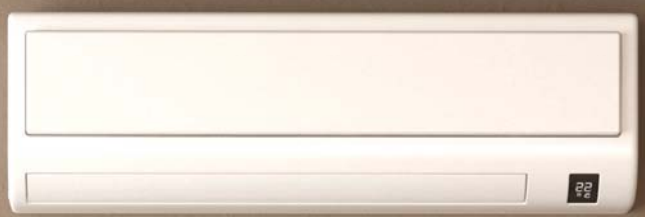
July–September 2020

ENERGY FUTURE

The Complete Energy Magazine

Volume 8 • Issue 4 • Annual ₹800



COVER STORY

COOLING INDIA WITH ENERGY EFFICIENT SOLUTIONS

FEATURE

ACCELERATING THE TRANSITION TO EFFICIENT COOLING

VIEWPOINT

MEETING COOLING DEMAND SUSTAINABLY

teri

Head Office
TERI
Darbari Seth Block, IHC Complex
Lodhi Road, New Delhi – 110 003
Tel. +91 (11) 2468 2100 or 711
Fax +91 (11) 2468 2144 or 2468 2145

Regional Centres
Southern Regional Centre
TERI, CA Site No. 2
4th Main, 2nd Stage Domlur
Bengaluru – 560 071
Email: terisrc@teri.res.in

North-Eastern Regional Centre
TERI, Chachal Hengrabari
Express Highway, VIP Road
Guwahati – 781 036

Western Regional Centre
TERI, F-9, La Marvel Colony
Dona Paula, Panaji – 403 004 (Goa)
Email: teriwrc@goatelecom.com

Affiliate Institutes
TERI North America
1152 15th Street NW Suite 300
Washington, DC 20005
Email: terina@teri.res.in

TERI Europe
27 Albert Grove, London SW20 8PZ, UK
Email: ritukumar@aol.com

Overseas Representation
TERI Japan
C/o IGES
Nippon Press Centre Building (8th Floor)
2-2-1, Uchisaiwai-cho, Chiyodi-ku
Tokyo, Japan - 100-0011
Email: teris@iges.or.jp

TERI South-East Asia
Unit 503, 5th Floor, Menara Mutiara Majestic
15 Jalan Othman, Seksyen 3, 4600 Petaling Jaya,
Selagor Darul Ehsan, Malaysia
Email: nimtech@tm.net.my

TERI Gulf Centre
Flat No. 105, Dalal Building, Al Qusais,
Dubai, UAE

From the editor's desk...

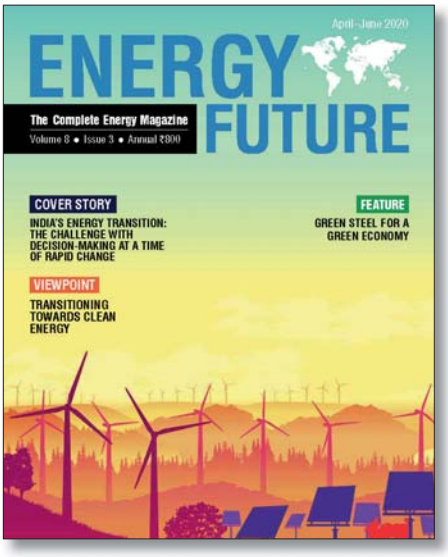
Temperature is an essential climate quantity that directly affects human well-being. Recently, the Ministry of Earth Sciences, Government of India, published a report titled "Assessment of Climate Change on Indian Territory". According to this study, the average frequency of hot days and nights in the country has increased in the last several years. Annual mean, maximum, and minimum temperatures averaged over India during 1986–2015 show significant warming trends. Research has already established how increasing heat conditions can adversely affect our health. High temperatures in the atmosphere increase the risk of heat stroke, cardiovascular and neurological diseases, and stress-related disorders. If we examine this perspective in depth, then it becomes clear to us that in the coming years the need of cooling in our country will increase manifold. This increasing need for cooling is not only related to our improving lifestyles, but also to the basic reasons that directly relate to people's health and their productivity. In other words, as temperatures and heat waves increase due to climate change, cooling is becoming a basic necessity. Keeping these realities in mind, India has developed a detailed cooling action plan that not only analyses the cooling needs in different sectors of the country's economy but also lists ways to reduce cooling demands. Undoubtedly, increasing cooling demand will also require more energy, which has a direct bearing on our climate change mitigation strategies.

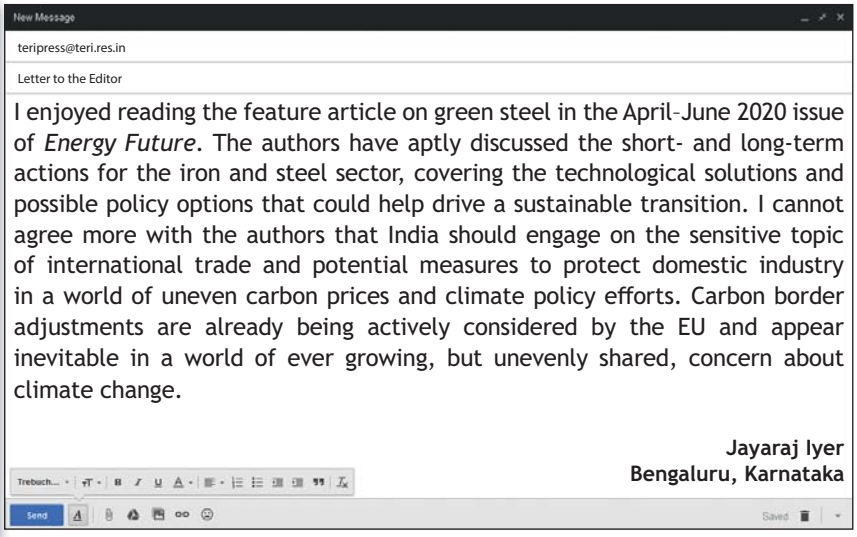
While today it is electricity-driven air conditioning that comes to mind whenever the issue of cooling is dwelled upon, the time has come to think beyond it. If the endeavour of the government is to proliferate market with super-efficient air conditioners, then there is no reason as to why research and development of super-efficient evaporative or desert coolers is not accorded a similar priority. While fans and desert coolers are losing their importance in this race of modernism on the one hand, on the other hand the irony is that we are forgetting our traditional skills, our ancient architecture. These practices of our cities and of our buildings can help to keep the temperatures down, not only the inside ones but also the outside ones, thereby minimizing the factors that exacerbate climate change.

Amit Kumar

Amit Kumar
Senior Director, Social Transformation, TERI

Editor: Amit Kumar Radheyshayam Nigam
Printed and published by Dr Ajay Mathur for The Energy and Resources Institute, Darbari Seth Block, IHC Complex, Lodhi Road, New Delhi- 110 003. Tel. +91(11) 24682100, Fax +91(11) 2468 2144 or Email: teripress@teri.res.in,
and printed by Batra Art Press, A-41 Naraina Indl. Area PH- II, New Delhi-28.





"Your cover story on "India's Energy Transition" is a very timely one as India has set ambitious targets towards the achievement of the dual goals of climate action and sustainable development through its nationally determined contributions and energy access commitments. As India starts a new decade of energy transition, it is an opportune time to assess where India stands in achieving its targets as well as to identify the key challenges being faced during this transition. We should remain all the more optimistic despite the COVID-19 pandemic as the Union Minister Shri R K Singh has repeatedly expressed confidence that the target of 175 GW of the installed renewable energy capacity will be met by the year 2022 as planned."

Praveen Negi
Dehradun, Uttarakhand

Thank you very much for your encouragement. The editorial team of Energy Future will ensure that the magazine caters to your information and knowledge needs. We welcome your suggestions and comments to further improve our content and presentation.

Email: teripress@teri.res.in
Editor
Energy Future

"I am a B.Tech student and have read that hydrokinetic energy is the energy generated by the movement of a body of water. The earth's tides, waves, ocean currents and free-flowing rivers contain an untapped, powerful, highly concentrated and clean energy resource. Traditional hydropower (river dams and conduits) is also produced by moving water. It was great to learn from your article that hydrokinetic energy is a promising source of renewable energy whose effective utilization has implications for rural electrification of remote areas, as well as in utilizing irrigation canals for energy generation. Keep publishing such informative articles.

Saima Rehman
New Delhi

"The article published in the Energy Insights section of the April–June 2020 issue of *Energy Future* is quite an apt one. I feel overall the market and system design must accord high priority to consumer freedom and choice for integration. Besides this, the market design cannot be based on general knowledge; it has to be designed by people with domain knowledge and with the knowledge of economics, laws, and governance.

Shekhar Sahoo
Faridabad, Haryana

CONTENTS

HOW REWA SOLAR PARK HELPED INDIA'S GREEN ECONOMY TURN A CORNER

Spread over 1590 acres, there are many firsts to the Rewa Ultra Mega Solar Ltd (RUMSL), a joint venture of state-owned Solar Energy Corp. of India Ltd (SECI) and Madhya Pradesh Urja Vikas Nigam Ltd (MPUVNL).

One of the world's largest solar park, it caught global attention and became an anthem for India' clean energy evangelists by landing a then record low-winning bid of ₹2.97 per kWh in the country through intelligent risk distribution. By breaking the electricity grid parity barrier in February 2017, the project brought home the point that solar energy is no longer a green fad but a game changer in India's energy mix.

Clean energy projects now account for more than a fifth of India's installed power generation capacity. India has 34.6 gigawatt (GW) of solar power, with an aim to have 100 GW of solar capacity by 2022. "The Rewa Project has been acknowledged in India and abroad for its robust project structuring and innovations. Its payment security mechanism for reducing risks to power developers has been recommended as a model to other states by MNRE", the PMO statement added. . EF

Source: https://www.livemint.com/industry/energy/how-rewa-solar-park-helped-india-s-green-economy-turn-a-corner-11594352166677.html

SOLAR SECTOR MAY NOT WITNESS LOW TARIFFS IF IMPORTS RESTRICTED, SAY EXPERTS

As India focuses on promoting 'Aatmanirbhar Bharat' and reducing imports from China, the solar sector may not witness a repeat of ₹2.36 per unit tariff discovered recently unless and until the country achieves scales, experts said. The tariff discovered in the recently concluded Tranche IX auction for inter-state transmission systems (ISTS) solar projects by Solar Energy Corporation of India is lower at ₹2.36 per unit than the tariff of ₹2.44 per unit discovered in May 2017.

"The tariffs discovered in this bid are purely on the back of import of solar components from China. Since the bids were tendered before the call for Aatmanirbhar Bharat, it was clear that bidder can import modules and whatever required duties will be paid on import, they shall be given a pass through. As a result, we see such lower tariffs being quoted", All India Solar Industries Association Chairman Hitesh Doshi told.

Modules form 60% of the total project cost of a solar project and almost 85–90% modules are imported from China. Besides these, other equipment are also imported largely from China. EF

Source: https://economictimes.indiatimes.com/industry/energy/power/solar-sector-may-not-witness-low-tariffs-if-imports-restricted-say-experts/articleshow/76857822.cms

BP TO INVEST USD 70 MILLION IN INDIA'S GREEN GROWTH EQUITY FUND

UK's energy major BP will invest $70 million in the Green Growth Equity Fund (GGEF) with an aim to rapidly scale up commercially viable low carbon solutions, the company said in a statement.

The two-year-old fund already includes investments from India's National Investment and Infrastructure Fund (NIIF) and the UK Government's Department for International Development (DfID). The fund expects to reach about $700 million commitment at final close and grow further through leveraged capital options, the company said.

Following its investment later this year, BP will become a limited partner in GGEF and have representation on its advisory committee, as well as the rights to coinvest in projects alongside GGEF, the company said.

Earlier this year, BP announced its ambition to become a net zero company by 2050 or sooner.

GGEF invests in renewable energy, energy efficiency, energy storage, e-mobility, resource conservation and associated value chains. EF

Source: https://economictimes.indiatimes.com/industry/energy/oil-gas/bp-to-invest-usd-70-million-in-indias-green-growth-equity-fund/articleshow/76835182.cms

ODISHA PLANS SOLAR POWER PROJECTS TO RAMP UP RENEWABLE ENERGY GENERATION

The Odisha government is planning several solar power projects to enhance the renewable energy generation in the state, officials said on Tuesday. Chief Secretary A K Tripathy, during a high-level meeting, directed officials to work out a detailed road map with time frames to enhance solar power generation on a commercial basis. He suggested that the Green Energy Development Corporation of Odisha Limited (GEDCOL) and the Odisha Renewable Energy Development Agency (OREDA) adopt the latest technology to reduce the cost of production, the officials said.

Both the state-run bodies work in the field of renewable energy. "The state needs to produce 1500 MW of solar power by the year 2022 to meet the renewable power obligation (RPO). At present, Odisha is capable of generating solar power at a competitive price of around ₹2.71 per unit, and hence it is commercially feasible to ramp up the production", GEDCOL Chairman B P Sethi said. EF

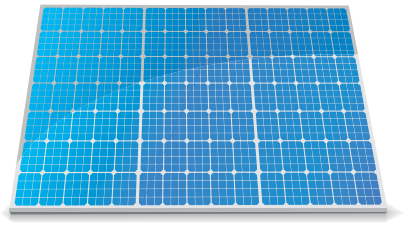
Source: https://economictimes.indiatimes.com/industry/energy/power/odisha-plans-solar-power-projects-to-ramp-up-renewable-energy-generation/articleshow/76828771.cms

DOMESTIC MANUFACTURING ONLY MEETS HALF OF INDIA'S SOLAR EQUIPMENT DEMAND: POWER MINISTER R K SINGH

Domestic manufacturing capacity of solar cells and modules meets only half of the country's demand, union power and renewable energy minister R K Singh said. This means that the dependence on China for India's solar imports is bound to continue. The minister recently announced a slew of duties to be levied on them, starting this year. At present, the solar cell manufacturing capacity is at 2.5 GW, with another 5 GW under construction. A further 3 GW has been approved, Singh told reporters at a virtual press conference.

Singh stressed the need for self-reliance in India, saying that goods manufactured in India did not lack quality. "Solar modules are exported from India, and so it is not a knock on their quality", the minister said.

2 GW of the 3 GW commissioned solar capacity will be part of Adani Green's ₹45,000 crore project, the biggest in the world. As part of the winning bid, Adani



will develop a capacity of 8 GW by 2025 and will also establish a further 2 GW of solar cells and modules by 2022. EF

Source: https://economictimes.indiatimes.com/industry/energy/power/india-still-needs-to-rely-on-china-for-solar-equipment-power-minister-r-k-singh/articleshow/76781107.cms

NTPC AWARDED PROJECT MANAGEMENT CONTRACT FOR 500-MW SOLAR PARK IN MALI

NTPC has been awarded the project management consultancy contract for the development of 500 MW solar park in the Republic of Mali, Ministry of New and Renewable Energy (MNRE) said.

According to the press release, the announcement was made in an event hosted by the International Solar Alliance and was chaired by renewable energy minister R K Singh.

Sekou Kasse, the Ambassador of Mali, attended the event along with Upendra Tripathy, Director General, ISA; Sanjeev Nandan Sahai, Power secretary; Indu Shekhar Chaturvedi, MNRE secretary; and Economic Relations secretary Rahul Chhabra. In 2019, ISA had endorsed NTPC as a Project Management Consultant through a competitive process for the member countries to avail the services of NTPC.

Earlier, the Republic of Togo had engaged NTPC for similar support for development of 285 MW solar park. NTPC plans to anchor 10,000 MW of solar parks in ISA member countries in the next 2 years. EF

Source: https://energy.economictimes.indiatimes.com/news/renewable/ntpc-awarded-project-management-contract-for-500-mw-solar-park-in-mali/76615168

ANDHRA PRADESH GOVERNMENT NODS FOR 10,000 MW MEGA SOLAR POWER PROJECT

The Andhra Pradesh cabinet approved a proposal to set up a 10,000 MW mega solar power project to ensure uninterrupted 9-hour power supply to farmers during the daytime, besides establishing an Integrated Renewable Energy Project (IREP).

In a statement, Information and Public Relations Minister Perni Venkataramaiah said as part of the IREP, 550 MW of wind power, 1200 MW of hydropower, and 1000 MW of solar power would be generated. Under the Green Energy Development Charge, the state government would be earning a revenue of ₹32 crore, it said.

Besides, the state cabinet has cleared the detailed project report (DPR) of the Ramayapatnam port project, which would be completed in five phases, with an estimated budget of ₹3736 crore in the first phase of works.

The cabinet also gave the green signal for the establishment of Andhra Pradesh State Directorate of Revenue Intelligence to monitor tax evasions by granting 55 posts. The Outsourcing Corporation would be strengthened to avoid middlemen in recruitments. EF

Source: https://www.deccanherald.com/national/south/andhra-pradesh-government-nod-for-10000-mw-mega-solar-power-project-848498.html

ABOUT 15,000 MW OF WIND-SOLAR HYBRID CAPACITY TO COME UP IN 5 YEARS: CRISIL

As the government continues to focus on increasing the share of renewable energy in the country, nearly 15,000 MW of wind-solar hybrid capacity is expected to come up over the next 5 years, Crisil said. Out of this 15,000 MW, works on nearly 10,000 MW are already either under construction or are being tendered and are expected to start feeding the grid by fiscal 2024.

In the hybrid option, the system is designed using solar panels and small wind turbines generators for generating electricity.

"We expect the hybrid market to grow and evolve as the number of projects and developers who seek to unlock value from the hybrid increases. Riding on strong support from central public sector undertaking, Solar Energy Corporation of India, and several state governments, we expect nearly 15,000 MW of hybrid capacity will come up over the next 5 years", Crisil Director Rahul Prithiani said.

In addition, Crisil expects 1100 MW of hybrid projects to come up as part of 5400 MW projects under the government's round-the-clock or RTC power scheme, which has a mandatory 51:49 blend of renewable energy and thermal. EF

Source: https://economictimes.indiatimes.com/industry/energy/power/about-15000-mw-of-wind-solar-hybrid-capacity-to-come-up-in-5-years-crisil/articleshow/76301994.cms

HAWAIIAN ELECTRIC PROJECTS $3.5-$4B TO BE INVESTED INTO 29 RENEWABLE ENERGY PROJECTS

Touting the investment as a potential boost to Hawaii's recovery from COVID-19, Hawaiian Electric announced last week that its planned 29 grid-scale renewable energy projects on four islands will represent $3.5-4 billion for the economy.

Of those projects, 14 are currently underway on Oahu, 8 on Hawaii Island, and 7 on Maui. Moreover, rooftop solar continues to expand: more than 3000 private rooftop solar projects have been interconnected on the islands this year, representing more than $65 million in investments from businesses and homeowners on Oahu alone. Those investments will end up offsetting electric bills and contribute to larger renewable energy goals for the state.

Today, Hawaiian Electric hosts a renewable portfolio standard of around 28%. The company notes that all of these efforts have the potential to jump that percentage up to more than 60% by 2026. On Hawaii Island, nearly 100% of energy could become renewable. Of the projects previously listed, all but three will also be built, owned, and operated by independent power producers selling electricity to Hawaiian Electric. EF

Source: https://dailyenergyinsider.com/news/26169-hawaiian-electric-projects-3-5-4b-to-be-invested-into-29-renewable-energy-projects/?amp

HUGE ACCELERATION OF CLEAN ENERGY INNOVATION NEEDED TO MEET NET-ZERO TARGET: IEA

A global goal to achieve net-zero carbon emissions by 2050 will not be met without a huge acceleration in clean energy innovation, the International Energy Agency (IEA) said. The 2015 Paris Agreement set a target to curb global warming and reach net-zero emissions in the second half of the century.

In a special report, the IEA analysed more than 400 clean energy technologies and said that although renewable technologies in use now can deliver a large amount of emissions reductions, they are not enough on their own. It found that there are currently few technologies available for reducing emissions to zero in sectors such as shipping, trucking, aviation, and heavy industries.

"Without decarbonizing the transport sector, there is no chance whatsoever of meeting climate targets", IEA Executive Director Fatih Birol told Reuter.

The four most critical clean technologies needing innovation are battery technologies, carbon capture and storage, bioenergy, and low-carbon hydrogen, which are currently mostly in the development phase and/or costly. EF

Source: https://www.deccanherald.com/science-and-environment/huge-acceleration-of-clean-energy-innovation-needed-to-meet-net-zero-target-iea-856094.html

AUSTRALIA'S INFIGEN BACKS REVISED IBERDROLA TAKEOVER OFFER

Australian wind and solar firm Infigen Energy Ltd recommended an offer from Iberdrola to its shareholders, after the Spanish company waived most conditions from its A$856 million ($589 million) bid.

Iberdrola and rival Philippine conglomerate Ayala Corp both raised their respective bids for Infigen, hoping to take control of its seven wind farms and a large pipeline of projects. Ayala increased its offer for the Australian company to A$0.86 per share and declared it free of all conditions, while Iberdrola raised its bid to A$0.89.

Infigen said that Iberdrola had also waived the conditions on its bid, excluding the conditions that it receives approval from Australia's Foreign Investment Review Board (FIRB) and is accepted by more than half of Infigen shareholders. Infigen said in a statement that it expected both these conditions to be met and urged shareholders to reject Ayala's takeover approach. EF

Source: https://energy.economictimes.indiatimes.com/news/renewable/australias-infigen-backs-revised-iberdrola-takeover-offer/76704621

PRO-NUCLEAR ENERGY PROTESTERS RALLY AGAINST GREENPEACE IN PARIS

A group of pro-nuclear protesters demonstrated against the closure of a major reactor in France – taking their rally to the Paris headquarters of Greenpeace, the activists known for their eye-catching campaigns in favour of shutdowns.

The protest comes as the state-controlled utility EDF plans to shut down the second and last ageing nuclear reactor of its Fessenheim plant near the German border overnight.

The French government is working to reduce the share of atomic power in its electricity mix to 50% by 2035 from the more than 71% currently, as well as to promote more renewable energy, sparking an intense debate.

Advocates of nuclear power say it is essential to providing sufficient quantities of carbon-free energy to balance intermittent renewable sources, such as wind and solar. Opponents say it is not carbon free over its entire life cycle.

Several dozen protesters carried banners in front of the Greenpeace headquarters in Paris, with slogans such as "less nuclear means more coal". EF

Source: https://energy.economictimes.indiatimes.com/news/renewable/pro-nuclear-energy-protesters-rally-against-greenpeace-in-paris/76704654

JUST LAUNCHED: RENEWABLES 2020 GLOBAL STATUS REPORT

The report released shows that growth in renewable power has been impressive over the past 5 years. However, too little is happening in the heating, cooling, and transport sectors.

Overall, global energy consumption keeps increasing, eating up the progress made in renewable generation. The journey towards a climate crisis continues unless we make an immediate switch to renewable energy in all sectors.

To make the switch, policy change is needed. GSR2020 shows that today's progress is largely the result of policies and regulations initiated years ago, which focus on the power sector. Major barriers seen in heating, cooling, and transport have remained in place for almost a decade.

GSR2020 provides a comprehensive overview of global developments in

renewable energy markets, investments, and policies in 2019. This year's report includes a feature chapter on citizen support for renewable energy projects. 2019 highlighted the important role of community action in the push for renewables, as supporters call for change at both the local and the global level. EF

Source: https://www.bnamericas.com/en/news/just-launched-renewables-2020-global-status-report

RENEWABLES COULD BE THE BIG WINNER IN THE POST-PANDEMIC WORLD

Although the coronavirus crisis has slowed down clean energy investments and installations, renewable energy and green technologies have the chance to emerge as the winners in the post-COVID-19 world.

Undoubtedly, the global health crisis has impacted every corner of the energy industry, including renewables. Yet, renewable energy has so far been the energy source most resilient to lockdown measures. Demand for renewables is set to grow this year. This will be the only energy source to grow in 2020 compared to 2019, in contrast to all fossil fuels and nuclear, according to a recent report from the International Energy Agency (IEA).

In 2019, renewables dwarfed conventional generation sources in terms of both capacity additions and investment, a new report from Frankfurt School of Finance & Management, UN Environment Programme (UNEP), and BNEF showed. As much as 78% of net gigawatts of generating capacity added globally in 2019 was renewable energy, with investment in renewables – excluding large hydropower – more than three times the investment in new fossil fuel powered plants. EF

Source: https://oilprice.com/Alternative-Energy/Renewable-Energy/Renewables-Could-Be-The-Big-Winner-In-The-Post-Pandemic-World.html

HOW COVID-19 HAS DEMONSTRATED THE VALUE OF RENEWABLE ENERGY

As COVID-19 swept the globe, it has put hundreds of thousands of lives at risk and threatened to collapse the world's strongest economies. But there is always a silver lining. In this case, COVID-19 did wonders for our environment. Rivers have never been cleaner and air pollution levels were at all-time lows. So, despite the economic hit, all this mess hopefully made us realize the value of renewable energy.

Businesses across the world were put to a halt as the lockdown measures kept half of the world's population in quarantine. This is estimated to cause a fall in global energy demand by 6%. Consequently, this year's carbon emissions are set to decline by around 8%. The International Energy Agency (IEA) estimates that the demand

for renewables will surge. COVID-19 induced measures of social distancing and lockdown measures propelled a shift towards more reliable and cleaner sources of energy. These sources are wind, hydropower, and solar photovoltaic (PV) where solar light energy is converted into electrical energy. EF

Source: https://finance.yahoo.com/news/covid-19-demonstrated-value-renewable-155036577.html

UN CHIEF SEEKS END TO FINANCING OF COAL TO SMOOTH CLEAN ENERGY SHIFT

UN Secretary-General Antonio Guterres urged countries to stop financing for coal and commit not to build new coal-fired power plants to enable a shift to clean energy.

He spoke at a virtual clean energy transition summit of 40 countries representing 80% of energy use and greenhouse gas emissions. They discussed steps to buoy economies, cut emissions, and make energy systems more resilient to climate change.

As countries look to revive their economies from the slowdown caused by the coronavirus pandemic, governments and investors have been calling for recovery packages to focus in part on green stimulus.

The European Union and South Korea have already pledged environmentally-minded recovery programmes. But Guterres said some countries have used them to also prop up fossil fuel companies, which were already struggling financially, and others have

chosen to jump-start coal-fired power plants.

"Coal has no place in COVID-19 recovery plans", Guterres said in a videolink speech to the summit, hosted by the International Energy Agency (IEA).

He said the business case for renewables was better than coal in nearly every market and that green jobs and sustainable growth are both crucial. EF

Source: https://www.hindustantimes.com/world-news/un-chief-seeks-end-to-financing-of-coal-to-smooth-clean-energy-shift/story-A82TKy7I2B3DK3gr9eHITL.html

COOLING INDIA WITH ENERGY EFFICIENT SOLUTIONS

With rapid urbanization and a growing population, there is a demand for sustainable, clean, and energy efficient cooling solutions. Access to cooling has become a development need and an equality issue. The interplay of a variety of factors is important to understand in order to encourage energy efficiency in cooling. In this article, **Ritika Jain** talks about suitable solutions for clean and energy efficient cooling in India.

Rising temperatures have affected people across the globe, and it is therefore imperative to address the importance of cooling for all. With rapid urbanization and a growing population, there is a demand for sustainable, clean, and energy efficient cooling solutions in India. A large part of the population lies at the risk of being exposed to life-threatening temperatures, as the frequency of heatwaves across the country increases due to climate change. Therefore, access to cooling has become a 'development need' and an equality issue. It can add on to the larger developmental goals on clean energy, sustainable cities, health, and well-being. How can India overcome existing challenges to meeting the rising cooling demand without further warming the planet?

An Overview of Policies and Global Commitments

Energy efficient and sustainable cooling lies at the intersection of key international multilateral agreements,[1] that is, Kigali Amendment to the Montreal Protocol, the Paris Agreement under the UNFCCC, and the UN Sustainable Development Goals (SDGs).

Recognizing 'cooling as a development need' is important, as it is linked with achieving the SDGs, such as the health and well-being (SDG 3), decent work and economic growth (SDG 8), sustainable cities (SDG 11), and climate action (SDG 13). The Kigali Cooling Efficiency Program[2] (K-CEP) is a philanthropic programme on the global scale, which has been launched to support the successful implementation of the Kigali Amendment to the Montreal Protocol. It promotes collaborative research to help countries find innovative cooling solutions and make an accelerated shift away from hydrofluorocarbons (HFCs). Ratification by 65 countries or parties brought the amendment to force on 1st January 2019. However, India and major countries such as China, USA, Brazil, Thailand, and South Korea, which make up about 77% of AC compressors' trade flow, have not yet ratified the Kigali Amendment.

The Government of India launched the India Cooling Action Plan (ICAP)[3] in 2019 to provide a 20-year view on the evolving cooling demand, along with several short-term and long-term recommendations to achieve sustainable cooling. If robust policies are implemented to encourage the use of best available energy efficient cooling technologies in the cooling sector, the associated emission (GHG) reductions from cooling will also decrease. The ICAP has close links with several other governmental programmes, such as the Pradhan Mantri Awas Yojana (Housing for All), Smart Cities Mission, and National Mission on Enhanced Energy Efficiency.

Mainstreaming of Energy Efficient Cooling Technology and Non-HFC-Based Refrigerants

Energy systems that power Indian cities today will decide how cities meet challenges in the future and make resources available for their residents. A major share of the increase in energy use for space cooling comes from emerging economies, such as India, China, and Indonesia – the three nations that are predicted to account for half of the global cooling energy demand growth by 2050.[4] In India, roughly 8% of the households were air-conditioned as of March 2018. This coverage is expected to rise to 50% by 2050, which would translate into a significant increase in energy needs in addition to HFC leakage from AC units.[5]

The government can support interventions and energy efficiency measures in cooling through standards and labelling schemes, as well as by introducing new ways to regulate energy consumption, such as MEPS (minimum energy performance standards). Energy efficient appliances will not only help consumers save money, but also reduce overall energy consumption and therefore emit less CO_2 over their lifetime. The interplay of a variety of factors is important to understand in order to encourage energy efficiency in cooling.

Technology

Consumers tend to buy air conditioners whose average efficiencies are less than half of what is available on the market.[6] There is a need to bring energy efficient and low global warming potential (GWP) non-HFC-based refrigerants to the mainstream. To enable this transition, the ICAP highlights the importance of an accelerated 'HFC phase-down' process and further development of cooling technologies. This includes the use of energy efficient appliances with environment-friendly refrigerants. The current models of high efficiency ACs are either unaffordable for majority of Indian consumers or their additional benefits are unknown to most consumers. Hence, it is key that any technology that expects mass adoption must be affordable for consumers. Relevant policy interventions for market transformation, including public procurement of energy efficient

1 IISD SDG Knowledge Hub. 2019. Kigali Amendment Enters into Force, Bringing Promise of Reduced Global Warming. Details available at https://sdg.iisd.org/news/kigali-amendment-enters-into-force-bringing-promise-of-reduced-global-warming/ last accessed on 29th June 2020

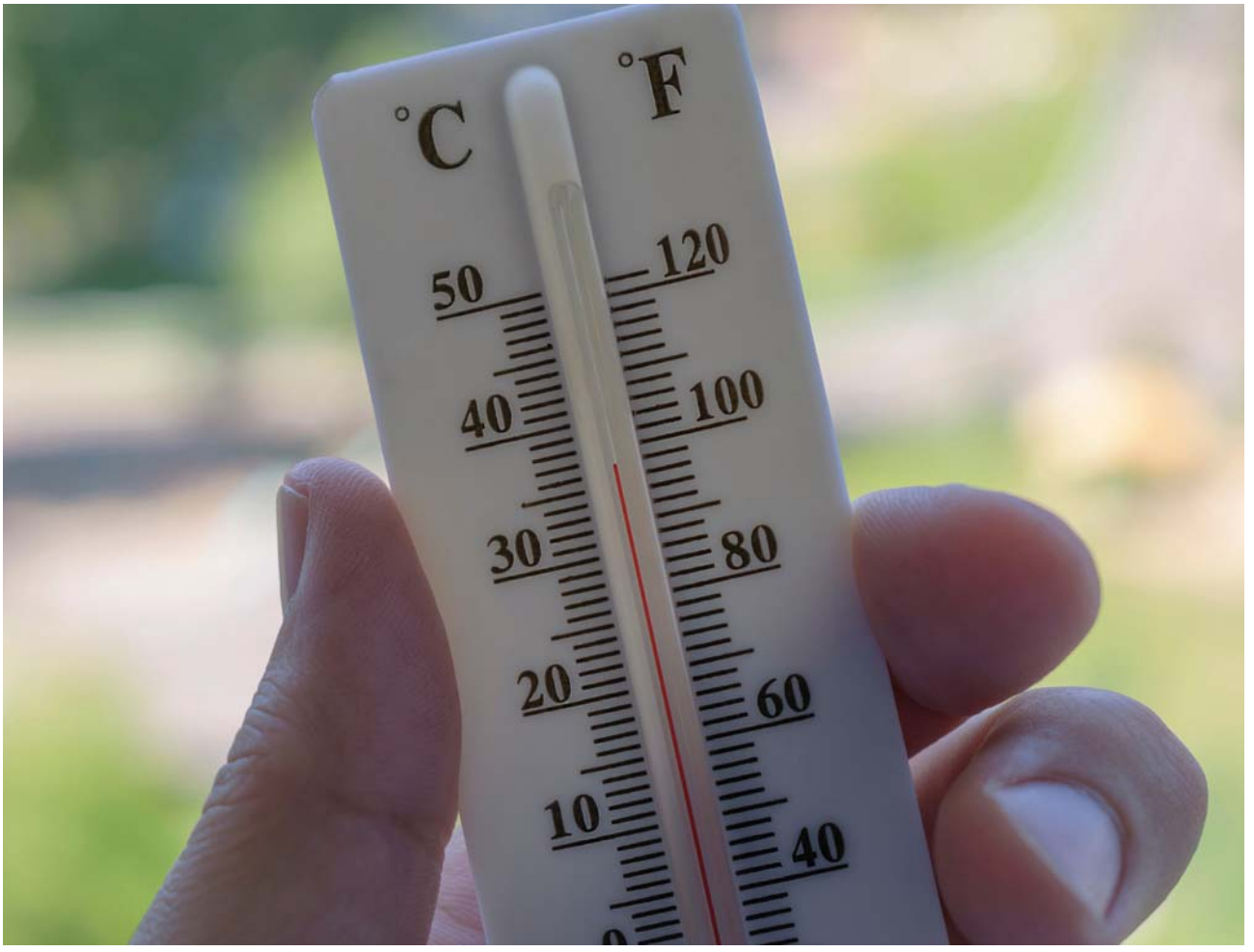
2 Kigali Cooling Efficiency Program (K-CEP). 2019. Details available at https://www.k-cep.org/

3 Ministry of Environment, Forest, and Climate Change. 2019. India Cooling Action Plan Launched. Details available at https://pib.gov.in/PressReleaseIframePage.aspx?PRID=1568328, last accessed on 25 June 2020

4 International Energy Agency (IEA). 2018. The Future of Cooling. Details available at https://webstore.iea.org/the-future-of-cooling, last accessed on 1 July 2020

5 Reese, A. 2018. As countries crank up the AC, emissions of potent greenhouse gases are likely to skyrocket. Science, March 08. Details available at https://www.sciencemag.org/news/2018/03/countries-crank-ac-emissions-potent-greenhouse-gases-are-likely-skyrocket, last accessed on 27 June 2020

6 Ibid



equipment, are key to speed up transition.

As per an IEA report, 'not-in-kind' solutions are likely to play a key role in the area of climate-friendly HFC-free cooling. These include various types of cooling systems, such as evaporative cooling, adsorption cooling systems, and district cooling, where a central cooling facility is in use and cool water is delivered to houses in the district. Other climate-friendly systems are available that reduce the electricity consumption by being paired with a waste heat energy source or a solar thermal energy source, such as solar adsorption chillers. Many 'not-in-kind' technologies are still in the early stages of research and development.[7]

[7] Details available at https://eia-global.org/initiatives/hfc-free-technologies, last accessed on 29 June 2020

Refrigerant use

The transition to low GWP and natural refrigerants will have several economy-wide impacts and would require companies and research institutions to come together and discuss changes required in the national policy. Direct impacts of this transition include GHG emission reduction, energy savings, cost of technology change, and so on. Some of the indirect impacts could be job creation and skill development. There would be further impact on other sectors, such as hydrocarbon/HFC manufacturing, copper manufacturing, and the automotive industry. A systematic phase-down schedule for HFCs is needed that can specify how their usage can be reduced, and by how much, as per a timeline that best suits India's economic conditions. Such a phase-down plan will ideally need to be regularly updated with the latest developments in each sector, market trends, and changing consumer perspectives. Policy reforms must ideally focus on controlling the use of refrigerants with high GWP and promote the use of natural refrigerants.

Building guidelines and behaviour change

India needs to define thermal comfort in order to guide interventions for energy efficiency in buildings. Building codes should be amended to ensure all buildings are designed such that passive design is preferred. Passively cooled building design and natural ventilation can reduce cooling load and minimize peak power requirement.

New housing coming up across urban centres in India is mainly focused on being 'affordable' as it is backed by the

housing scheme Pradhan Mantri Awas Yojana (PMAY). The PMAY is primarily aimed at achieving government's objective of housing for all and has also been included in the COVID stimulus package. The scheme also attempts to boost demand for affordable housing and create jobs. However, it is important that the building envelope should comply with the requirements of Eco-Niwas Samhita 2018 to ensure thermal comfort for the occupants of these upcoming housing projects. This increased residential building stock is linked with an increase in electricity use for space conditioning. Studies carried out by the NITI Aayog indicate that by 2047,[8] the electricity consumption for the residential sector is expected to increase several folds because of this development.[9] Therefore, low energy cooling options for affordable homes need to be promoted.

The ICAP encourages the uptake of climate responsive built spaces and passive cooling. This can be done through (i) increased public procurement of energy efficient ACs, chillers, fans, and so on and (ii) providing consumer incentives and awareness campaigns to drive market demand of energy efficient cooling appliances and equipment. HVAC manufacturers now recognize this as a potential opportunity and are trying to introduce such products in the Indian market.[10] From a behaviour change perspective, a communication campaign targeted at building awareness on the climate benefits of HFC-free and low energy consuming appliances may also boost their sale in the market over time.

Cooling as a Service and District Cooling

Efficient consumption of electricity for cooling can be achieved with the

[8] NITI Aayog, 2015

[9] Kumar, S., M. Singh, S. Chandiwala, S. Sachar, and G. George. 2018. Mainstreaming thermal comfort for all and resource efficiency in affordable housing: status review of PMAY-U mission to understand barriers and drivers. New Delhi: Alliance for an Energy Efficient Economy (AEEE)

[10] TERI, NRDC, and IGSD. 2018. Improving Air Conditioners in India. Details available at https://www.nrdc.org/sites/default/files/cooling-india-issue-brief-2018_0.pdf, last accessed on 29 June 2020

Cooling as a Service (CaaS) model. This pay-per-use innovation eliminates the need for upfront investment in the clean cooling technology and customers can pay per unit of cooling they consume. In turn, the service provider owns the equipment and oversees maintenance and utility bill payment. As per the Climate Finance Lab, this model has significant incentives to improve the overall system energy efficiency to reduce the cost of operation.[11]

District energy systems can be powered by local power generation plants using the combination of energy efficient technologies such as trigeneration, industrial-grade electric chillers, and recovery of waste heat. Such a system provides cooling or heating through a network of pipes with hot or cold water to reach multiple buildings in a neighbourhood or the industrial area in a city.[12] It enables a strong synergy between production and supply of heating or cooling and can also be integrated with other municipal systems such as power supply or sanitation. The 'District Energy Initiative' by the UNEP highlights the potential offered by these systems to make a cost-effective transition to sustainable refrigerants and energy efficient cooling, as well as reducing primary energy consumption.[13]

Development of Energy Efficient and Clean Cold Chain

The COVID-19 pandemic has affected almost all sectors of the economy and several economic package and

structural reforms have been announced by the Indian government to tackle the situation. As a positive side effect, the opportunity for a faster transition to clean energy across key sectors of the economy has opened up. In addition to this, special emphasis is being placed on doubling farmers' income. Urban slums and rural poor have been identified as one of the most vulnerable groups that need access to cooling with rising temperatures.[14]

It is important to focus on a sustainable cold chain, which forms the basis of a more inclusive economy and broader economic development. Integrated cold supply chains can help small farmers get a higher value for their products as they are able to access more distant markets. They play a critical role in ensuring longer shelf-life of produce and reduction in post-harvest food loss. Not only for agri-produce supply chains, a reliable and robust cold chain is of high importance for vaccine and medicine delivery. Vaccines require thermally controlled conditions for storage, right from the point of production to the point they reach the final recipient. This shows a strong link between a robust cold chain infrastructure and livelihood provision for farmers and prospects for overall economic success and well-being. Developing a reliable cold chain network is also an important step towards addressing Sustainable Development Goals and alleviating poverty and hunger.

Challenges and solutions

Maintaining an integrated cold chain is an energy intensive application.[15] A key challenge with clean cold chain development in India is the availability of uninterrupted power supply and the adoption of energy efficient technologies. To begin with, it is important to estimate the state level as well as the national requirement for temperature controlled logistics. The development of cold chain infrastructure should be based on the renewable energy resource, new thermal technologies, less harmful refrigerants with more efficient electricity, and the fuel consumption technology. Moreover, if access to cooling can be designed as a service for the benefit of the rural community, then it could be utilized to fulfil a wider range of cooling needs, such as veterinary care, storage

[11] Global Innovation Lab for Climate Finance. 2019. Cooling as a Service (CaaS): lab instrument analysis. Details available at https://www.climatefinancelab.org/wp-content/uploads/2019/03/Cooling-as-a-Service_Instrument-analysis.pdf, last accessed on 28 June 2020

[12] Details available at http://www.districtenergyincities.org, last accessed on 28 June 2020

[13] Details available at http://www.districtenergyinitiative.org/power-district-energy, last accessed on 28 June 2020

[14] SEforAll. 2018. Chilling Prospects: Providing Sustainable Cooling for All. Details available at https://www.seforall.org/publications/chilling-prospects-cooling-for-all-report, last accessed on 28 June 2020

[15] Details available at https://nccd.gov.in/, last accessed on 31 July 2020

of vaccines and medicines, domestic refrigeration, food processing, and ice for fisheries. Such multi-use models for cooling are being explored by the University of Birmingham to design an integrated 'community cooling hub' with support from Shakti Sustainable Energy Foundation. It is a step towards enhancing the commercial viability of a cold chain infrastructure and creating social impact.[16]

To keep food fresh as it travels from 'farm to fork', cooling solutions that can optimally preserve its value and minimize energy consumption are required. Perishable foods such as fruits and vegetables, meat, poultry, and dairy require an uninterrupted cold chain. A Global Food Cold Chain Council (GFCCC) study[17] highlights how the expansion of the food cold chain in developing countries can reduce food waste related greenhouse gas emissions by a large percentage. A thorough review of the entire value chain is needed to identify the risk involved at each stage and create appropriate mitigation strategies and set policies.

Need for Data-Driven Decision-Making

Better data collection on cooling needs across different sections of the society, urban and rural areas, and commercial and residential sectors will lead to more reliable estimates of the cooling requirement, energy demand projections, and appropriate technical solutions. The new 'clean cold chains' must be seen as a key component of the agri-supply chain. The journey of produce from the farm to end consumers should occur with minimal environmental impact. Information flow through mobile-based apps and technologies can have a significant impact on establishing a data-driven decision-making for the farmer community. This can help prevent unnecessary storage and wastage and increase energy efficiency.

It is important to foster collaboration across different stakeholders from the industry, think tanks, academic institutions, and so on to understand the cross-sectoral nature of cooling. Sharing experiences will help formulate the most suitable solutions for clean and energy efficient cooling in India. EF

[16] Details available at https://shaktifoundation.in/report/promoting-clean-and-energy-efficient-cold-chains-in-india/, last accessed on 30 June 2020

[17] GFCCC (Global Food Cold Chain Council). 2015. Assessing the potential of the cold chain sector to reduce GHG emissions through food loss and waste reduction. GFCCC and UTC

Bibliography

Ospina, C. 2018. The trouble with air conditioning. The Climate Institute. Details available at https://climate.org/cooling-your-home-but-warming-the-planet-how-we-can-stop-air-conditioning-from-worsening-climate-change/

Green Cooling Initiative. Details available at https://www.green-cooling-initiative.org/cooling-sectors/overview/

Kumar, S., S. Sachar, S. Kachhawa, A. Goenka, S. Kasamsetty, and G. George. 2018. Demand Analysis of Cooling by Sector in India in 2027. New Delhi: Alliance for an Energy Efficient Economy

Disclaimer: The views presented in this article are personal and not necessarily the views of Shakti Sustainable Energy Foundation.

Ritika Jain, Program Manager (Energy Efficiency), Shakti Sustainable Energy Foundation

ACCELERATING THE TRANSITION TO EFFICIENT COOLING

The impact of climate change is manifesting itself in increasingly erratic weather patterns. Increasing focus has been placed on cooling and promoting sustainable cooling at affordable cost. There is a growing recognition that access to sustainable cooling is a necessity in a warming world. The growing demand for cooling will increase global warming. In this article, **Manjeet Singh** and **Vasudevan Rangarajan** examine how a transition to climate-friendly and energy-efficient cooling would avoid emissions and allow an increase in cooling access that would contribute substantially to the Sustainable Development Goals.

The impact of climate change is manifesting itself in increasingly erratic weather patterns, and even these are increasing in frequency and severity. Heatwaves in the summer months across the hemispheres are becoming more the norm than the exception. The 2019 report by the Intergovernmental Panel on Climate Change (IPCC) estimated that around 2.3 billion people could be both exposed and vulnerable to heatwave events due to 1.5°C of global warming. Human hardship, the report also pointed out, would be compounded by the impact on food production, with food loss and waste likely to contribute around 10 per cent of annual greenhouse gas (GHG) emissions. Ensuring food security, particularly fruits, vegetables, and other fresh produce, is likely to become more challenging due to the impact of climate change.

Unsurprisingly then, in 2018 and 2019, the issue of cooling and promoting sustainable cooling at affordable cost emerged as a focus of governments, health care companies, food manufacturers, real estate firms, air conditioning and refrigeration equipment manufacturers, refrigerant producers, and financial institutions. Rather than viewing access to cooling as a luxury, there is a growing recognition

that, in a warming world, access to sustainable cooling is a necessity.

Global Warming is Creating Increased Demand for Cooling

Global energy demand for air conditioning in buildings more than tripled between 1990 and 2016, from about 600 to 2000 TWh (terawatt hours). As per International Energy Agency (IEA), the projected growth in residential and commercial space cooling capacity from 11,670 GW in 2016 to over 36,500 GW in 2050 will leave substantial cooling needs unmet. Air conditioner ownership, in particular, is rising very rapidly with income in countries with hot and humid climates, where cooling is essential for people to live and work in comfort. Statistically, cooling demand globally is being met through refrigerant-based cooling across sectors, such as buildings, cold chain, refrigeration, and transport.

As far as India's air conditioning is concerned, the production of room air conditioners has been growing at 13% per year since 2010 and the demand for air conditioners is expected to grow by 11–15% per year over the 2017–27 period. Consequently, India's aggregate cooling related energy demand is expected to soar from 90 TWh in 2015 to 1350 TWh by 2050, signifying a 15-fold increase. India, along with China and Indonesia, is expected to extract a lion's share in energy for space cooling by 2050, contributing to half of global cooling energy demand growth. Also, the country's peak electricity load for space cooling is projected to jump from 10% now to 45% in 2050. This poses adverse environmental and societal impacts – significant additional power generation capacity, peak load impacts, and an enormous GHG footprint.

ICAP – An Action Plan for Reducing the Environmental Footprint of Cooling in India

The growing demand for cooling will increase global warming – from emissions of hydrofluorocarbons (HFCs) used in cooling equipment as well as CO_2 and black carbon emissions from mostly fossil fuel-based energy currently powering cooling. A transition to climate-friendly and energy-efficient cooling, however, would avoid these emissions and allow an increase in cooling access that would contribute substantially to the Sustainable Development Goals (SDGs).

Keeping this in view, the Ministry of Environment, Forest and Climate Change (MoEFCC), Government of India has developed the India Cooling Action Plan (ICAP). The ICAP presents a 20-year outlook on how the cooling demand in India will evolve across priority demand sectors and outlines strategies and actions to promote sustainable and smart cooling practices across the nation while mitigating adverse impacts.

This landmark policy document demonstrates unprecedented inter-ministerial and cross-sectoral collaboration in laying out actionable pathways and identified ambitious goals. ICAP underscores the environmental and socio-economic benefits of sustainable cooling through five ambitious goals, including recognition of 'cooling and related areas' as a thrust area of research under the National Science and Technology Programme to support the development of technological solutions and encourage innovation challenges. The action plan seeks to reduce cooling demand by 20–25% and refrigerant demand by 25–30% across sectors by 2037–38. Other goals include reduction of cooling energy requirements by 25–40% by 2037–38 and training and certification of 100,000 servicing sector

technicians in synergy with the Skill India Mission by 2022–23. As meaningful as these goals are to proactively and effectively manage India's future cooling needs, what makes the ICAP even more important are the significant co-benefits – above the energy and emissions reduction – that are inherent in the pathways recommended for the cooling sectors.

Cross-Sectoral Alignment in the Sector Necessitates Effective Communications

Cooling is essentially cross-sectoral in nature, involving residential and commercial buildings, transport, cold storage, and industries, each with differing demands and priorities. Implementation of ICAP thus becomes a challenging task for the government as well as industry players, with the cross-sectoral nature of cooling raising key aspects that need to be addressed, including aligning priorities and regulatory and institutional contradictions.

To effectively implement SMART (specific, measurable, achievable, realistic, and time bound) levers to achieve sustainable cooling, it is imperative to understand perceptions and attitudes of key stakeholders. It is necessary to gauge priorities and challenges and identify opportunities so that any policy decision is effectively translated into desired outcomes.

The behaviour of different stakeholder groups and their perception towards issues and challenges in the sector become very critical while designing policies and communication strategies and assessing capacity building needs. Activities can be complementary, thus reinforcing each other and achieving better results with optimal efforts. To bring about a desired change through behavioural change, some elements that are required to be kept in mind include time taken to devise action plans, seeking strategies through collaborations between various stakeholders, identifying effective previous work done in comparable

fields, involving appropriate expertise, and highlighting the importance of specific behavioural targets and time frames.

TERI's Research to Gauge Stakeholder Perceptions and Behaviour

The lack of perceptions and behaviour research in the cooling sector has till now been a key gap in the overall understanding of the sector. To better understand key issues and challenges, TERI is conducting a national level perception study with respondents across key stakeholder groups, including policymakers at the central and state levels, industry, consumers, and servicing technicians. The survey has revealed interesting insights into perceptions, behaviour, and expectations of key stakeholders.

For consumers, energy efficiency is seen to be a major factor in selecting home ACs and refrigerators. Almost 9 of 10 consumer respondents cited the star rating of an appliance as the most important aspect in choosing a cooling appliance. Energy efficiency and ozone-friendly coolants are seen by consumers to be major innovations in the sector. Consumers in urban India are also seen to be relying increasingly on information available online to make their decisions.

One of the key consumer behavioural aspects investigated was related to maintenance of ACs. Consumers have a clear preference for company trained servicing personnel – an overwhelming 75% of consumer respondents preferred company personnel. The reason is trust. About 84% of consumers surveyed said that they trust the servicing personnel to do the right thing, fill the correct coolant, and so on, with a perceived trust factor in the technical competence of company technicians or company authorized technicians.

Servicing personnel were another major focus of the survey. For a clear opportunity here is to bring more servicing technicians into the formal workforce – almost a third of technicians surveyed did not have formal training. Any such move is also likely to be welcomed by the servicing workforce, as a majority indicated that training and refresher courses directly and positively impact competence and job prospects. With an increasing need for servicing personnel, given the massive growth projected in the sector, this provides an excellent opportunity to both skill people and provide jobs, while also improving the maintenance life cycle of cooling equipment.

Manufacturers in the cooling industry believe that transition should not leave consumers unsatisfied in terms of costs as consumers tend to be very price conscious. They are of the view that the newer environment-friendly refrigerants can be more flammable and to avoid casualties, safer installation practices must be followed. Increasing training centres for servicing personnel and ensuring job security can be beneficial for the overall sector. From a policy perspective, manufacturers have sought clarity on the roadmap for ratings, signalling that a clear expression of intent from policymakers can potentially increase appetite to invest in technology.

Policymakers engaged with this survey acknowledged the possibility of gaps between policies and levels of awareness about the policies even among manufacturers. A feedback loop was sought so that policies are not made in a vacuum but take into account ground realities. Policymakers indicated that there is a need for more platforms for consultation and collaboration, especially in research.

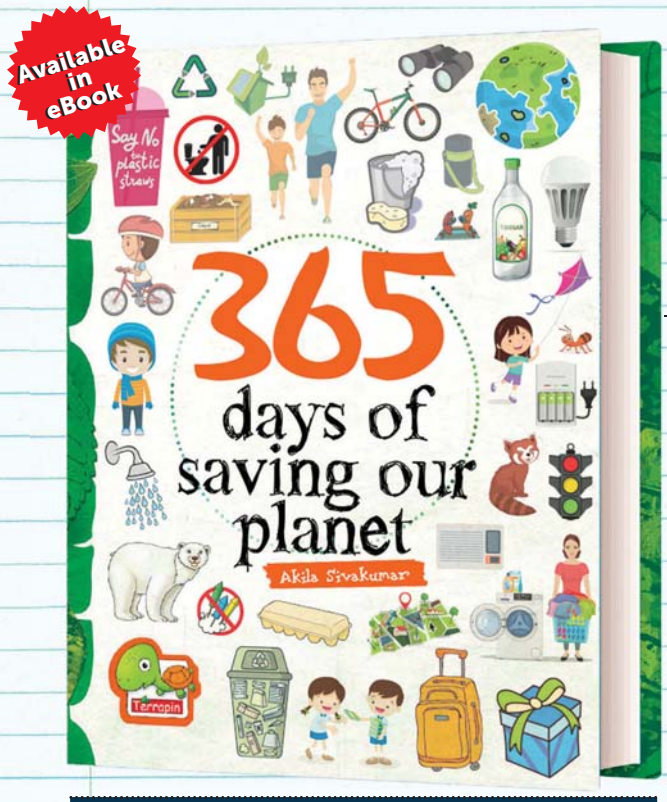
An initial analysis of these perceptions points to some clear pathways:

1. *Collaboration*: There should be formal and informal consultations and collaborations between industry, between industry and government, perhaps also between different ministries and departments of the government so that there is alignment at all levels.
2. *Cost rationalization*: Cost is always likely to be an issue for both consumers and manufacturers. Collaborations, especially on R&D, may spread risk and reduce the cost of development. Innovative market models, such as demand aggregation, may also be explored to further reduce cost to consumers.
3. *Training*: There is a clear need for more training. Conventional training can perhaps be supplemented by leveraging digital and social platforms for micro-skilling and knowledge transfer.
4. *Awareness*: It is imperative to spread awareness among all stakeholder groups. Feedback loops to inform policy, awareness about policy among manufacturers, and awareness about technology and the benefits of ratings among consumers can drive a holistic intervention to achieve a faster transition to efficient cooling.
5. *Effective communication*: This underlies all the above activities. Only when stakeholders know can they participate effectively. Only then can decisions be better informed and only then will consumers also buy into this transformative process. Effective communication at all levels will be vital to the success of any initiative in the sector.

This study will effectively identify the levers to synergies in relation to policy, awareness, and capacity building to facilitate the implementation of the ICAP and to push and pull the correct levers for the targeted stakeholder groups. More importantly, the study provides a valuable baseline assessment that can be used to measure transformation and identify areas that may require more focused analysis in the future to fine-tune future policy interventions. EF

Manjeet Singh, Associate Fellow, TERI; Vasudevan Rangarajan, Corporate Lead – Delhi, Edelman

One healthy habit a day!



- Innovative lessons and practical ideas
- Special 'Environmental Days' celebrated worldwide
- Bright and colourful illustrations
- Engaging and fun DIY activities

Ages: 5-7 years • ISBN: 9789386530875 • Price: ₹250*

Switching off the lights when not in use, turning off running/leaking faucets, and planting trees are some of the simplest habits to save our planet. *365 Days of Saving Our Planet* encourages children to pick up one green habit a day to do their bit for planet Earth. From preventing food wastage, adopting healthier activities such as walking and cycling to reduce the carbon footprint, saving water, conserving flora and fauna, going organic, proper disposal of waste, to choosing renewable sources over non-renewables, this book is about sustainability and eco-friendly methods. Say 'Yes' to acting green!

The Energy and Resources Institute
Attn: TERI Press
Darbari Seth Block
IHC Complex, Lodhi Road
New Delhi – 110 003/India

Tel. 2468 2100 or 4150 4900
Fax: 2468 2144 or 2468 2145
India +91 • Delhi (0)11
Email: teripress@teri.res.in
Web: http://bookstore.teri.res.in

To purchase the book, visit our online bookstore at http://bookstore.teri.res.in or send us your demand draft or cheque in favour of TERI, payable at New Delhi (outstation cheques are not accepted).

Price is subject to change

Sustainable Thermal Comfort in Buildings Through Prioritizing Occupant Needs

A major reason for the poor satisfaction with thermal environment is the lack of individual and personal control over the environment. Building environment control systems can be designed by incorporating personalized control systems for greater satisfaction at much less energy consumption. In this article, **Asit Kumar Mishra** and **M Ramgopal** present a simple three-level approach that can achieve this goal and lead to a sustainable thermal comfort system.

Recent studies show that many occupants of air-conditioned buildings are not satisfied with the thermal environment even though the environment meets the currently followed thermal comfort standards. This cannot be justified in view of the large amount of energy spent in maintaining the thermal environment. Studies suggest that a major reason for the poor satisfaction with thermal environment is the lack of individual and personal control over the environment and the designing of indoor spaces for a theoretical, average occupant, instead of actual individuals. Hence, it is suggested that building environment control systems be designed by incorporating personalized control systems for greater satisfaction at much less energy consumption. A simple three-level approach is suggested to achieve this goal, which can lead to a sustainable thermal comfort system.

Owing to changing lifestyles, human beings are found to spend increasingly more and more of their lives indoors. Studies show that now people spend nearly 90% of their lives inside some kind of building or the other [1]. Considering this fact that most of our lives are spent inside buildings, it should come as no surprise that buildings account for 38% of equivalent greenhouse gas emissions and 40% of global end energy usage [2]. And in buildings, a considerable amount of energy is expended to keep people thermally comfortable. For example, in India, 31% of the energy budget in commercial buildings is for air conditioning and ventilation [3]. With such large amounts of energy being used, it would at least be considered worthwhile to find if occupants were really being kept comfortable. Unfortunately, several studies show that this is not always the case. An overview of thousands of surveys filled by occupants in office spaces, collected over the last 20 years, showed that around 39% of occupants are dissatisfied with the temperature in their workspace [4]. With such surprisingly widespread levels of dissatisfaction with indoor thermal conditions in spite of spending so much energy, it is only appropriate that the thermal comfort of occupants should be examined from a fresh perspective. This is especially important for countries like India that are aspiring to provide comfortable dwellings to billions of their populace. At present, the market penetration of air conditioning is still very low in India, but it is rising fast as shown by the sales of air conditioners and air conditioning systems [3]. In fact, even with such low penetration levels, the not-too-infrequent power blackouts that are seen during the peak of summer months are partly attributed to the increased use of air conditioners in urban areas. Hence, the added burden a further rise in energy intensive air conditioners will place on Indian energy sector cannot be overstated. And even more unfortunate is the fact that such a rapid rise in air conditioning is not likely to satisfy the occupant needs completely, as gathered from the existing evidence.

Thermal Comfort in Built Environment

The American Society of Heating, Refrigerating and Air Conditioning Engineers (ASHRAE) defines thermal comfort as "a condition of mind that expresses satisfaction with the thermal environment and is assessed by subjective evaluation" [5]. Since it is difficult to assess and quantify the mental conditions of occupants, designers need to rely on thermal comfort standards and guidelines to make sure that the indoors provide comfortable living and working environment. In this, they are guided by international and local standards, such as ASHRAE Standard 55, European Standard EN15251, or National Building Codes of India. For most of the standards worldwide, comfort in air-conditioned spaces is based on the predicted mean vote (PMV) model [5]. The PMV model has been in use for more than four decades now. The PMV value provides an average thermal sensation vote of occupants on a seven-point scale (–3 to +3), with the thermal sensation ranging from cold (–3) to hot (+3), with neutral (0) in the middle. Achieving neutral vote is generally considered as the goal for thermal comfort design. The PMV calculated based on indoor thermal conditions, occupant clothing, and activity is used to calculate an index called predicted percentage dissatisfied (PPD), which represents the percentage of occupants that are likely to be dissatisfied with the existing thermal conditions. Figure 1 shows the variation of PPD with PMV. As shown in the figure, according to the PMV–PPD model, the lowest value of PPD that can be achieved at neutral condition (PMV = 0) is 5%.

Buildings are further classified into different comfort classes depending on what PPD fraction they are designed for. Buildings designed for lower PPD values, that is, supposedly higher satisfaction among occupants, are said to belong to higher thermal comfort class. For example, according to ISO 7730-2004, the design PPD values should be less than 6% for Class A buildings, less than 10% for Class B buildings, and less than 15% for Class C buildings. Because of the manner the PMV model works, lower PPD values require that buildings be run within narrow temperature ranges. Many Indian offices tend to be designed for operating within narrow temperature ranges of 22.5 ± 1 °C, throughout the year, to be able to satisfy stringent requirements of a higher class [3]. This, in turn, means a higher energy cost. However, these buildings with narrowly maintained temperatures have been found to afford no greatly improved

PMV and PPD

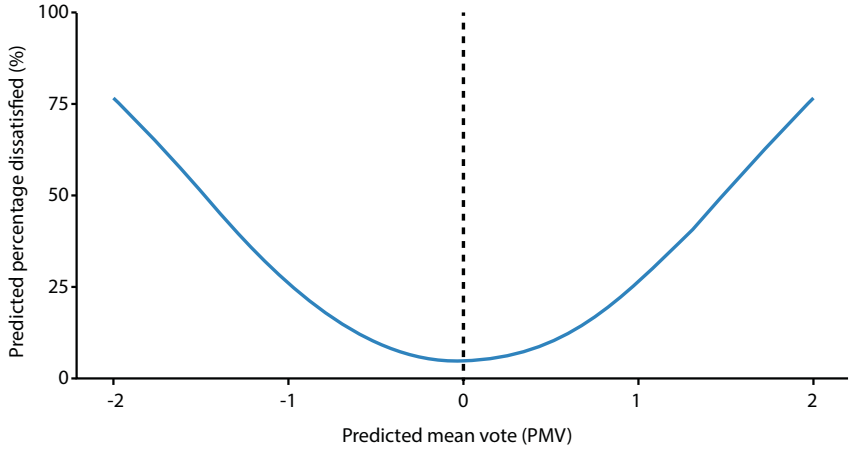


Figure 1 Predicted percentage dissatisfied and its variation with predicted mean vote. The plot is based on Ref. [5]

satisfaction levels to occupants as trade-off for their higher energy use [6, 7].

Putting a big question mark on the utility of the PMV model, analysis of the ASHRAE Global Thermal Comfort Database II showed that the PMV model was only about 34% accurate in predicting the observed thermal sensation of occupants, irrespective of the building being air-conditioned, naturally ventilated, or operating in mixed mode [8]. This implies that this universally adopted model is less accurate than the toss of a coin in predicting if an occupant is finding the indoor thermally comfortable or not! It was also found that PMV and PPD prediction errors got worse as the actual votes moved farther from neutrality [8].

Trouble with Tradition?

What could be the cause of the high levels of inaccuracy observed with the traditional PMV model? After all, it is based on solid theory and physical principles of heat balance between the human being and the surrounding thermal environment, and it has been in use for several decades now throughout the world. Initially, the discrepancy was found to be greatest when this model was applied to non-air-conditioned or what is called free-running or naturally ventilated buildings. Studies were initiated in the 1970s to understand this phenomenon of PMV model failing badly in naturally ventilated buildings. It was found that in naturally ventilated buildings, to remain comfortable, the occupants tend to adapt to the thermal environment by resorting to various adaptations, such as adjusting their clothing, opening windows, and moving to cooler spaces. This observation and the subsequent studies gave rise to the concept of "adaptive thermal comfort". The PMV model assumes the human beings to be passive and does not consider the possibility of the humans trying to adapt to the environment when it is not favourable. Hence, the model tends to fail in naturally ventilated buildings where occupants exercise the option of adaptation, while it is more successful in air-conditioned buildings where there is little need or scope for adaptation. Though there were few takers for the concept of adaptive thermal comfort as an alternate model in the beginning, with more and more studies carried all over the world, it slowly gained acceptance with time. Towards the beginning of this century, the concept of adaptive thermal comfort was adopted by multiple thermal comfort standards as a predictor of thermal comfort for naturally ventilated buildings [9]. It is to be expected that adoption of the adaptive thermal comfort standard for naturally ventilated buildings ensures that they are not air-

conditioned unnecessarily, which would have been the case if the PMV standard was applied to these buildings. However, as far as the air-conditioned buildings are concerned, it is assumed and strongly believed that the PMV model works well for these buildings and hence is recommended as the standard to be adopted for air-conditioned spaces throughout the world. But the new data now suggests otherwise!

A hint as to why this is so was possibly given by a summary of thermal comfort surveys carried out in office buildings across Europe and North America. During these surveys, it was found that the satisfaction levels are much higher for occupants with access to means of controlling their local thermal conditions compared to occupants without access to such means of local control [10]. It is found that, in general, people prefer to have a certain modicum of control over their thermal environment. This is further supported by more recent works which also showed that greater control leads to greater satisfaction with thermal comfort, with control over personal ventilation being the major influencing factor [11]. As our individual differences have a marked effect on thermal comfort [12], a one-size-fits-all solution is unlikely to solve the needs of everyone. These individual differences at least partly explain why PMV model, which tries to evaluate the thermal comfort for one average person, fails when trying to account for the perception of individual occupants, even in air-conditioned buildings. Once again, a look at the ASHRAE Global Thermal Comfort Database II shows that occupants in buildings accept temperature ranges that are two to three times wider than the ranges recommended by the current standards, that is, 7.4–12.2 °C versus 2–6 °C [7].

Personalizing Thermal Comfort

Wider temperature ranges for comfort conditioning inherently would lead to

elimination of unnecessary overcooling and overheating. Extended set-points help reduce air conditioning energy use. Building performance simulations suggest that increasing the upper limit of cooling set-point by just about 3 °C can help in reducing the energy consumption by 29% [13]. But as the preceding discussion suggests, while the range of temperatures across which occupants may be comfortable is wider, there is no single temperature that would be able to satisfy all occupants – be it warmer or cooler. This puts forth the challenge as to how this observation can be exploited for saving energy while at the same time ensuring comfort of each individual.

This is where personalization of thermal comfort comes up. Since no two individuals are the same, their thermal comfort needs also cannot be the same, and they would be best served by having access to means that helps them to ensure their own comfort. This leads us to the concept of personal comfort systems (PCS). Any device that may be used by individual occupants to improve their own thermal comfort without affecting the overall space temperature settings would come under the umbrella of PCS. PCS technology does not have to be something complicated or of the next age. It could be personal fans (ceiling, floor, or desk fans), personal ventilation air jets (ceiling, floor, or desk jets), chairs with cooling/heating modules, or foot/palm warmers. Their effect is generally limited over a space immediately around an occupant. Hence, a person can use them without being concerned that it may disturb other nearby colleagues. The use of PCS opens up further energy saving opportunity; the use of fans for wider comfort set-points can lead to HVAC energy savings of 32–73%, depending on the local climate [13].

How much a certain PCS can push the comfort band is presented as a corrective power (CP) of the system, and an overview of different PCS suggests CP ranges between 1 °C and 6 °C [14]. And

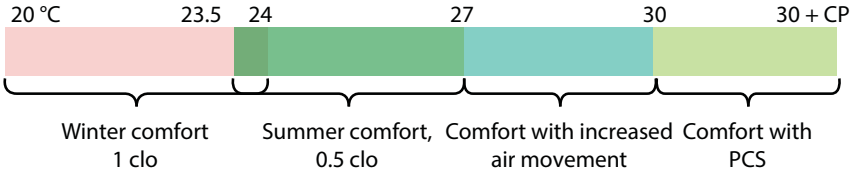


Figure 2 A schema of broadening the thermal comfort zones through the use of air movement from PCS and further relaxation based on the corrective power of PCS

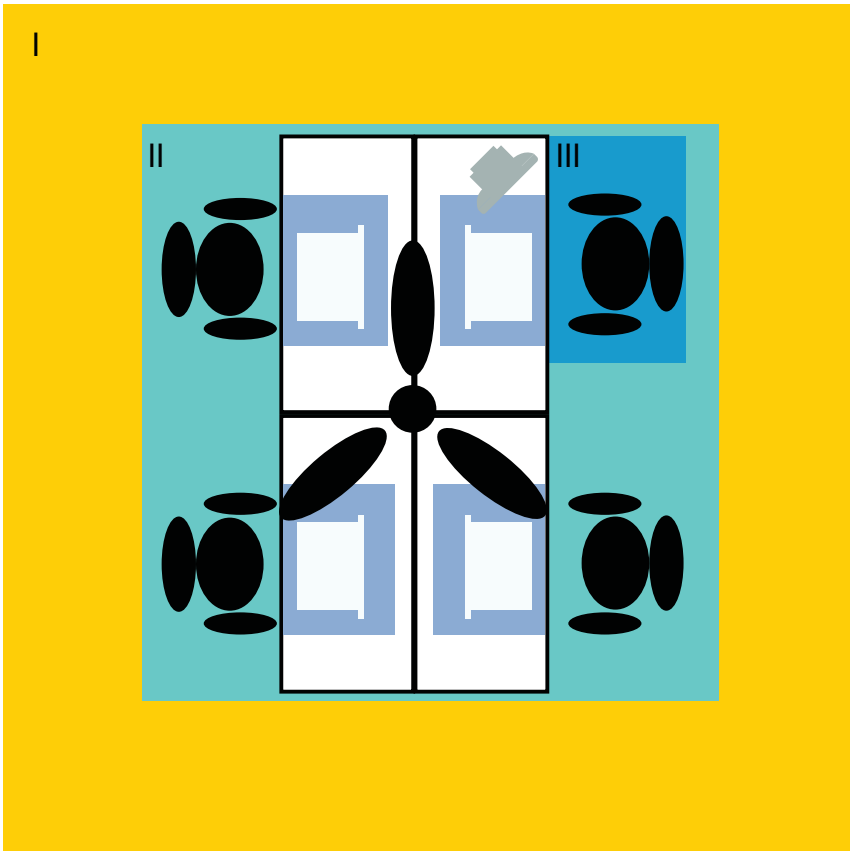


Figure 3 A conceptual schema of a three-level conditioning regime, prioritizing occupants and avoiding overcooling of bulk spaces

since a PCS is empowering individuals to ensure their comfort, occupant satisfaction levels close to 100% can now be targeted. Figure 2 presents a schema of how PCS can further widen thermal comfort zones.

A design that takes into account the availability of PCS for individual occupants can take a hitherto unrealized modular approach to thermal comfort. We present this approach for cooling dominated climate in Figure 3. As an example, in this schema, we present a three-level approach. At the outermost/floor level, the thermal comfort requirements can be at a gross level, and as such the bulk volume may be maintained by the centralized system at relatively warm temperatures, hence lower energy consumption. This would include transitional and common use spaces, such as lobbies, stairways, and break rooms. Going one level down, in the zones where occupants are likely to spend most of their time, those specific locations can be maintained at a slightly cooler condition along with ceiling fans serving clusters of occupants. Finally, at the desk level, occupants can have access to their personal desk fans to use and control the speed as per their own cooling needs.

We now come back to the idea we started with. To ensure comfort for all occupants in buildings, we need a change of perspective, from centralized comfort to personalized comfort. We have used this article to point out why this shift is needed and why personalization is the way to go. We conclude with a look at future directions of research that can help achieve this transition.

To address the needs of individuals, it is necessary to understand better individuals' physiological (e.g., skin temperature, heart rate, skin wettedness) and psychological (e.g., subjective thermal comfort response, thermal preference, affects response) differences under a range of thermal environments. This information would also improve our understanding of how PCS can aid comfort and consequentially improve their effectiveness.

The next broad direction of investigation would be interpreting and incorporating the physiological and psychological responses into thermal comfort needs. With increased access to computational resources, this line of work could heavily depend on machine learning and AI algorithms.

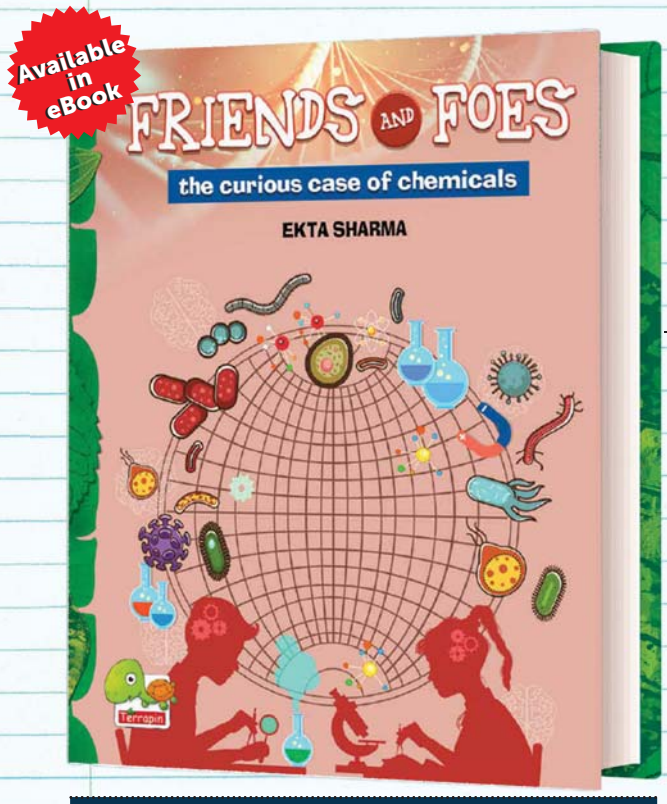
Finally would be the step requiring design/improvement of PCS and control systems that can take into account the results from the previous two steps. This step would round up the efforts made towards personalizing indoor thermal comfort and provide the road map for comfortable, low-energy built environment that aims for a 100% occupant satisfaction by catering to the needs of each occupant. EF

References

1. Klepeis, N. E., W. C. Nelson, W. R. Ott, J. P. Robinson, A. Tsang, P. Switzer, J. V. Behar, S. C. Hern, and W. H. Engelmann. 2001. The National Human Activity Pattern Survey (NHAPS): a resource for assessing exposure to environmental pollutants. *Journal of Exposure Science & Environmental Epidemiology*, 11(3): 231–252
2. UNEP. June 2012. Building design and construction: forging resource efficiency and sustainable development. Details available at https://s3.amazonaws.com/legacy.usgbc.org/usgbc/docs/Archive/General/Docs19073.pdf
3. Manu, S., Y. Shukla, R. Rawal, L. Thomas, and R. de Dear. 2016. Field studies of thermal comfort across multiple climate zones for the subcontinent: India Model for Adaptive Comfort (IMAC). *Building and Environment*, 98: 55–70
4. Graham, L. T, T. Parkinson, and S. Schiavon. 2020. Where do we go now? Lessons learned from 20 years of CBE's Occupant Survey. Center for the Built Environment, UC Berkeley. Details available at https://escholarship.org/uc/item/8k20v82j
5. ASHRAE. 2017. ANSI/ASHRAE Standard 55-2017: Thermal Environmental Conditions for Human Occupancy. *American Society of Heating, Refrigerating and Air Conditioning Engineers*
6. E. Arens, M. A. Humphreys, R. de Dear, and H. Zhang. 2010. Are 'class A' temperature requirements realistic or desirable? *Building and Environment*, 45(1): 4–10
7. Li, P., T. Parkinson, G. Brager, S. Schiavon, T. C. T. Cheung, and T. Froese. 2019. A data-driven approach to defining acceptable temperature ranges in buildings. *Building and Environment*, 153: 302–312
8. T. Cheung, S. Schiavon, T. Parkinson, P. Li, and G. Brager. 2019. Analysis of the accuracy on PMV – PPD model using the ASHRAE Global Thermal Comfort Database II. *Building and Environment*, 153: 205–217
9. Mishra, A. K. and M. Ramgopal. 2013. Field studies on human thermal comfort—an overview. *Building and Environment*, 64: 94–106
10. Huizenga, C., S. Abbaszadeh, L. Zagreus, and E. A. Arens. 2006. Air quality and thermal comfort in office buildings: results of a large indoor environmental quality survey. *Proceeding of Healthy Buildings* 3: 393–397
11. Kwon, M., H. Remøy, A. van den Dobbelsteen, and U. Knaack. 2019. Personal control and environmental user satisfaction in office buildings: results of case studies in the Netherlands. *Building and Environment*, 149: 428–435
12. Wang, Z., R. de Dear, M. Luo, B. Lin, Y. He, A. Ghahramani, and Y. Zhu. 2018. Individual difference in thermal comfort: a literature review. *Building and Environment*, 138: 181–193
13. Hoyt, T., E. Arens, and H. Zhang. 2015. Extending air temperature setpoints: simulated energy savings and design considerations for new and retrofit buildings. *Building and Environment*, 88: 89–96
14. Zhang, H., E. Arens, and Y. Zhai. 2015. A review of the corrective power of personal comfort systems in non-neutral ambient environments. *Building and Environment*, 91: 15–41

Asit Kumar Mishra, SinBerBEST, Berkeley Education Alliance for Research in Singapore, Singapore; M. Ramgopal, Department of Mechanical Engineering, IIT Kharagpur, India

Chemicals: Good or Bad?



Major topics covered

- Medicines That Heal
- Chemicals We Eat
- Chemicals We Use at Home
- Industrial Mishaps
- Making Sense of Chemicals

Ages: 11-14 years • ISBN: 9789386530912 • Price: ₹250*

What's the first thing that comes to your mind when you hear the word 'chemicals'? Friendly, hostile, smelly, radioactive, volatile—chemicals are all these and much more. And it's not possible to do without them in our daily lives because they are present in just about everything. So the next best thing to do is to separate the good chemicals from the bad ones and the absolutely deadly ones! Peppered with curious facts and useful information, *Friends and Foes* explores the lesser-known, mystifying universe of chemicals and guides you towards a better judgement of what chemicals to avoid and what to limit. It is your guide to the most pressing need of the hour—a healthier and environment-friendly life.

The Energy and Resources Institute
Attn: TERI Press
Darbari Seth Block
IHC Complex, Lodhi Road
New Delhi – 110 003/India

Tel. 2468 2100 or 4150 4900
Fax: 2468 2144 or 2468 2145
India +91 • Delhi (0)11
Email: teripress@teri.res.in
Web: http://bookstore.teri.res.in

To purchase the book, visit our online bookstore at http://bookstore.teri.res.in or send us your demand draft or cheque in favour of TERI, payable at New Delhi (outstation cheques are not accepted).

*Price is subject to change

MAKING COLD CHAINS COST-EFFECTIVE

According to the United Nations Development Programme, nearly 40% of the food produced in India is wasted from the farm to the fork. That translates to roughly ₹250 crore per day or more than ₹90,000 crore per year. These losses result in a lower income for the producer (farmer) and increases the cost for consumers. But the most significant impact is that it challenges our overall food security, as we need to feed our ever-growing population. It is estimated that saving even one-fourth of the food currently lost or wasted would be enough to feed the hungry people in India.

Food loss happens very differently in developed and developing countries. In developed countries, food waste and loss occurs largely at the end of the chain. It is estimated that in the United States, 31% of food loss occurs either at retail due to dumping of over-ordered or spoilt food or at the consumer end when they buy or cook more than they need and choose to throw out the extras. However, in developing countries like ours, most of the food loss occurs at the beginning of the chain. It occurs after harvest or during transit from the farm to the large consumption areas based in urban markets. This can be attributed to poor storage, cooling, and transport infrastructure.

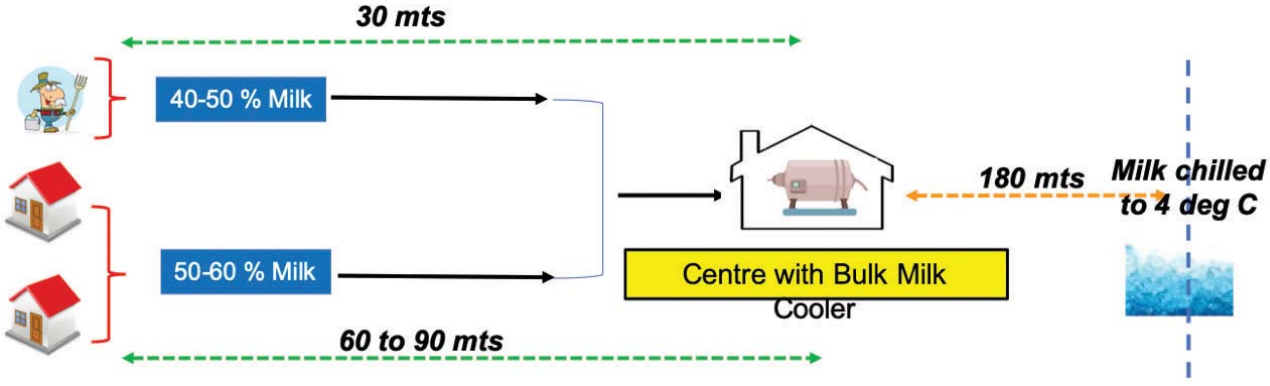
Critical Elements in the Cold Chain

There are four critical elements of the cold chain that need to be implemented from the farmer to the consumer.

1. Post-harvest chilling and storage of produce in the village itself
2. Chilled transport of the produce from the village to the processing/ aggregation centre
3. Chilled transport of the finished product to the market
4. Cold storage at the distributor/ warehouse and refrigerated transport delivery to the retailer/ consumer in the city

The number of stages may vary depending on the commodity, nature of business, or scale of operations. However, implementation of all applicable elements is imperative

The loss of food produced happens differently in developed and developing countries. In developing countries like India, much of the food loss occurs at the beginning of the chain. This can be attributed to poor storage, cooling, and transport infrastructure. In this article, **Jofi Joseph** discusses the obstacles to penetration of cold chain in rural India and the implementation of a cost-effective cold chain from the farm to the fork.



to reduce loss due to spoilage and ensure that both the producer and the consumer benefit.

It is observed that implementation of cold chain is more prevalent in the post-processing phase (factory to consumer) than in the pre-processing phase (farm to factory). This is in the form of investment in reefer trucks for movement of finished goods from the factory to the city or in the form of cold rooms at warehouses in the city itself. This can be attributed to processors having more control on the produce from the factory gate and the propensity to invest in cold chain for the finished products, which have more value than the raw material. However, the challenges faced in implementing cold chain infrastructure in rural areas where the food production happens are the main reasons for poor implementation of cold chain in the pre-processing stage.

Challenges in Implementation of Cold Chain in Rural Areas

The dairy industry has invested heavily in cold chain at the pre-processing stage. Owing to its perishable nature, 100% of the milk collected from farmers is chilled to 4 °C before it is taken to the processing plant. Even then, less than 20% of the milk is chilled at farms or even the village itself. The balance 80% is transported at ambient temperature in cans over long distances and chilled in centralized chilling centres.

Promethean Power Systems conducted a study in 2016 to understand why a low percentage of milk was chilled near the source. We wanted to understand the barriers to investment in cold chain infrastructure in villages. This study was focused on the dairy industry, which constituted the largest base of our customers, and was conducted through extensive primary and secondary research. The study highlighted that the barriers were capital expenditure, operating costs, managing operations, and visibility.

The biggest challenge to implementing cold chain in rural areas is the cost. The cost includes both capital expenditure and operational expenses. The chilling infrastructure has to be replicated and distributed across multiple farms in multiple villages. A very few individual farmers have the capability, skills, and scale to invest in and operate chilling equipment. The unreliable electric grid supply means that the chilling equipment has to be operated using diesel generator backup more than half the time. At the current rates of diesel and electricity, chilling cost of using a diesel generator is five times that of using grid electricity. Moreover, the management of diesel fuel (procuring, storing, and filling) to run diesel generators adds additional costs and hassles. The twin challenges of who will bear the capital expenditure of the chilling equipment and high operating costs involved due to an unreliable grid power are obstacles to penetration of cold chain in rural India.

The second major challenge is in operations. Even if the chilling equipment is installed across thousands of farms and villages, the chilled produce still has to be taken to processing/aggregation centres for value addition. This involves regular lifting and transport of the produce, while at the same time ensuring that

temperature rise during this process is minimal. Here, the challenge is of scale and infrastructure. We also need feet on the ground to ensure that the whole system works effectively.

There is also the challenge of no visibility to the produce being chilled. Most of the village level chilling equipment is operated by agents or third parties. The produce is lifted only once a day and it has to stored hygienically and maintained constantly at a low temperature. This entire process has to be managed by agents and the processor has to be sure that the cleaning protocols are being maintained, there is no adulteration or pilferage, and the temperature integrity in being maintained at all times.

After implementation of systems and processes to handle all the listed challenges, the biggest question arises: Can the costs of installing chilling infrastructure, ensuring seamless operations, and effective control be recovered from the consumer?

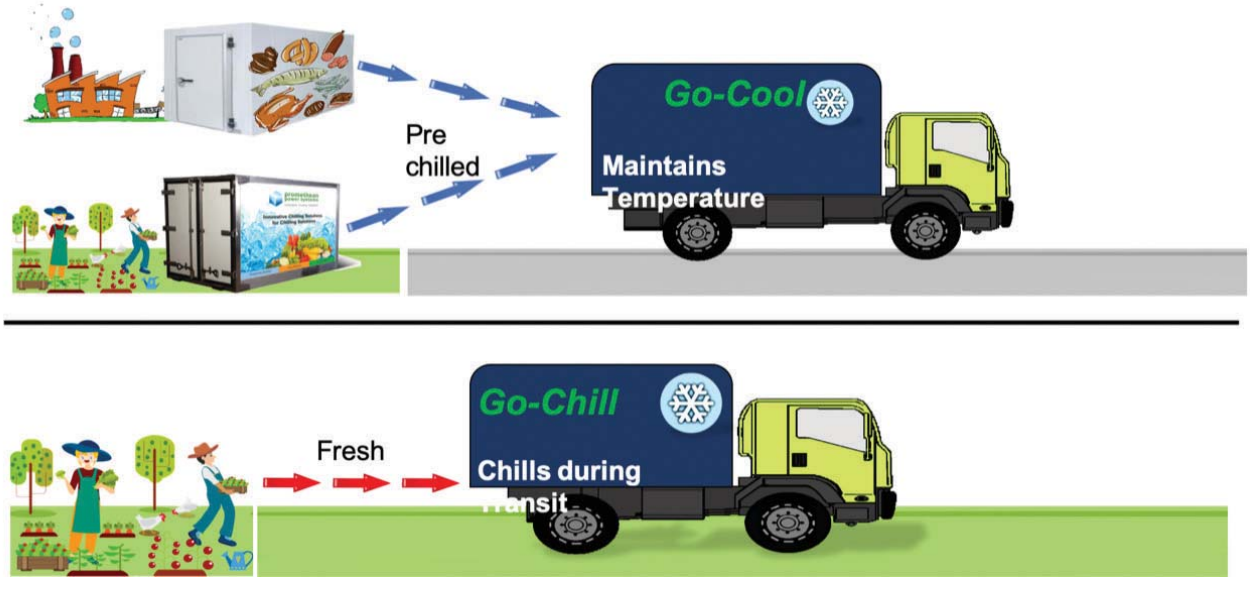
Indian Dairy Industry

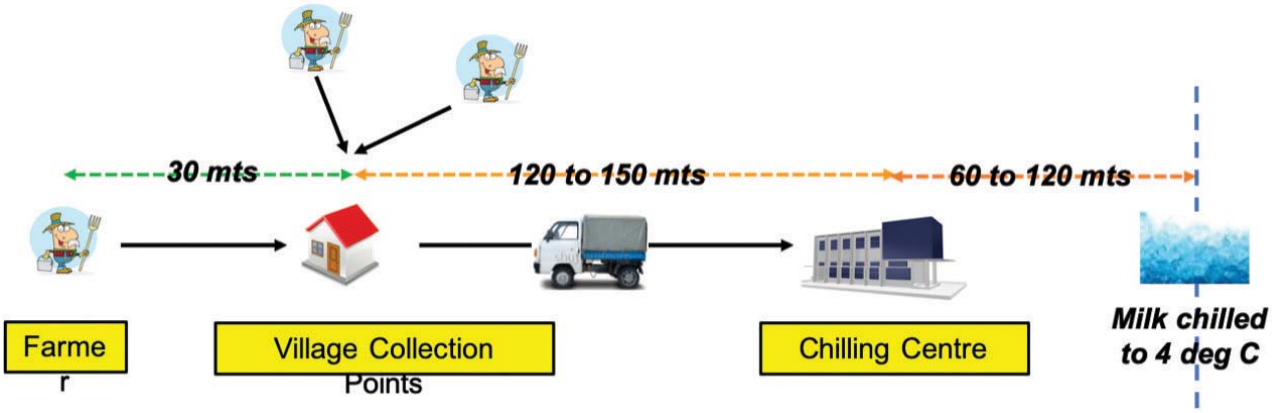
The Indian dairy industry is an interesting study from a cold chain perspective. The industry has a large scale, with collection from more than 100,000 villages across India. Pre-processing chilling infrastructure is a must and prices vary widely depending on the consumers' perception of quality and freshness.

In the last 50 years, India has progressed from being a milk deficient nation to the largest producer of milk in the world. We produce more than 400 million litres of milk per day, which is almost 20% of the global milk production. Milk is the single largest crop in India today. The organized sector (dairy companies) accounts for nearly 25% (100 million litres) of the total milk produced in the country. The rest is either local sales or for home consumption. The size of the dairy industry (organized) is over ₹100,000 crore per annum. The phenomenal growth of the dairy production can be attributed to the pioneering efforts of Dr. Verghese Kurien and the Amul model of milk collection. Milk is collected at a community centre in villages from millions of smallholder farmers (average less than 10 L/day) by hundreds of dairy processors (both private and cooperative) across the country. The milk is collected centrally in the village and then lifted by the dairy twice a day. This process continues for 365 days of the year. As long as the milk collected from the farmer is not adulterated or spoilt and meets some basic criteria, he is assured of a buyer and transparent prices. The farmer only has to transport the milk from his farm to the collection centre.

Milk, due to its very nature, is highly perishable and the bacterial growth starts the moment it is milked from the animal. This means that every one of the 100 million litres of milk collected by the organized sector in India has to be pre-chilled before it goes to the factory dock for processing. This pre-chilling happens either at the farm itself or at the village through *bulk milk coolers* or in centralized *chilling centres* where milk from multiple villages is collected and chilled. The milk is chilled to below 4 °C and then transported to dairies in insulated tankers, which ensure that the temperature at the dock does not exceed 7 °C. The entire investment in the chilling infrastructure is made by the dairy.

The end consumer prices vary widely across sellers. Most of our dairy customers sell the milk in standard pouches at the rate of ₹42–45 per litre. However, we also have customers who sell their milk at over ₹100 per litre. And many customers sell at various price points between these two extremes. Over 90% of the milk sold in the market today is at the standard rates. Dairies that are able to capture higher rates have added value to their offering in terms of quality, freshness, feed, or even the breed of the cow.





Cold Chain in the Dairy Industry

Pre-Processing Stage

We saw earlier that dairy industry has invested heavily in cold chain at the pre-processing stage. While the collection of milk is directly from farmers in the villages, the chilling takes place either in village-based bulk milk coolers or in centralized chilling centres at distant locations that cater to a cluster of villages.

The initial capital expenditure involved in setting up chilling infrastructure in villages throws up two challenges. The chilling equipment is never able to operate at 100% capacity due to seasonality, competition, and cyclical nature of the industry. This increases the per litre cost. For the cooperative sector, the problem is solved to a certain extent through government subsidies. However, the private sector, which is larger than the cooperatives and growing faster, receives no subsidies. Moreover, the per litre cost of the chilling and lifting of milk is higher at lower volumes. Hence, setting up chilling infrastructure is not viable in most villages that have a small volume of surplus milk. The dairy industry has solved this problem by setting up chilling centres to cater to clusters of villages. It may end up in raw milk of varying quality arriving at the dairy dock due to the time gap from milking to chilling. However, it also enables the dairy to chill 100% of their milk volumes before processing. The milk once chilled to 4 °C is carried in insulated tankers from villages to processing plants. This is a highly efficient mode, with the cost being limited to ₹0.40–0.60 per litre.

Post-Processing

The finished dairy products are stored in large cold rooms and freezers at the plant itself before being dispatched to markets in either refrigerated or insulated trucks. For larger dairies, milk products are then stored in cold rooms in city-based warehouses or distributor points, from where they are transported to the retail. Pouch milk, as it is bought and consumed on a daily basis, is normally carried in insulated trucks, which are timed such that they reach the retailer points early in the morning.

The key aspects of the dairy industry that we need to keep in mind are:

» Community level collection and chilling infrastructure that addresses the challenge of scale at individual villages by connecting multiple villages to a common infrastructure
» Anchor buyers who are responsible for investing in the chilling infrastructure and also ensuring transparent payment to the farmer for all the milk produced

» Customers who are willing to spend more depending on the product attributes

Can the India Dairy Industry Model be Replicated?

Collection in the dairy sector happens on a daily basis from villages and the chilling of the milk is done in community level chilling infrastructure. Farmers are offered transparent rates and assured of a buyer. The processors have a vested interest in preserving the quality of milk in the pre-processing stage as it reduces the spoilage, increases shelf life, and enables them to market high margin value-added products.

If we need to replicate the same model for fruits and vegetables, the first thing required would be to invest in community level collection and chilling infrastructure. Today we have subsidies being offered to individual farmers to install cold rooms, which do not really help due to the low utilization. Chilling infrastructure has to be common given that a huge percentage of our farmers are smallholders.

There would be need to have anchor tenants as buyers at these community level chilling centres. These buyers should not only give transparent rates to farmers but also invest in or subsidize the chilling equipment. The buyers will also need to invest in refrigerated trucks to transport the produce in temperature-controlled environment to markets.

Finally comes the pricing. Degradation or loss in fruits and vegetables from the farm to the consumer varies from 4–5% for root vegetables to as high as 25% for leafy vegetables. Back-of-the-envelope calculations show that the investment in chilling infrastructure pays for itself