iit TECH AMBIT

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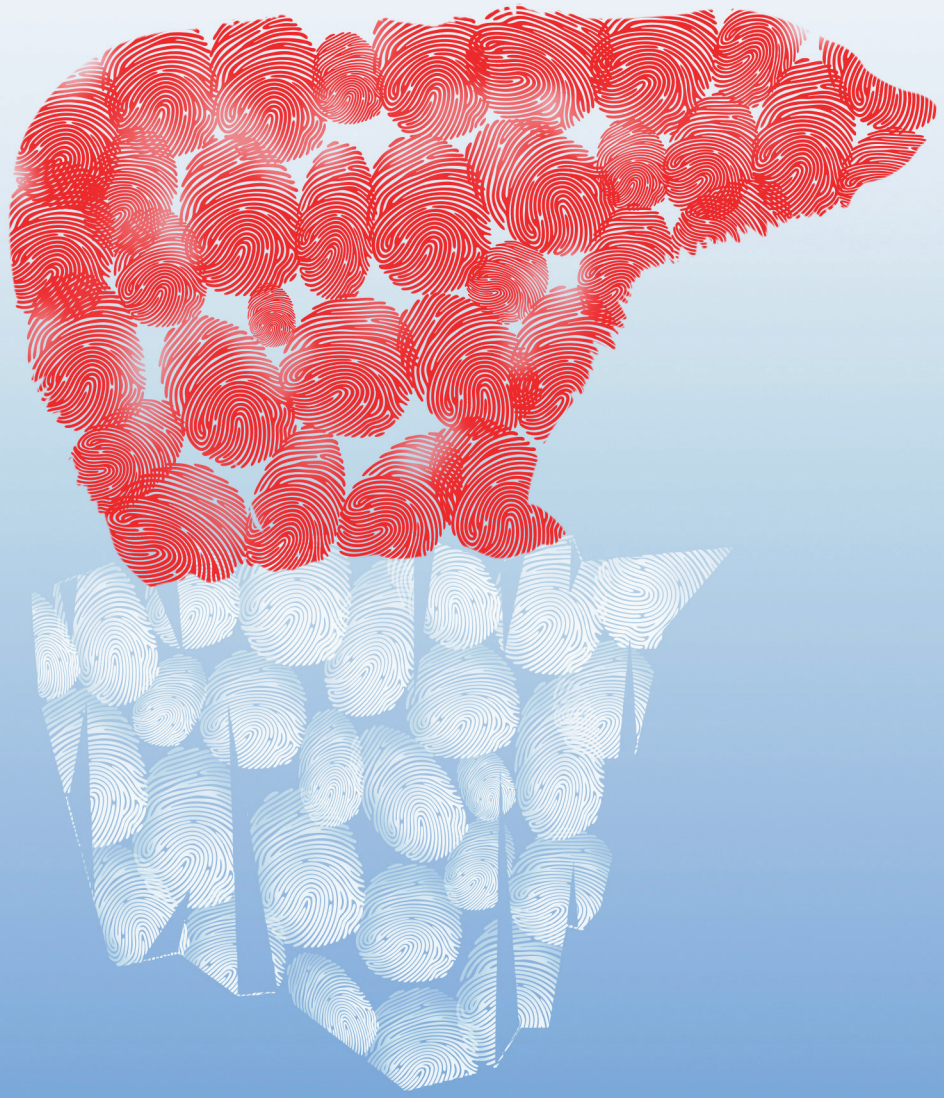

CLIMATE CHANGE IS HERE

IIT TECHNOLOGY AMBIT

IIT Technology Ambit tries to identify emerging technologies, contemporary research, and start-ups born out of the IIT ecosystem. The analysis of the impact of these developments is done to assist the Tech Sphere of India and beyond to keep pace with the latest.

We actively look forward to contributions from all stakeholders of all IITs.
By stakeholders, we refer to the trinity of alumni, professors, and students of IITs.

ABOUT THIS EDITION

The July issue, while continuing our monthly practice of indulging in a plethora of knowledge about technology, science and business, is a special one which focuses on climate change mitigation (to whatever extent we can) and the state of affairs of technology affecting our future environment.

Archi writes about the delay in the 3-stage nuclear program that Homi J Bhabha promised will be our solution to limitless power. While safety concerns from world mishaps have always loomed over, policy decisions seem to make matters more uncertain. is India's nuclear dream decaying?

Chennai, Bengaluru and Hyderabad, known for their race to become the IT Hub are currently in a different race altogether- who runs out of water first? Pranav writes about the water crisis developing in the country. All is not lost for Faclon Labs may just be on time to clear the chaos.

While some places struggle with water availability, there are those that struggle with accessibility. Rohit Sar, our guest writer for the month writes about his experiences in the development sector figuring out various strategies to provide drinking water facilities to villages.

India has invested in solar technology for quite some time. With targets to meet by 2020, Koshiki gives us her brief on the technology in use, the challenges to beat and the current state of affairs.

Shaurya talks about the technology and policy changes that are influencing the much exciting electric vehicle market in India. With NITI Aayog setting e-mobility targets for sale of only electric vehicles by 2030, is India electric enough to achieve them?

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From the tech GOSPEL

"Perhaps my factories will put an end to war sooner than your congresses: on the day that two army corps can mutually annihilate each other in a second, all civilised nations will surely recoil with horror and disband their troops."
Albert Nobel, 1891

Aye, I'm the Tech Gospel, a magnanimous preacher of the Philosophy of Technology. Magnanimity is personified in me by the fact that I will ignore your ineptitude towards ruminating on the Philosophy of Technology or rather in the concept of philosophy itself.

I believe the questions that science and philosophy pose and answer though different, are also naturally linked. This link is what forces us to introspect about our values and make tough compromises while we are on a rewarding path of science, technology or business. Unfortunately, scientists and managers are often implicit or even unaware of the value systems that inform their decision-making. Good decision making requires us being cognizant and explicit about our values and being able to defend or challenge them.

Climate change is going to affect the world disproportionately but when it's done, there may not be any survivors. One of the reasons that climate change is so challenging is because it forces us to dive into the difficult and more often than not, the personal work needed to solve it. The people engaged with the global issues of life well-being, resource sharing and continuance of society are all engaged in moral philosophy. Working at these scales defy our inherent judgement and our complacent desire to maintain our status quo.

While the "common but differentiated responsibilities" of the Paris Agreement help in understanding the political strategy and moral principles for countries, we as individuals need to find ways to inspire action for the hope of a future. Refining our goals and ambitions under the threat of climate change is an incredible ethical challenge that will require creativity, versatility and inter-disciplinary conversation. It is the war of the coming decades but this time we are on the same side.

For me, technology is the only blade and I sharpen my blades on philosophy.

That's all for this issue.


Via pixabay.com

DATA IN THE TIME OF WATER CRISIS: FACLON LABS HAS AN IOT DRIVEN SOLUTION TO SOLVE OUR WATER WOES


via futurelearn.com

India is in crisis.
We have grown up much of our short lives listening to and learning about Climate change and the consequences of global warming, but as much of human experience, we only begin to take action once faced with a problem. The Strauss-Howe generational theory – a sociological idea often referred to as the Fourth Turning – talks about how every generation faces a significant 'crisis', be it war, an economic downturn or natural disaster. Today in 2019, our crisis is here, and it is water.

A dire situation

600 million people in India are currently facing high to extreme water stress. August – supposedly peak Monsoon time across the subcontinent – is upon us already, and with a few geographical exceptions, we have resigned ourselves to an uncomfortable truth: the rains have failed this year too. There is now an aggregate rainfall deficit of 21% and a deficit exceeding 50% in some Meteorological Dept. subdivisions in the North and North-West of the country.

Climate change is not the only reason behind this situation, however. We are slowly waking up to the fact that man-made mistakes and mismanagement has done a lot to bring us to the edge. A ground-breaking June 2018 report by NITI Aayog was the first to comprehensively assess the current situation of the country and deliver some hard facts to where we're going if we don't correct our course. 21 Indian cities will run out of groundwater by 2020. Chennai, Bangalore and Hyderabad already face an extremely dire situation, where municipal supplies to some areas have long ceased and millions of residents are forced to line up daily for water or pay exorbitant amounts for water from private tankers.

Chennai: a city in the quagmire

The situation in Chennai, in particular, is shocking. It bears thinking about when the sixth-largest city in India faces its worst water crisis ever, a mere three years after its worst floods in a century (the 2015 Chennai Floods).

The four major reservoirs that cater to the city's demands have practically run dry in just a year; essential services like hospitals, schools and businesses have found operation so difficult, they've been forced to shut down; everyday activities like washing utensils or clothes have to be done with much less water, or none at all. Water, being a state concern, has every chance of becoming political. Multiple disputes have broken out in recent years between Tamil Nadu and Karnataka over sharing of the River Cauvery, and the state has only just

begun accepting water from Kerala to tide over the immediate effects of this shortage. Two million litres of water arrive every morning in Chennai by train – the city's daily water usage is close to 820 million litres.

There are deep-rooted problems behind this shortage, and very soon the entire country will have to wake up to the very real possibility of a 'Day-zero' scenario – where an entire city runs out of water, like Cape Town in South Africa had desperately to avert. By 2030, India's demand is projected to be almost double of current supply. In a conservative high-use scenario, 1180 BCM (Billion Cubic Metres) of demand is far beyond present availability of 695 BCM, and even below a total possible water supply of 1137 BCM. The knock-on effects are projected to be as high as a 6% loss in GDP, devastating for a young country with high aspirations, and a burgeoning desire for world-beating development to lift entire populations out of poverty.

CWMI: An attempt to bring order to chaos

The 2018 NITI Aayog report was sanctioned for the creation of a Composite Water Management Index, or CWMI which intends to "provide an annual snapshot of the water sector status and the water management performance of the different states and UTs in India". The index was comprised of 9 themes, with 28 indicators for the same, covering groundwater and surface water restoration, and rural and urban water supply among others. (link to report if necessary)

The findings of the report are interesting, and it is in light of this that the work of the featured start-up, Faclon Labs, assumes great significance.

According to the information provided by the CWC (Central Water Commission), the authors found that one of the biggest problems we face is the lack of water data. It goes on to say, "Data systems related to water in the country are limited in their coverage, robustness, and efficiency". Firstly, detailed data about usage patterns and allocation, for critical sectors such as domestic and industrial use is only available in aggregate, and hence "lacks the level of detail required to inform policies and allocations". Even more problematic is the reliability of the data currently possessed by policymakers and in the public domain – because of outdated methods of data collection and an un-updated database. An outrageous example from the 5th Minor Irrigation Census in 2017 is how "estimates on groundwater are mostly based on observation data from 55,000 wells, while there are 12 million wells in the country". Compounding both issues is the fact that water in India is a state concern, as mentioned before. Data, if at all it exists, is in silos, with very little inter-state or centre-state coordination.

The observant reader might have noticed something here – the potential for technology to come in and revolutionise the field is enormous. Till now, tech companies have shied away from public sector related infrastructure and social entrepreneurship, thanks to the perception that anything involving collaboration with state machinery is messy and comes with its inherent bureaucratic red-tape. The advent of 5G and easier integration of Internet-of-Things solutions in the Indian ecosystem, along with the Central Government's desperate push for digital solutions and an embrace of technology-driven by necessity, means there's now an opportunity like never before.

Enter the Faclon

A case in point of a company that's raced to capitalise on this opportunity is Faclon Labs. Started in Mumbai in 2016 by Rishi Sharma, Archit Naraniwal and Utkarsh Srivastava, they've developed a product that offers hardware and software solutions for water management, backed up by, in their words, an 'I/O Sense IoT Suite'.

Sharma and Naraniwal are both IIT-Bombay Alumni, who worked at the global auditing and consultancy firm, PricewaterhouseCoopers, for nearly a year, before quitting to start Faclon with Srivastava and former batchmate Ankit Parashar (Parashar has since left the company). This is one tech start-up where the IIT influence is clearly visible. Mechanical and Civil Engineering graduates respectively, they worked on a project in 2015 under CTARA, the Centre for Technology Alternatives for Rural Areas, IIT Bombay. Tasked with developing a 'water distribution schedule', in the rural district of Parbhani, central Maharashtra, they realised quickly that the on the ground scenario

was dismal, coming to the same conclusion that the NITI Aayog committee came to last year.
Without a well-structured, dynamic distribution system that drew on real-time data from various locations, the water supply was almost random. Demand and supply were manually mapped, outdated estimates. The result? A mismatch in water allocation with some areas receiving water only once a week for a few hours, or in some cases not for weeks together. If this scenario sounds familiar, it's because cities under water stress today are going through the same misallocation and lack of reliable supply, because the pace of urban changes in water demand is so rapid that real-time monitoring is absolutely essential.

Based on their experiences in Parbhani, the team realised that before you could even think about generating a better water distribution schedule, you had to map the consumption and have reliable data backing it up. Barely able to do that in the 4-month duration, they understood that mapping was easier said than done. That becomes the premise of their company's core offering.

IoT under the hood

Down to specifics: Faclon Labs' primary B2C product is a prepaid water meter and valve that integrates real-time data collection and operability. It consists of a flow-meter, an RFID device and a valve. The meter contains a mechanical counter as well as a 'pulsator' for digital readings – from water level to pressure and flow rate. The RFID device is the brains of the operation. It controls the amount of water flow based on the limit for the day and can control the valve to shut off the water supply and then restart the next day. An ordinary automated water valve, you say? Not quite. Where IoT comes in, is the potential for precise monitoring and data collection, not only from this one valve but potentially every water outlet in a distribution system.

According to the company, this 'gateway device' collects sensor data and sends it to remote cloud infrastructure using either GSM (4G wireless/WiFi) or GPRS, and is capable of multiple customizations due to its modularity. Their Internet-of-Things solution talks to LoRa nodes, using the LoRaWAN protocol, feeding into their backend software platform. Faclon accumulates and processes the real-time data, and provides custom analytics which it claims could be of high value to stakeholders like municipalities or even office buildings, residential complexes and educational institutions.

The applications of this minor, yet significant implementation of technology are many. Faclon says they've been using their predictive analytics to detect leaks, track supply and provide insights on local water consumption patterns. Currently, their devices and water management system have been


via worldmissionmagazine.com

implemented in the village of Ganeshpuri, 100 kilometres from Mumbai, as well as two hostels at IIT-B. Company media releases also claim their solution has been "deployed across 100-plus locations in Uttar Pradesh, Bihar, Gujarat, Delhi, Bengaluru, and Mumbai".

Traction and Growth

Despite an innovative product filling the lacuna of technology in a vital field, Faclon Labs faced big hurdles early on. Investors wanted something 100% tested and reliable, and had concerns regarding costing – water as a product does not offer great Return on Investment, said Sharma. Installation was an issue too, because this being a sector that has seen little change in decades, authorities would be turned off if it took more than even 15 minutes, he said. A typical Engineering-graduate problem also came their way – they were too focused on product and needed to shift focus from R&D to business development, or the company would never see the light of day. It helped, therefore, that on inception they were taken on by thinQbate, a Mumbai-based start-up incubator. thinQbate typically invests Rs 15 lakh in exchange for a 5-12 percent equity stake in the ventures it backs, and Faclon Labs, like their other ventures, currently works out of thinQbate premises.

A recent seed-funding round in January 2018, was led by Vish Sathappan, representing the investment arm of Bennett, Coleman and Co Ltd (The Times Group), and had participation from Neev Angel Advisors and LetsVenture. Despite the seed amount being undisclosed, the funding has certainly served as a shot in the arm for the company, both in terms of being able to scale up product development and commercialisation efforts, but also in an upturn of the mood surrounding its prospects.

Where does Faclon Labs look to now for their big break, and their opportunity to create a real social impact? Indian cities might be giving us the answers themselves. Lack of maintenance of existing infrastructure, and inefficient water allocation strategies in Urban areas cause staggering losses of almost 40 per cent. Parameswaran Iyer, Secretary, Ministry of Drinking Water and Sanitation, in a recent opinion piece strongly recommended a decentralised, but integrated water resource management and service delivery, with a key focus on water conservation, source sustainability, storage and reuse wherever possible, by involving the communities themselves. The availability of reliable and current data could only help manifold, this aim to reform our management of a lifegiving resource.

Technology driving India's policy measures

Scarcely a month ago, the new government announced the establishment of the 'Jal Shakti Mantralaya', a bold integration of the erstwhile Ministry of Water Resources, River Development and Ganga Rejuvenation with the former Ministry of Drinking Water and Sanitation. The result is the formation of a single new ministry focused on water, and this is a step to be lauded. The ministry has announced an ambitious plan to provide piped water connections to every household in India by 2024. This is a huge infrastructural move, involving laying massive new pipeline networks, having to deal with many times more wastewater, as well as a potential compounding of current problems like rapid depletion of groundwater, deterioration of local water bodies and leakage losses. Researchers at the Centre of Science and Environment, a public research and advocacy organisation in Delhi, think that the enormous carbon footprint generated, as well as the preference for land and infrastructure over water and community interests, mean that this is a bad move.

There is certainly a multitude of highly volatile factors to consider in developing a sustainable, large-scale water solution for India and Indian cities. But equally encouraging is that the establishment of such an initiative posits the possibility of integrating pioneering technology like this, to make our water distribution systems more sophisticated and efficient than any currently seen in the world. India has always been a country with unique challenges, and tackling them requires looking at a scale, efficiency and optimal utilisation of resources unlike anywhere else. Necessity is the mother of invention, and our 'crisis' is here, literally and figuratively. But our every step and plan from here on out will be accompanied by the constant drip-drip of the tap in the background.
Time, like water, is running out.


Via pixabay.com

THE DECAYING NUCLEAR DREAM


Via pexels.com

As this article is being written, it is estimated that around 3.22% of the total energy consumed by the act of writing this article, comes from India's Nuclear power reserves. Nuclear energy, in a controlled form first made its debut as an energy alternative on December 2, 1942, when the research reactor known as Chicago Pile-1 achieved self-sustaining power. Today, about 10% of global electricity generation is accounted for by Nuclear Energy, which becomes a healthy 20% when one only looks at the United States' power usage.

The Indian Nuclear Dream - Numbers falling short?

India's nuclear power sector was coddled by the government because it served the dual purpose of providing the capacity to produce nuclear weapons and also the promise of limitless sources of energy. This was premised on Homi Bhabha's three-stage plan that involves making fast breeder reactor (FBR) to use plutonium reprocessed from the spent fuel from the first stage PWHR plants.

Stage 2 FBRs will use a mixed oxide fuel to produce more plutonium than they consume.
In Stage 3, thorium would be used to blanket the reactor to yield Uranium 233 for the third-stage reactor, which can be refuelled by abundant natural thorium after its initial fuel charge.
Nuclear energy received the bulk of the government's research and development (R&D) funding during the 1950-1970 period. It got around 15 per cent in the 1990s, at a time when the Indian Space Research Organisation (ISRO) got 20 per cent and renewables got less than one per cent. Even then, Nuclear power is only the fifth-largest source of electricity in India after coal, gas, hydroelectricity and wind power. By 2020, India's installed nuclear power generation capacity was expected to increase to 20 GW. But the 2020 capacity will not exceed 7 GW, as the 2018 operating capacity is 6.2 GW, and only one more reactor is expected online before 2020. Nuclear power produced a total of 35 TWh and supplied 3.22% of Indian electricity in 2017. The country was promised a 10,000 MWe capacity by the year 2000, but even now it has only touched 7,000 MWe. After the Indo-US nuclear deal in 2008, there was talk of boosting nuclear energy to 63,000 MWe by 2032. But in 2011, following the blow-back from the nuclear liability legislation, this was scaled down to 14,600 MWe by 2020 and 27,500 by 2032.

Costs of establishing a Nuclear energy-based industry is high too. In the dawn of the nuclear era, the cost was expected to be one of the technology's advantages, not one of its drawbacks. The first chairman of the Atomic Energy Commission, Lewis Strauss, predicted in a 1954 speech that nuclear power would someday make electricity "too cheap to meter."
Half a century later, we have learned that nuclear power is, instead, too expensive to finance.
The first generation of nuclear power plants proved so costly to build that half of them were abandoned during construction. Those that were completed saw huge cost overruns, which were passed on to utility customers in the form of rate increases. By 1985, Forbes had labeled U.S. nuclear power "the largest managerial disaster in business history."

The industry has failed to prove that things will be different this time around: soaring, uncertain costs continue to plague nuclear power in the 21st century. Between 2002 and 2008, for example, cost estimates for new nuclear plant construction rose from between $2 billion and $4 billion per unit to $9 billion per unit, according to a 2009 UCS report, while experience with new construction in Europe has seen costs continue to soar.

Nuclear power - A policy challenge or a safety issue?

In 2010, the controversial Nuclear Liability Act was passed in both houses of the parliament after facing severe criticism from the opposition. The Act aims to provide a civil liability for nuclear damage and prompt compensation to the victims of a nuclear incident through a no-fault liability to the operator, the appointment of Claims Commissioner, the establishment of Nuclear Damage Claims Commission and for matters connected therewith or incidental thereto. This was one of the last steps needed to activate the 2008 Indo-U.S. civilian nuclear agreement as the US nuclear reactor manufacturing companies required the liability bill to get insurance in their home state. The government had encountered fierce opposition when trying to push this bill through parliament on several occasions. This is because it contains several controversial clauses that the opposition parties claimed to be 'unconstitutional'. The opposition believed the bill was being pushed through due to US pressure though this was denied by the government.

The most primary point of opposition to this act was the amendment it made to the Atomic Energy Act of 1962, allowing private investment in the Indian Nuclear Programme. India, being a country that still retains some socialist and bureaucratic norms in spite of being a liberal economy, this was a problem. Handing over the responsibility of such a large country's nuclear programme over to foreign corporations meant less accountability on the part of the corporation in case of a disaster. On 2nd December 1984, a gas leak incident at the Union Carbide India Limited's Pesticide Plant in Bhopal took at least 3800 lives, and several more were claimed to be dead. UCC being a US company is another point of hesitation for Indians to allow foreign, especially US intervention in the Indian Civil Nuclear programme. In a country as densely populated as India, losses both in terms of property and lives would be a thousandfold compared to the 2011 Fukushima Disaster in Japan.

The question that pops up here is: Is this foreign intervention a diplomatic luxury, or an R&D necessity that'd help India bridge the gap it itself can't.

India is still in its nascent Stage-I of its 3 Stage Nuclear Plan. Its long term goal is to develop an advanced heavy-water thorium cycle which does not seem to be happening anywhere in the near future, given the track record of Nuclear R&D in India. The department of atomic energy (DAE) could not scale up the 220 MWe Canadian reactors it had got in the 1960s to 700 MWe. We have just about managed to start a 1000 MWe reactor in Andhra Pradesh's Kakrapar in 2018 while the world norm for power reactors is 1,000-1,500 MWe. India still uses Pressurised Heavy Water Reactors (PHWRs) which are costly and technologically behind the cheaper LWRs (Light Water Reactors). At the same time, LWRs imported from other nations are far costlier than the ineffective PHWRs. All of this points towards India's stuck up position - it can't fully embrace indigenous development of nuclear power yet, due to lack of technology and failure to meet safety standards, and it also can't fulfil its energy requirements from other countries - either due to outdated and out of place policies, lesser

Via pixabay.com

disposable finances, bureaucratic norms and public sector monopoly. In a letter dated 27 June 1961, Nehru expressed his annoyance at the criticism of India's economy as "post office socialism". The phrase was coined by Galbraith, a renowned economist who also served as the US ambassador to India, whose definition of India's public sector enterprises as firms which "operated at no profit, hopefully, no loss, with no particular efficiency and with no clear purpose in mind" fits NPCIL almost perfectly. Decades later, the burden of a public sector monopoly in atomic power is certainly obvious.

The Three-Stage Nuclear Programme and the case of Thorium

In the now-famous 'three-stage nuclear programme', first coined by legendary physicist Homi J. Bhabha, the roadmap laid out what needs to be done to eventually use the country's almost inexhaustible Thorium resources. The first stage would see the creation of a fleet of 'pressurised heavy water reactors', which use scarce Uranium to produce some Plutonium. The second stage would see the setting up of several 'fast breeder reactors' (FBRs). These FBRs would use a mixture of Plutonium and the reprocessed 'spent Uranium from the first stage, to produce energy and more Plutonium (hence 'breeder'), because the Uranium would transmute into Plutonium. Alongside, the reactors would convert some of the Thorium into Uranium-233, which can also be used to produce energy. After 3-4 decades of operation, the FBRs would have produced enough Plutonium for use in the 'third stage'. In this stage, Uranium-233 would be used in specially-designed reactors to produce energy and convert more Thorium into Uranium-233—you can keep adding Thorium endlessly.

Seventy years down the line, India is still stuck in the first stage. For the second stage, you need the fast breeder reactors. A Prototype Fast Breeder Reactor (PFBR) of 500 MW capacity, construction of which began way back in 2004, is yet to come on stream.

The problem is apparently nervousness about handling liquid Sodium, used as a coolant. If Sodium comes in contact with water it will explode, and the PFBR is being built on the humid coast of Tamil Nadu. The PFBR has always been a project that would go on stream "next year". The PFBR has

to come online, then more FBRs would need to be built, they should then operate for 30-40 years, and only then would begin the coveted 'Thorium cycle'! Nor is much capacity coming under the current, 'first stage'.

Conclusion:

In contrast to nuclear power, India has usually exceeded its targets, at far lesser investment, in the area of renewable energy. The country's installed wind-power capacity is 34,000 MW, hydropower 44,000 MW and solar power 25,000 MW, with a target of 100,000 MW by 2022. Wind and solar power have not been provided with the kind of investment that has been made in nuclear energy. Around the world, nuclear energy has taken a back seat because of the risks that reactors bring with them. Three Mile Island, Chernobyl and Fukushima have dampened the ardour of the developed world. The US, which has over 100,000 MWe capacity, stopped issuing licences for nuclear plants between 1979 and 2012. Even now, just two are under construction, while 34 have been shut down.

The global slowdown in the Civil Nuclear Race has its roots in the Chernobyl and Fukushima disasters, following which several power plants in Germany and France were either shut down or had their output capacities reduced. Even though in itself Nuclear energy is a clean form of energy, the entire industrial process, also known as the "Nuclear Cycle" starting from its mining till the moment the reactor is started, is very precarious. These kinds of hazards ask for better prevention systems, which further increases the already high costs of establishing a nuclear power plant. In the Indian context, due to lesser available funds, more opposition both politically and by social groups residing around power plant facilities and more restrictive policies mean that it'll be a long time before India finally enters Stage II of its Three-Stage Plan. Till either the tangle of bureaucracy or the technological backwardness starts receding, we cannot expect to make Nuclear power a sustainable energy alternative.


Via pixabay.com

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GOING SOLAR-GOING TOWARDS THE RIGHT FUTURE

Via pixabay.com

Keeping in mind the huge negative environmental externalities caused by electricity generation from conventional sources of energy like fossil fuels, shifting to cleaner renewable sources of energy is the need of the hour.

As Gawdat Bahgat says in 'Alternative Energy in the Middle-East', " The use of alternative energy is inevitable as fossil fuels are finite". In particular, India's fossil fuel consumption has risen at an alarming rate, from 1 MWh per capita in 1965 to 5.5 MWh per capita in 2015. This being the case, the day when we finally run out of these non-renewable sources of energy does not seem to be too far off. Also, the visible damage caused to the environment by our indiscriminate consumption of fossil fuels can no longer be ignored. Every year human activity dumps roughly 8 billion metric tonnes of carbon into the atmosphere, 6.5 billion tonnes from fossil fuels and 1.5 billion from deforestation. In addition, the poor quality of Indian coal with its high ash content (40%) has highly deteriorating environmental effects. Hence, it is only natural that India has been making efforts to increase its total grid-connected renewable power generation capacity. Geographically, India is an ideal country for solar energy. We get 300 days of sunshine, our peak power demand is in the evening and not during daytime (driven by cooling requirements), and we have a seasonal peak in the summer. The fact that solar energy is renewable or unlimited, environment-friendly and has low operating costs makes it a great alternative to fossil fuels. Having understood the immense future potential of solar energy, India has been making great strides in the field of solar power production and consumption.

How to go solar?

The technology which directly converts solar energy into electrical energy is called a solar photovoltaic cell. When radiation falls on a photovoltaic cell it absorbs the light depending on the bandgap of the cell, this absorbed photon creates electron-hole pair which flows into the external circuit and hence generates the electric current. The amount of electrical energy generated depends on internal quantum efficiency and external quantum efficiency.

The first efficiency is the conversion of incident photons into the number of electron-hole pair while the second efficiency is indicating how

many numbers of electrons excited from the semiconductor after being generated. The overall efficiency of the photovoltaic cell varies widely depending on the type.

There are two types of system configuration for solar photovoltaic namely Grid-tied and Stand Alone photovoltaic system, each one of them having its own pros and cons as well as applications. In a Grid-tied photovoltaic system, light falls on a solar panel and is converted to DC power. This is fed to an inverter which converts this DC to AC power which will be matching phase, frequency and voltage as that of the grid. Off-grid or Stand-alone photovoltaic system includes the storage of the power that is generated when the demand is less than what is generated. A component called charge controller is introduced in the system which is managing the charging process of the battery by regulating the electric current that is being generated by the solar panels. The working of the charge controller is divided into three modes: First is when the power generated is completely utilized by the AC load, the charge controller does not charge the battery and supplies direct power to the inverter which is then consumed by the loads. Second is when the AC load and DC load is working simultaneously, the charge controller will charge the battery and from there the current is fed to the load. The third is during the night time or no sunlight condition the charged battery is being consumed up to its set low voltage value. Solar thermal power plants or STEs have a huge number of Grid-tied or stand-alone photovoltaic systems to convert solar energy into electricity.

Another new method of harnessing solar energy is Concentrated Photovoltaic Cells or CPVs. It employs sunlight concentrated onto photovoltaic surfaces for the purpose of electrical power production. Solar concentrators of all varieties may be used, and these are often mounted on a solar tracker in order to keep the focal point upon the cell as the sun moves across the sky. CPV plants provide power by focusing solar radiation onto a photovoltaic module, which converts the radiation directly to electricity. There are many technologies available to convert solar radiation into heat and finally to electricity using different energy conversion system. The technologies which convert solar to heat are the parabolic trough, Linear Fresnel, Heliostat tower and Dish Stirling engine.


Via pixabay.com

Parabolic trough technology consists of a curved, mirrored trough which reflects the direct solar radiation onto a glass tube containing a fluid which is heat transfer medium running through the trough length, positioned at the focal line of the reflectors. Single-axis or daily tracking is introduced in this technology so that the heat transfer fluid is continuously heated up during the day-length. The temperature can rise up to 400°C. The hot liquid is passed through a series of heat exchangers to generate steam and drive a turbine.

Heliostat tower is formed by a field of heliostat which is a plane mirror spread over a large area such that they reflect the radiation at a central receiver where a heat transfer medium or heat storage medium is circulated. This medium achieves a temperature of 600°C. This fluid is again used to generate steam which rotates the turbine and hence generates power.

Linear Fresnel technology consists of long flat reflectors which are reflecting radiation on one or more pipes containing heat transfer medium which has the same working as previous technologies. The main advantage of this technology is cost and space utilization being minimum; while the thermal storage technology for linear Fresnel is still under development.

Dish Stirling engine comprises a dish-shaped concentrator (like a satellite dish) that reflects solar radiation onto a receiver mounted at the focal point. The receiver is a Stirling engine coupled with a generator. Dish systems are said to be more suitable for standalone, small power systems due to their modularity. However, such small power dishes can be installed in DNI rich area to obtain enough generation.

While the promise is large, there are some limitations

Solar energy has a number of advantages in India, the most important being that it is a renewable and hence unlimited source of energy. It is environment-friendly and does not release greenhouse gases into the atmosphere like fossil fuels. Solar panels have low operating costs and can be installed anywhere. It has diverse applications like heating, drying, cooking or electricity which is suitable for rural parts of the country. It does have its fair share of limitations as well, such as the fact that it cannot be generated at night. Also, it is weather- dependent and hence a less reliable solution. Solar panels also require inverters and storage batteries to convert direct electricity to alternating electricity so as to generate electricity. While installing a solar panel is quite cheap, installing other equipment becomes expensive. The land space required to install a solar plant with the solar panel is quite large and that land space remains occupied for many years altogether and cannot be used for other purposes. Energy production is quite low compared to other forms of energy. Solar panels require considerable maintenance as they are fragile and can be easily damaged. So extra expenses are incurred as additional insurance costs.

India's solar policy - a step ahead

A number of acts, policies and targets have been proposed for increasing solar power production in India. The National Action Plan on Climate Change (NAPCC) in June 2008 identified the development of solar energy technologies in the country to be pursued as a National Mission. India is ready to launch its Solar Mission under the National Action Plan on Climate Change, with plans to generate 1000 MW of power by 2013. A complete package has been proposed to propel the power sector into 'solar reforms' that could lead to an annual production of 20,000 MW by 2020 if phase 1 of the solar mission goes well. In November 2009, the Government of India approved the "Jawaharlal Nehru National Solar Mission" (JNNSM). The Mission aims at the development and deployment of solar energy technologies in the country to achieve parity with grid power tariff by 2022. There are several electricity policies in the last few years that have talked about the need and priority to promote renewable energy. Foremost amongst them is the Electricity Act (2003) which de-licensed stand-alone generation and distribution systems in rural areas [18,19]. The National Rural Electrification Policy, 2005 [20] and National Rural Electrification Policy, 2006 also stress the need for urgent electrification [21]. The New Tariff Policy (2006) stated that a minimum percentage of energy, as specified by the Regulatory Commission, is to be purchased from such sources.

However, India still has a number of problems to overcome in order to reach its target in solar

power production. The policy currently is purely for industrial rooftop projects. They do not have considerable benefits for a residential rooftop. State electricity utilities and distribution companies across India aren't supportive as it could hurt their finances. As more and more commercial and industrial users, who bring the maximum revenues to state discoms take to solar power, the revenues of electricity generators and distributors would fall. The government is yet to come out with uniform policies around net metering that allows users to sell surplus power to electric utilities.

India - the cheapest solar energy producer

India is now the forerunner in producing solar power at the lowest cost globally and is far ahead of other nations in low average production costs, a report said. Beating countries like China, which usually is the cheapest manufacturer of everything, India has also left behind the US, UK, Canada and France among others. While the global average of installing utility-scale solar PV projects was $1210 for a kilowatt, the same was found to be as low as $793/kW in India in 2018, the report by the International Renewable Energy Agency (IRENA) said. India's neighbour China also saw very competitive installation costs of $879/kW compared to the highest rate of $2,427 per kW in Canada. Among European countries, Italy saw very competitive installation costs for 2018 at $870/kW. In recent years, the growth of solar energy in emerging markets has been phenomenal. India has already overtaken the US and has become the second-largest solar power market in the world (in terms of solar power installations). The country currently stands with ~25 GW of grid-connected solar power capacity as compared to 9 GW in 2015. Large scale solar installations in India account for 87 per cent solar capacity while rooftop sector is all set to pick up. Last year, solar accounted for nearly 53 per cent of new energy capacity additions in the country.

Conclusion

Given the current rates of global warming and the alarming rate at which our environment is deteriorating, adopting cleaner sources of energy like solar energy as a large-scale power production method is imperative. Besides the environmental benefits it will bring, solar energy development in India can spur regional economic development. India's solar market could be worth billions of dollars over the next decade - India's solar potential is real enough, and the support environment is improving fast enough, to forecast a $6 billion to $7 billion capital-equipment market and close to $4 billion in annual revenues for grid-connected solar generators over the next decade. The secure electric supply it will provide can help to foster domestic industrial development. To conclude with the words of Bjork, "Solar power, wind power, the way forward is to collaborate with nature -- it's the only way we are going to get to the other end of the 21st century."


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IS INDIA ELECTRIC ENOUGH FOR THE NEXT DECADE?

Last month, the government's think tank, Niti Aayog proposed a plan to shift entirely to electric vehicles by 2030. This may seem too ambitious a goal, particularly if we consider other countries like China and Norway diluting their targets to 2040 at least. However, the cabinet was quick to realise that the aim is far beyond what seems possible right now and thereafter shifted to a more realistic 30% electric vehicle goal until 2030. A pushback by the industry and the fear of job losses were amongst the reasons the government chose to tone down the targets.

Nonetheless, the Modi government has been quite bold in its policies regarding electric vehicles, with the latest FAME-2 scheme very encouraging for electric vehicle manufacturers. Investments have doubled to $1.4 billion under the new scheme, which is significant. These include incentives for electric buses, three and four-wheelers used for commercial purposes. Also, a part of this amount will be invested in charging stations. Furthermore, Shifting to electric is essential for India, given that 15 of the 20 most polluted cities are in India. And with promising schemes like the FAME-2, the Indian auto segment is ready for an electric mobility revolution, or is it?

The Resistance to the EV revolution

The challenges to such a shift are huge and diverse. One of the major reasons electric vehicles still haven't really taken off as expected is the premium price over the conventional Internal Combustion Vehicles. Add to that an inconsistent battery ecosystem with no standardisation and things don't look too good. In order to reduce costs, it's imperative that most electric vehicles are manufactured in India itself which will also help boost the country's economy. However, scarcity of skilled engineers in this field and a steep learning curve are big barriers to overcome.

"The technology within electric vehicles changes every six months. Auto manufacturers are used to doing 1-2% improvement on internal combustion [IC-engine] units year-on-year. But EV tech has to be understood and built from scratch. It's very challenging for a workforce that hasn't been exposed to this tech before because 60% of the electric powertrain is different from an IC-engine" says Chetan Maini, creator of the first Indian electric car, REVA, which he sold to Mahindra in 1999.

In the global scenario, collaborations between the industry and academia have resulted in significant talent output in the EV sector. Such collaborations are virtually non-existent in India. Indian institutions like the IITs are putting efforts to collaborate with industry and push for electric vehicle research and coursework in the college level itself to avoid a talent draught.

The Battery Dilemma

Another major area of concern is Battery tech. At the moment, the vast majority of Electric Vehicles use lithium-ion batteries which tend to be expensive. Generally, a battery accounts for almost half the price of the car, resulting in an unrealistically priced car, making Electric Vehicles a luxury product rather than the common man's car of choice. While Lithium prices have dropped more than 80% since 2010, with no reserves on its own, Indian OEMs have to depend on expensive Lithium imports. Finding an alternative to Lithium will be a breakthrough in the Indian EV industry. However, it is still an area of research around the world and depending on it entirely is not an option.

There are also technological and logistical issues regarding the charging infrastructure. The tech, in itself, is an active area of research with rapid developments. There are broadly 2 approaches to this battery charging dilemma. The first is using swapping batteries station, wherein people come to a station and get their drained battery swapped with a charged battery. The second option is the more conventional charging station, on similar lines as a petrol pump, but the only one which consumes lot more time charging a car with significantly lesser range. Even in a relatively mature market such as the United States, charging stations are still not systematised. The voltage at which cars can be charged can be 110 V or 240 V A/C but off late, the direct current has come into picture thanks to its fast-charging benefits. A shift to 60 V or 48 V direct current charging system could be a dramatic development which would transform the electric vehicle industry making it much more practical. However, technological and financial hurdles are formidable. Since the DC charging infrastructure requires significantly higher powers from the grid,

the expenses run considerably higher than the more conventional AC charging system. Also, as charging voltages increase substantially, thermal issues are also a concern. Therefore, the AC charging system has been more popular in the city, especially in places like parking spots, thanks to the low installation costs and long charging time.

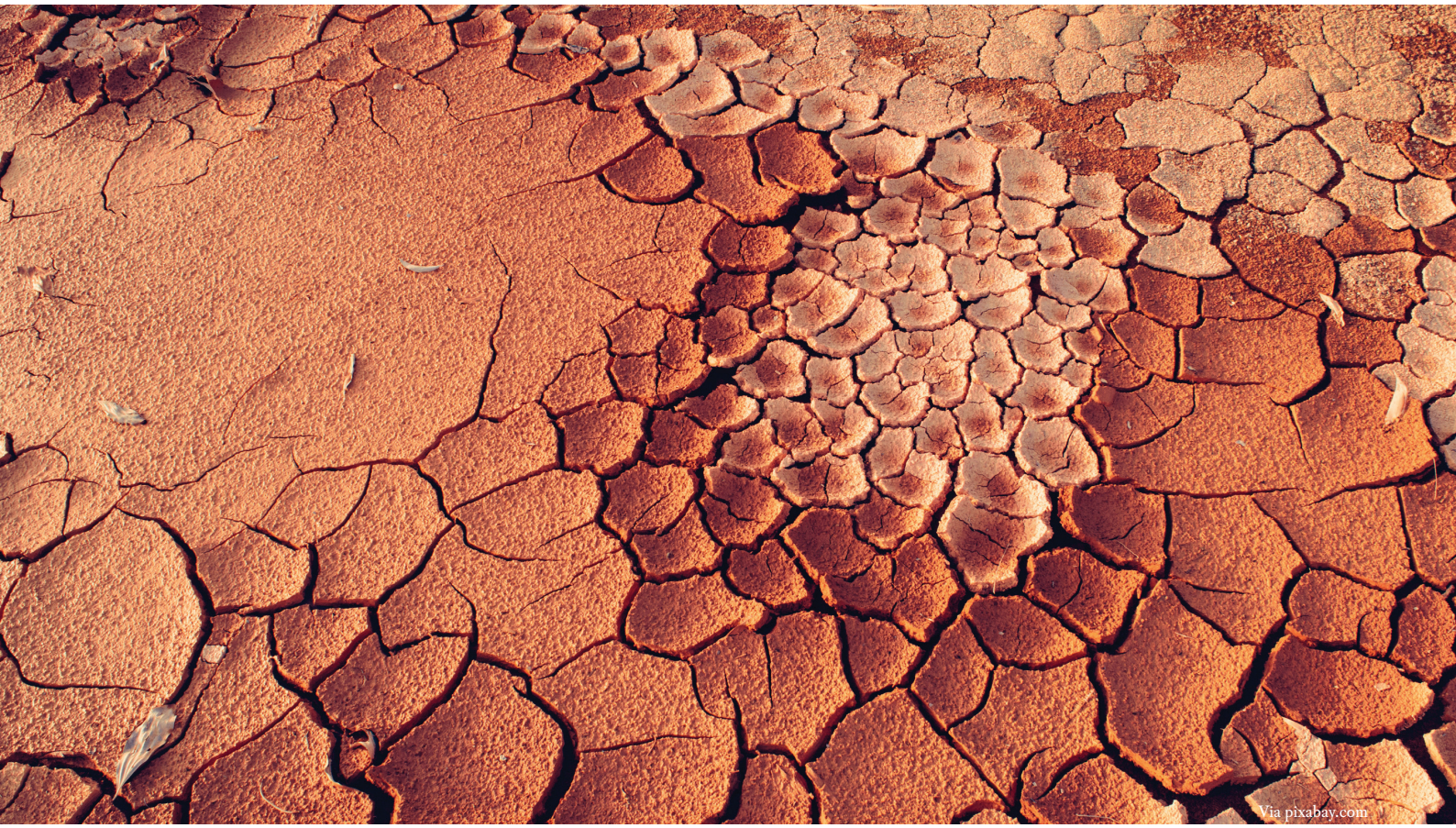
How will India Inc. respond?

Despite such monumental challenges, Indian OEMs are defiant in their attempt to make the auto sector greener. Tata Motors and Mahindra have reportedly been working on electric vehicle in-house to go up against the likes of Nissan, Hyundai and hopefully, Tesla. Maruti Suzuki, a company which owns a substantial market share in the Indian car industry hasn't made a move up until now but are reported to be working on bringing an electric vehicle as soon as late 2019.

The government has also decided to focus more on two and three-wheelers which have significantly higher market share than passenger cars. In the last financial year itself, the number of two-wheelers alone was more than 5 times the number of cars sold. The newest proposal by the government, therefore, aims to only allow the sale of electric two and three-wheelers by 2025. While the industry has responded positively to these slightly relaxed albeit encouraging schemes for the electric mobility industry, the lack of charging infrastructure is a serious handicap for the EV industry as of now.

On the positive side, the current situation is the perfect motivation for us to become a manufacturing superpower, and a leader in the small electric vehicle category, thanks to India's unique market demands. India is currently the world's biggest market for two-wheelers with more than 20 million units sold every year. The current push for electric vehicles from the government could disrupt the two-wheeler market and the Indian EV industry at large. Start-ups and companies like Ather Energy and Hero Motocorp have already come up with some interesting products and are emphasising on research in the EV category. Nirmala Sitaraman, the current finance minister, said in her budget speech that the government also envisions a "Detroit of electric vehicles" to be set-up in India. Investment of talent and research labs will lead to a better ecosystem, one which is conducive for the upcoming revolution. Will the industry stall in absence of talent draught or negative market response? Or will India succeed in its approach to become the global leader in electric vehicles?

Via pixabay.com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SCALABLE WATER ACCESS IN RURAL INDIA


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This summer I had the incredible opportunity to work with the Tata Trusts and their Tata Water Mission (TWM) initiative, exploring avenues to provide scalable water access to stakeholders in rural communities. TWM is one of the Trusts' flagship initiatives in India, at the forefront of ensuring Water Access, Sanitation and Health through multiple programs across the nation. I had the privilege of working with Mr Divyang Waghela, National Head and Mr Rajat Pati, Area Manager, North-East and a host of partner organizations across multiple project sites in Assam. I had been looking to spend my summer doing something that was meaningful, challenging and exciting and as I pondered on a suitable endeavour, Madhav Datt, friend, senior at IIT Kgp and part-time senpai suggested I take a look at the development sector. Madhav's initiatives in this area with his NGO, Green the Gene had for some time captured my imagination.

Green the Gene is an entirely youth-run organization, pioneering extremely low-cost technology and data-driven solutions to help local communities in acute and immediate environmental crises across the world. I set off to look for someone who would want a bright-eyed undergrad on their team, and with Mr Waghela happening to be just that person, a few weeks later I found myself bunking down with a rural community two hours out of Guwahati. The experience I had this summer was eye-opening in so many ways. It allowed me to appreciate the sheer scale of the water crisis this nation is facing and the battle that TWM and organizations like it are fighting every single day. It also taught me that context-specific solutions are critical, that there is a need to engage stakeholders at multiple levels and that young people are among the biggest assets in the fight to provide clean water to every individual.

The importance of context-specific solutions became increasingly clear as I spent more time on the ground in Assam. The topography, climate and hydro-geological composition of Assam varies quite significantly throughout the state. When I arrived at my first project site in Nalbari, some two hours out of Guwahati, I found it to be humid, hot and extremely wet. It appeared to rain here a good half the year and the whole district was full of sources of static surface water, like lakes and ponds. One could almost start to wonder what sort of water crisis could possibly affect this area. Unfortunately, despite an apparent abundance of water, the one source that was used at scale by the vast majority of the community, groundwater, might as well have been poison with extremely high concentrations of Iron and Arsenic, over 10X the WHO mandated limit, contaminating the groundwater reserves in some villages.

Tata Water Mission was partnering with Gramya Vikash Mancha (GVM), the NGO I was embedded within Nalbari, and Drinkwell Technologies to implement and maintain a few Water ATMs in the district which provided clean drinking water to hundreds of households. Prior to the implementation of these automated filtration and supply systems, communities had been ravaged by chronic gastrointestinal illness and cases of cancer caused by mineral pollution of the water.

An account:

While the Water ATMs provided a steady and reliable supply of drinking water, it became quickly

apparent that the severity of the pollution in the water table necessitated alternate solutions. The ATMs hit bottlenecks with maintenance issues and limited supply capacity due to the extreme stress that was placed on the filtration systems. For long term sustainability, contamination-free sources of water had to be identified, mapped and solutions had to be built around them to serve the community. I spent several weeks in Nalbari, trying to better understand this situation and do something about it. Madhav's work with Green the Gene in developing water purification technology for rural Africa had inspired me to head to Assam. It also gave me a solid insight into how to approach solution building in a rural environment, leading me to believe, that while best practices, manuals and handbooks provided a solid understanding into the technical challenges, the actual solution would come from within the community.

As such, I would cycle several kilometres every day, through the beautiful bucolic landscape, to a nearby village of about 1500 people, Kothora, that was the project site for the first Water ATM. I spent a lot of time with the community to hear out their grievances and their opinions on feasible solutions. People complained about long lines, travel distances and the significant amount of time spent obtaining water from Water ATM. With most of the village engaged in service and not agriculture, losing an hour a day made a direct impact on that day's wages and as such proved to be a major inconvenience. Sit downs with village administrators such as the Headman and the Panchayat President highlighted the possible opportunity in utilizing surface water from ponds and lakes that were abundant. Working with the community, I was able to map the water resources in the village, estimate capacity and prepare a plan for a community-scale water filtration system utilizing water from the large ponds in the village. The system has the potential to eliminate 6.5 Lakhs Person Kilometers and 1.3 Lakh Person Hours spent annually on collecting potable water. It also reduces the cost for both the NGOs and the stakeholders by nearly 50%. The sheer potential took everyone by surprise in that only about 15% of the water in a single large pond was capable of providing uninterrupted annual water supply to the entire village.

At Tezpur District, in North East Assam, near the Arunachal Pradesh border, the situation was a lot different. Located at the foothills of the Eastern Himalayas, this was a region with lesser rainfall, a distinct lack of lakes and ponds and whose rocky terrain made it very challenging to sink wells to tap groundwater. Groundwater Iron contamination had once again been identified as a major problem. The households there had no access to electricity or clean drinking water supply. Residents drank water from fetid streams and small pools of water in the surrounding marshy area. Households had no firm habits in terms of boiling water or even performing rudimentary filtering it prior to consumption and as such water-borne stomach illness was rampant in the community with multiple episodes of illness every year. It was absolutely urgent that a simple, energy independent and scalable solution should be implemented in this region as soon as possible.

In Tezpur, I worked for a couple of weeks with another one of the Trusts' partner organizations, Balipara Foundation and another regional NGO, Mahila Shakti Kendra (MASK). It was with Mr Dhruba Das from MASK that I biked almost 150km a day to visit several village clusters across the district, to listen to grievances and look for possible solutions. We focused on the Bogijuli Forest Village Cluster, a region with around 500 households some 30km from Tezpur. It quickly became apparent that the entire region was crossed by a network of streams and rivulets originating from springs in the foothills. The villagers had additionally diverted these streams to help irrigate their crops. Accompanied by enthusiastic members of the local community we set out to chart and map these streams, following them into the hills as far as we could go. We were able to measure the flow rate, gauge capacities and conduct multiple interviews with community leaders and village elders to gain local knowledge on seasonal flow variations and weather patterns. I also leveraged the wealth of experience the Trust had gained by piloting initiatives across the country to identify an electricity independent filtration system that would work in this context. Having obtained the required information, I was able to design a system that sources water from the running water channels crisscrossing the area to provide scalable water access to this district.

As with Nalbari, the potential was massive. Less

than 1% of the annual stream water potential in the region was sufficient to provide for the community. Both of these solutions leveraged the natural environment and opportunities presented therein. They were also cost-effective when benchmarked against other projects that had been executed. A sensible co-financing structure set up between the community and the NGOs, implemented as an EMI payment scheme by the stakeholders, could fund the projects and sustain them over time at a very nominal cost to both the stakeholders and their NGO partners.

Cohesive groups a way ahead

Engaging stakeholders at multiple levels is crucial to the success of any intervention, even more so in an environment that has not been exposed to any such prior intervention. In Nalbari this was quite visible in how the Trust had built its local network. It has partnered with committed local organizations with the motivation and capability to deliver scalable impact, provided them with funding, technology and best practices and then let that percolate into the community down to the individual level. The Water ATM in Nalbari was community managed and maintained, with support from GVM. GVM is a well-established and trusted entity in the local community and has a proven history of delivering scalable impact.

In Tezpur, the aim is to build similar connections with the communities. The Trust has very strong partners in the Balipara Foundation which has since 2007 carried out experiments in ecological protection and the rapid restoration of the Eastern Himalayan Region through the concept of NaturenomicsTM. The foundation is very well established, has a large footprint and dedicated team of individuals working across various domains. Mahila Shakti Kendra, the organization at the forefront of initiatives in Tezpur, is another well-established community pillar. Local stakeholders will be critical to the project implementation in Tezpur. Diversions will have to be dug, streams will have to be tapped and all of this requires the local knowledge and assistance of the community. NGOs are increasingly looking at long term solutions to be community-owned and managed after an initial support period. In the long run, this ensures the feasibility of such projects and builds self-sufficiency within the community. Additionally, it is extremely important to build solutions that are aligned with the local context and aligned with the needs and requirements of the local stakeholders.

The war has just begun

My foray into the Development Sector taught me a lot about how solutions are to be designed and implemented and also showcased the sheer humanity involved in the stellar work that organizations like the Tata Trusts carry out. Looking at the dry, cracked soil across large parts of the country, falling water tables and delayed monsoons, one is reminded of the severity of the problem and the monumental task at hand. However, having spent the summer with some of the most dedicated and talented individuals and organizations working to make access to clean water a reality, I am convinced that the fight is far from over.

Via pixabay.com

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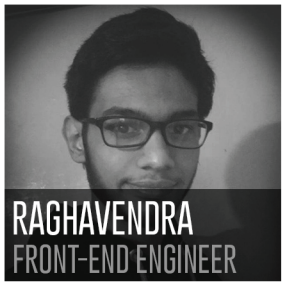
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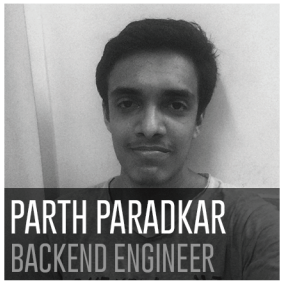
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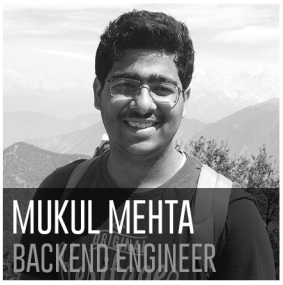
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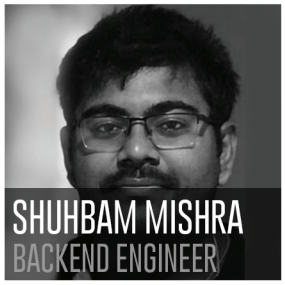
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