest number of cooling degree days per year are in India. As reported at the recent Clean Energy Ministerial, space cooling can account for 40-60% of peak-summer energy load in cities with hot climates, such as Delhi, and is the largest contributor to peak load from household appliances.[14]

The Lawrence Berkeley National Laboratory (LBNL) estimates that the number of urban Indian households with room AC will grow from approximately 3% in 2010 (4 million units), to 30% in 2020, and 73% by 2030 (116 million units).[15] Energy consumption from room AC in India is expected to grow from 8 TWh/yr in 2010 to 239 TWh/yr in 2030 (an increase of 2,887%). As noted by LBNL, "[m]eeting such additional demand would require a massive increase in electricity generation supply and have implications for energy security and balance of trade."

Significant efficiency improvements are possible in other sectors as well that would further increase the economic, energy and societal benefits for India. Recent analysis by the U.S. Institute for Energy Economics and Financial Analysis estimates the cost of a new coal-fired power plant in India is equivalent to $1 million per MW of capacity. [16] *At this rate, avoiding 120 power plants would save India US $60 billion in construction costs alone. Assuming the energy would come from imported coal, this would also save approximately US $1.33 billion annually in reduced energy imports as well as the considerable additional costs of transport, infrastructure, plant maintenance, etc.*

Consumer electricity prices in India are highly subsidized, producing one of the lowest retail electricity prices in the world. [17] *Improving room AC efficiency would save India the additional cost of subsidizing electricity to power appliances. Moreover, at an average price of 7.5 cents per kWh, Indian consumers would save an estimated US $8.85 billion annually from reduced electricity consumption.* [18]

Similar analysis by Goldman Sachs found that India could save US $2 billion annually from reduced energy imports by improving overall appliance energy efficiency by 50% by 2023. Finally, as coal currently provides two-thirds of India's electric generating capacity and is a significant contributor to regional air pollution, avoiding the need for additional generating capacity will decrease emissions of toxic mercury and other heavy metal-laden particulates, saving lives and improving health.

Historically, refrigerant conversions, driven by refrigerant phase-outs under the Montreal Protocol, have catalyzed significant improvements in the energy efficiency of refrigeration and air conditioning systems.

9 *U.S. Energy Information Administration (2014) INDIA ANALYSIS ("India was the fourth-largest energy consumer in the world after China, the United States, and Russia in 2011, and its need for energy supply continues to climb as a result of the country's dynamic economic growth and modernization over the past several years.").*

10 *U.S. Energy Information Administration (2014) INDIA ANALYSIS ("In the International Energy Outlook 2013, EIA projects India and China will account for about half of global energy demand growth through 2040, with India's energy demand growing at 2.8% per year."); see also International Energy Agency (2013) World Energy Outlook 2013 Factsheet, How will global energy markets evolve to 2035?*

11 *Indian Ministry of Petroleum and Natural Gas (2013) ROADMAP FOR REDUCTION IN IMPORT DEPENDENCY IN HYDROCARBON SECTOR BY 2030 – PART 1 ("The U.S. Energy Information Administration (EIA) estimates supply growth of all energy sources in India to be significantly below the rate of demand growth, widening the supply- demand gap to almost 50% of total primary energy demand by 2030.").*

12 *Indian Ministry of Petroleum and Natural Gas (2013) Roadmap For Reduction In Import Dependency In Hydrocarbon Sector By 2030 – PART 1*

13 *Goldman Sachs (2014) Asia Economic Analyst*

14 *Clean Energy Ministerial (2014) Energy Efficient Cooling and Demand Response.*

15 *Phadke A., Abhyankar N., & Shah N. (2014) Avoiding 100 New Power Plants By Increasing Efficiency Of Room Air Conditioners In India, Lawrence Berkeley National Laboratory ("We estimate that about 30% of the urban households are likely to own a room air conditioner by 2020 and about 73% are likely to own a room air conditioner by 2030").*

16 *US Institute for Energy Economics and Financial Analysis (2014) BRIEFING NOTE INDIAN POWER PRICES ("… the key assumptions for the coal fired power plant i.e. 4,000 MW at a cost of Rs242bm (US$4.0bn or US$1m/MW of capacity).").*

17 *US Institute for Energy Economics and Financial Analysis (2014) BRIEFING NOTE INDIAN POWER PRICES*

18 *Phadke A., Abhyankar N., & Shah N. (2014) AVOIDING 100 NEW POWER PLANTS BY INCREASING EFFICIENCY OF ROOM AIR CONDITIONERS IN INDIA,*

Low-GWP Energy-efficient Alternatives :

Today, most appliances using refrigerants produced and marketed in India use HCFC-22, an ozone-depleting substance and "super" greenhouse gas scheduled to be phased out under the Montreal Protocol beginning in 2015, and completely by 2040. [19] *Most Indian companies are currently planning to change from HCFC-22 refrigerant to HFC-410a (a blend of HFC-125 and HFC-32), which has a GWP of 208842 and lower energy efficiency than hydrocarbons (GWP 4).*

Transitioning directly to low-GWP energy efficient refrigerants in sectors where alternatives are currently available on the global market (e.g. residential refrigeration utilizing hydrocarbons as in the EU and China and with 400 million units operating worldwide), or are already being commercialized (as in the market for room AC using hydrocarbons as in China and India), will further minimize costs to Indian manufacturers and consumers by avoiding a double refrigerant transition and is a key opportunity to leverage the currently scheduled HCFC-22 phase-out in 2015 for the benefit of India.

There is widespread misperception in India that safe and commercially viable alternatives to HFCs are extremely limited and that most of these are also patented and require payment of royalties for use. Dupont and Honeywell's successful efforts to basically bar hydrocarbon use in the US domestic refrigerator market despite the safe global operation of some 400 million units today - mostly in the EU and China) is just one example of how the F-gas industry routinely promulgates false or misleading information about the availability, safety and efficiency of non-fluorinated refrigerants and other compounds. Independent and objective assessments tell the true story, such as that performed by Oko Recherche for the EU during revision of the European F-gas Regulation which found that HFCs could be phased out completely in almost 100% of all major refrigeration and A/C usage sectors by or before 2030. [20]

Safe, cost-effective and commercially viable low-GWP alternatives to high-GWP HFCs are widely and increasingly available. Alternatives to existing high-GWP HFCs fall into two basic categories: non-fluorinated substances with low-GWP, and fluorinated substances with low- to mid-range GWPs. The Montreal Protocol's Technical and Economic Assessment Panel (TEAP) uses the term "low-GWP' to refer to refrigerants with GWPs of 300 or lower while "moderate-GWP" refers to refrigerants with GWPs of 1000 or lower. For comparison, the GWP100-yr of HFC-134a, one of the most commonly used high- GWP HFC refrigerants today, is 1430. [21]

The most comprehensive way to evaluate the climate impact of any proposed refrigerant is to use Life Cycle Climate Performance (LCCP) methodology to calculate "cradle- to-grave" greenhouse gas emissions for a particular refrigerant and application. LCCP was developed by the TEAP and U.S. EPA and includes direct and indirect greenhouse gas emissions, energy embodied in product materials, greenhouse gas emissions during chemical manufacturing, and end-of-life loss (typically refrigerant leakage). [22]

Commercially available non-fluorinated or "natural refrigerants" primarily include ammonia with a GWP of near zero, hydrocarbons (e.g., propane and isobutane) with GWPs of less than 4, and CO2

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with a GWP of 1. Alternative fluorinated substances include primarily the low-GWP HFCs, also know as "HFOs", including HFC-1234yf and HFC-1234ze. According to the Inter–Governmental Panel on Climate Change's (IPCC) Fifth Assessment Report (AR5) these new low-GWP HFC alternatives have a GWP of less than one. [23] *Another alternative is HFC-32, which has a GWP of 677 according to AR5.54*

In the mobile air conditioning sector, which represents up to half of HFC emissions on a CO2e basis55, available low-GWP alternatives include HFC-1234yf, CO2, and HFC-152a (AR5 GWP100-yr =138).56

Currently, more than a dozen vehicle manufacturers in Europe, Japan, and North America have vehicles with the low-GWP refrigerant HFC-1234yf in the global market. Several German car manufacturers announced in March 2013 that they are developing CO2 as a low-GWP alternative for vehicle air-conditioning. In Norway, approximately 16% of new refrigerated truck and trailer systems were equipped with HFC-free refrigeration systems in 2011. Australia has recently begun using hydrocarbon A/C systems in commercial trucks with good results and the development of secondary loop systems has potential for use as fuel-efficient patent-free application for passenger vehicles.

The Indian manufacturer Godrej and the Chinese manufacturer Gree have developed models of propane (HC-290) room air conditioners. The Godrej models are up to 11% more efficient than the minimum requirements for the 5-Star energy efficiency rating set by the Indian Bureau of Energy Efficiency. [24]

A 2011 study for the European Commission concluded that technically feasible and cost-effective low-GWP alternatives exist for all major HFC subsectors. This analysis, which was prepared in association with industry, research institutes, and other technical experts, analyzed HFC alternatives available in 26 subsectors–all alternatives identified achieved at least equal energy efficiency & more often resulted in energy savings compared to commercially available HFC-based equipment. [25]

In Japan, an HFC-32 room air conditioner was awarded the 2012 Grand Prize for Excellence in Energy Efficiency and Conservation and the prestigious "Top Runner" as the most energy efficient room air conditioning available. [26] *Sobeys, Canada's second largest food retailer found that the new CO2 system it was using required 18% to 21% less energy than the high-GWP HFC equipment it replaced.*

Many safe and viable HFC alternatives exist already, and development and commercialization of new alternatives continues to grow at a rapid rate. It is in India's best interests to pursue energy efficiency aggressively and with minimal delay, being highly beneficial for India if it agrees to move towards such energy efficient markets before the mandating requirements, thereby getting a head start in achieving energy security.

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19 *U.S. EPA, (2010) Montreal Adjustment Phaseout Graph.*

20 *Schwarz W., et al. (September 2011), PREPARATORY STUDY FOR A REVIEW OF REGULATION (EC) NO 842/2006 ON CERTAIN FLUORINATED GREENHOUSE GASES, FINAL REPORT,, Tables 6.7 & 6.8.*

21 *Myhre G., et al. (2013) CHAPTER 8: ANTHROPOGENIC AND NATURAL RADIATIVE FORCING, in IPCC (2013) CLIMATE CHANGE 2013: THE PHYSICAL SCIENCE BASIS, Working Group I Contribution to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change.*

22 *Montreal Protocol Technology and Economic Assessment Panel (1999) The Implications to the Montreal Protocol of the Inclusion of HFCs and PFCs in the Kyoto Protocol*

23 *Myhre G., et al. (2013) CHAPTER 8: ANTHROPOGENIC AND NATURAL RADIATIVE FORCING, in IPCC (2013) CLIMATE CHANGE 2013: THE PHYSICAL SCIENCE BASIS, Working Group I Contribution to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change, Table 8.A.1.*

24 *Godrej Appliances (2013), Development and Handling of Room Air-Conditioning – the Godrej Experience (presentation at Bangkok Technology Conference, 29 June 2013);*

25 *Schwarz W., et al. (September 2011), PREPARATORY STUDY FOR A REVIEW OF REGULATION (EC) NO 842/2006 ON CERTAIN FLUORINATED GREENHOUSE GASES, FINAL REPORT, Annex IV: Global Data/Input Sheets.*

26 *Stanga M. (2013) Update on R32 Air-conditioning and Heat Pump Manufacturing and Sales -Progress Since Last OEWG in Bangkok 2012 (Daiken presentation at Bangkok Technology Conference, 29 June 2013).*

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Conclusion :

Now that the developing countries will have to start withdrawing from HCFC sectors, it is pertinent to know what technologies are we shifting to. In the given world scenario, the best option is to move to high energy efficient and low GWP alternatives so that we do not trade the climate for ozone protection. Energy efficient technologies would help reduce world emissions for carbon dioxide as well as paving the way for India's energy security.

Though the paper mentions the energy efficient technology currently present in the cooling sector, such technology currently is exorbitantly priced. This is mostly due to patent rights and capitalist tendencies of countries from which such technology is available. The high pricing therefore places an onus of responsibility on the developed countries to fund the transition of the developing countries to such technologies. With eventual increase in use of such technologies, economies of scale could be reached that would then help reduce the costs.

The paradox pointed in this paper is that the developed nations fail to acknowledge that the major technologies purchased by the developing countries for energy efficient alternatives are from the developed countries itself. Therefore, the funding they provide for are indirectly reimbursed into their own economies. It is quintessential to increased investments in improving energy efficiency, a potent guarantee of ensuring strong and sustained national economic growth and energy security, and perhaps the greatest contributing factor to realistic prospects for meeting current and projected energy demands for India. The developed nations must understand and acknowledge this funding paradox as an incentive to further fund technology transfer to energy efficient alternatives.

This year the Montreal protocol got its highest funding of all years, which was set at 507 million USD, re-iterating the need and the successful initiative in removing ozone depleting substances and as an underlying objective-energy efficiency. With the world trying to move towards energy efficiency, India should hardly be lagging behind.

Through effective implementation, technology transfer, regulation of refrigerants, and replacing the current technology with a more energy efficient alternative, India can move towards creating its energy security. It could use the funding provided by Montreal Protocol to further this initiative.

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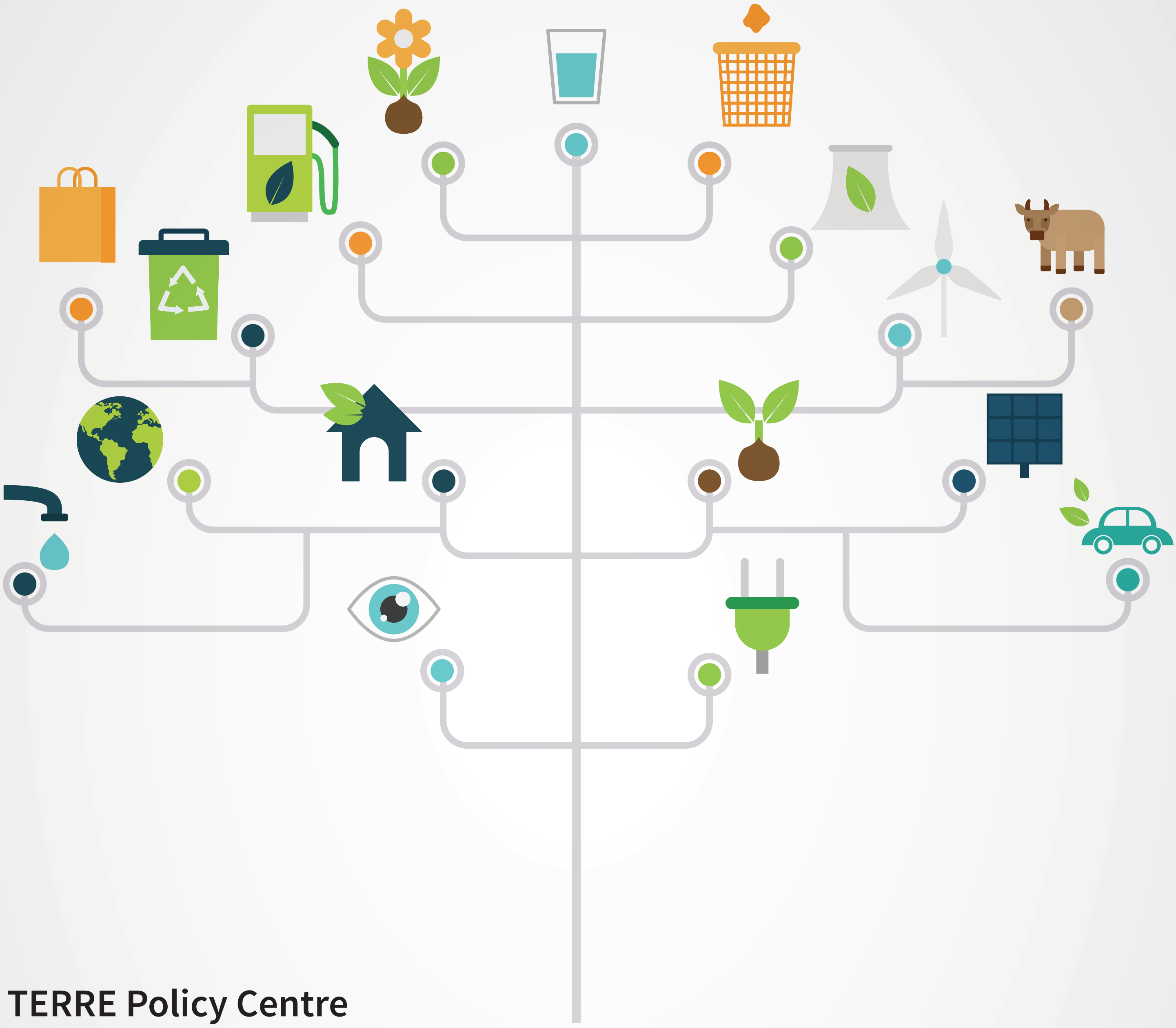

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