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Experimenting with Energyscapes: Growing up with Solar and Wind in Auroville and Beyond

The path to sustainable energy systems is never singular. Energy transitions are inherently experimental, requiring flexibility and recognition of the limits of site and scale. For Auroville in South India, overcoming limitations on the scale of renewable energy required moving development off-site and involved local, regional, and even national policy shifts. Such transformation includes not only technological novelty, but also new ways of thinking about what is possible. Each community, each nation, must take stock of its own resources, values, and opportunities to make effective choices for foreseeable futures that are, themselves, moving targets. The notion that such energy systems, whether at the household level or on a wider scale, would be developed once and then left alone is also unrealistic; instead, we must understand that living communities will grow and change, just as their technologies, resources, and systems must.

"The City the Earth Needs": Auroville, Sustainability, and the Anthropocene

Auroville, "the city the earth needs," is an intentional community founded in 1968. From a few dozen members at the start, the Auroville community grew to 2,700 members in 2017, representing 53 nationalities.[1] Auroville's energyscape (pace Appadurai)[2] transformed along with the landscape. The notion of energyscapes allows us to consider "the problem of energy in motion across social and physical spaces, shifting its cultural, social, economic, and technological values as it flows from one domain to the next."[3] The energyscape of the Auroville bioregion (encompassing parts of the state of Tamil Nadu as well as the Union Territory of Pondicherry) is significant because it illuminates critical aspects of energy production and distribution in relation not only to scale, but also to siting and context. All energy is not equal, and access to (or impacts

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1   "Census September 2018—Auroville Population," Auroville: The City of Dawn, last updated 7 September 2018, http://www.auroville.org/contents/3329.
2   Arjun Appadurai, *The Future as Cultural Fact: Essays on the Global Condition* (London: Verso, 2013).
3   Sarah Strauss, Stephanie Rupp, and Thomas Love, eds. *Cultures of Energy: Power, Practices, Technologies* (Walnut Creek, CA: Left Coast Press, 2013), 11.

from) the same resources can vary widely depending on location and interaction with other resources or activities.[4]

In Auroville, new generations of solar and wind technologies emerged as the trees grew and began to shade the original installations. This required new towers to be built, and connections between shade and sun, heat and light, energy and opportunity had to be reimagined. Auroville today provides an unusual window into a world where solar and wind power have been used continuously for 50 years. Along the way, Auroville's residents have developed new technologies and energy policies that affect people throughout India. Every phase of solar and wind innovation has been represented in this small community. These gradual transitions across the realm of renewables highlight not only the intersection of technologies—for example, from battery storage to grid-tied solar electric systems—but also a shift from basic subsistence to the panoply of consumer luxuries that abundant electrical power allows.

Auroville's experiences in navigating such complex and ever-changing cultural and sociotechnical terrain provide both templates and cautionary tales for rural and urban transformations across India and the world. The negotiation of power in all of its senses is an ongoing challenge for Auroville: it is a highly contested space, comprising over one hundred enclaves within the community and several villages at the margins. The transformation of the Auroville bioregion over the past two hundred years of colonial and postcolonial history is central to the story of Auroville's emergence, as the constraints and opportunities that engaged both the material context and the meanings of this social-ecological system have continued to feed each other. The "capacity to aspire"[5] for both local villagers and newcomer Aurovilians has been shaped by changes in the economic, environmental, and energy landscapes over time, especially with regard to forest and water resources.

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4   Robert McC Netting, *Smallholders, Householders: Farm Families and the Ecology of Intensive, Sustainable Agriculture* (Stanford, CA: Stanford University Press, 2013).
5   Appadurai, *The Future as Cultural Fact*, 187.

The Past: Deforestation in South India

In 1750 a local king hunted for elephants and tigers in the nearby forest, in what would become known as the Auroville bioregion in the twenty-first century. Forests were later cleared to remove the tiger threat. The last two-thousand-year-old neem trees were cut down in the 1950s to build boats. Blanchflower notes that at present, the only surviving forest is in sacred groves around temples.[6] By the 1960s, the Auroville bioregion was a desertified plateau with little agriculture and an impoverished population. Reforestation was a primary initial goal of Auroville's founders. The lack of shade in the searingly hot climate was a key motivator—not just for comfort, but to protect food plants, soil moisture, and water resources. Both food production and reforestation required immediate attention to water management with the specific goal of "net-zero" runoff. Water was trapped and allowed to infiltrate the ground to support crops as well as the regional water table. "Bunds"—dirt ridges built around fields—were built to prevent rainwater runoff and to increase water infiltration and retention. Today, we still see active bunds and infiltration ditches to collect runoff and reduce evaporation, maintaining groundwater at sustainable levels.

Into this Martianesque landscape (Figure 1a), The Mother[7] imagined a central structure that would be a focal point for the new community, and so began the Herculean task of making this part of her dream—what became the Matrimandir—a reality. The Matrimandir is an impressive construction by any standard, standing about 30 meters above the surrounding plains; in Figure 1b you can see it in the distance from the roof of the Auroville Foundation building next to City Hall, itself the site of one of the first grid-tied solar arrays in the state of Tamil Nadu. Begun in 1970, the Matrimandir was completed in 2008. Well before its completion, the Matrimandir's electrical needs were met by what was at the time India's largest photovoltaic array, commissioned in 1997. At the end of the twentieth century, Auroville accounted for about 15 percent of all installed photovoltaics in India. Renewable energy has been crucial to water

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6   In Eliza Kent, *Sacred Groves and Local Gods: Religion and Environmentalism in South India* (Oxford: Oxford University Press, 2013).

7   The Mother is the common name for Sri Aurobindo's soulmate, a French-Lebanese woman named Mira Alfassa, who dreamt of the founding of Auroville in the plains north of Pondicherry, where she and Aurobindo lived and taught in the first part of the twentieth century. According to the Mother, Auroville, the City of Dawn, would "belong to nobody in particular . . . [but] to humanity as a whole." ("The Auroville Charter: A New Vision of Power and Promise for People Choosing Another Way of Life," Auroville: The City of Dawn, last updated 21 November 2018, http://www.auroville.org/contents/1).

management and irrigation from Auroville's early days, in which first wind turbines and later photovoltaics were used to pump water out of wells. Today, some wind but predominantly photovoltaics remain the backbone of water management in Auroville. Photovoltaics power water-well, irrigation, and fountain pumps on the Matrimandir grounds just as they do around much of Auroville.[8]

Auroville's Energyscape

Solar photovoltaics, very expensive in the 1980s and 1990s, were installed on a house-by-house basis in small arrays for pump systems and lighting. Auroville's reforestation efforts could not proceed indefinitely without affecting these installations; the dynamics of this social-ecological system continued to evolve. The shifting landscape, with its deliberate afforestation, gradually impinged upon renewable energy systems. Trees began to block the sun (Figure 2) and likewise the wind, making wind-driven water pumping less viable. More recent photovoltaic installations were placed on new buildings in Auroville, sitting above much of the forest canopy or in sufficiently large clearings. But the changes have been in fits and starts. While the Matrimandir and larger Auroville construction projects have been carefully designed and executed, much of

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8   Sandra Loret, Samuel Martin, and Deoyani Sarkhot, "Sustainable Energy in Auroville: The Vision and the Reality," *Report to the Municipality of Auroville* (Auroville: Technology and Sustainable Development, École Polytechnique Federale de Lausanne, Switzerland, and IIT Madras, India, 2002), http://research. auroville.org/system/papers/attachments/000/000/627/original/Sustainable_Energy_in_Auroville_Sandra_Loret_Samuel_Martin_Deoyani_Sarkhot_2002.pdf.
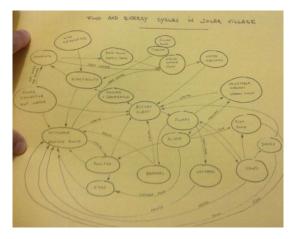
the rest of the community simply "grew up," with shifting residences and residents; changing environmental conditions created by storms or floods; and an assortment of technical problems and misalignments caused by differing timelines for the replacement of system elements (such as solar panels or batteries), or simply by shifting plans and priorities.

Individuals and small enclaves make independent decisions about household- to hamlet-scale options, although they also contribute to decision making at the wider community level. Experimentation is ongoing. Auroville is a complex entity; it is managed by consensus, with a Residents' Assembly and several working groups, and committees for day-to-day affairs and longer-term planning. The governance strategy means that, in theory, every Aurovilian has the ability to affect all decisions made for the group, but in practice only a small number participates in any given action. There are also a variety of enterprises that develop and produce new technologies, as well as think tanks and other organizations that consult with outside entities on a wide vari-

ety of topics, including renewable energy, organic farming, and reforestation. Such enterprises draw on both the prior experiences of Aurovilians and the experiments that they have conducted at Auroville itself. Very little at Auroville is obligated, except a requirement for individuals who would like to become newcomers or residents to adhere to the yoga of Sri Aurobindo and the Dream of the Mother,[9] but these are interpreted quite broadly within the context of understanding that Auroville is meant to be a place "where human relationships, which are normally based almost exclusively on competition and strife, would be replaced by relationships of emulation in doing well, of collaboration and real brotherhood."[10] Many different ways of being in the world, and of problem solving, have thus emerged. One person's vision of a "solar village" might be realized very differently from one enclave to another; down the road, one might find an elite community filled with Bollywood screen royalty or, across the field, a community living in thatched huts in the traditional local style. There is no single Auroville, just a set of ideals inscribed by Aurobindo and The Mother that might support progress toward human unity as they defined it.

Figure 3:
A food and energy flowchart for a proposed solar village in Auroville, 1980. Note that the technology considered viable in the South Indian context at the time was the use of biomass to create biofuels to run a generator for electricity. Photo by Sarah Strauss, with permission from Auroville Archive.

The vision of a self-sufficient community supported by renewable energy has developed over time in Auroville in ways that are closely connected to both available materials and a changing landscape. As an example, Figure 3 shows a flowchart for a proposed "Solar Village" in Auroville. This 1980 concept of a solar village uses solar collectors as a way to heat water. The connection of solar to electricity is indirect, through the medium of biogas. Indeed, the main form of solar energy in this solar village concept is biological photosynthesis—a vegetable garden, banana trees, an orchard—to provide both biomass (food and nonfood) and waste for

9   "Auroville Entry Policy 2017," Auroville: The City of Dawn, last updated 17 December 2018, https://auroville.org/contents/4450.
10   "A Dream: Envisioning an Ideal Society," Auroville: The City of Dawn, last updated 5 November 2018, https://auroville.org/contents/197.

a biogas plant that would supply fuel to run a generator and produce electricity. These systems were seen not just as sustainable, but sustainable in rural South India given the limits of village life, rather than an expensive renewable technology beyond the reach of the majority of the population. Context matters.

Power Intermittency and Energy Storage

Issues of energy storage have come to the forefront of global energy development as intermittent wind and solar energy sources reach a global scale and affect entire electrical grids. But Auroville's relationship with electricity was defined by intermittency long before photovoltaics were installed in relatively large quantities. Grid power was not available for much of each day, giving the advantage to photovoltaics in the minds of many Aurovilians. Grid intermittency led to relatively large local investments in infrastructure and to the widespread development of alternatives regionally, not just in Auroville. The community's municipal planners ("L'Avenir d'Auroville") pursued long-term solutions to grid intermittency that took advantage of new technologies at a different scale. Locally, many people purchased diesel generators to meet their needs when the grid power was off. However, generators and diesel fuel are expensive, and within Auroville their noise and exhaust were unwelcome.[11] Generators also do not start instantly, and power outages meant costly and unacceptable interruptions, especially with computers running and commercial transactions being conducted. Many locations around Auroville, including households, guesthouses and municipal offices, and businesses within Auroville therefore invested in battery-inverter systems to store energy from the grid to be used during power cuts.

Some consumers realized that, with existing investments in batteries and inverters, photovoltaics would be a relatively modest added expense. These small-scale solutions, implemented locally in the twentieth century, have analogs today at the global and grid scale. Massive wind and solar installations worldwide are being coupled to fossil-fuel-driven and nuclear-driven power systems not originally designed for intermittency. The problem of power intermittency in South India is not purely the result of greater demand for electricity than can be supplied. Intermittency is connected to policy. Choices must be made about who will lose power most frequently. Grid power

11 Loret, Martin, and Sarkhot, "Sustainable Energy in Auroville."

is provided for free to farmers to extract water from wells and irrigate fields, but the farmers are the first to lose power since priority for continuous power is given to the university and large industrial users. Auroville was previously not classified as a major power user and so experienced frequent power interruptions. By actively using more grid power, Auroville could achieve a new status that allowed for more reliable access. In a municipal power report,[12] it was also suggested that Auroville could invest in grid-scale wind turbines elsewhere in India, feed power to the grid, and be eligible for better terms from the power company. In late 2014, the Varuna project became reality: several grid-scale wind turbines (4.3 megawatts capacity), built elsewhere by Auroville, supplied power to the Tamil Nadu grid. Auroville then achieved a different status as a power consumer. Fewer power interruptions, improved reliability, and decreased prices all affected Auroville's power use; electricity was now perceived to be "free."

The expense and difficulty of renewable energy in Auroville initially limited power usage. One cannot just install solar panels, but must also face an array of "balance of system" costs and complexities including a racking system for the panels, batteries, battery maintenance, charge controllers, inverters, wiring—often with the help of a paid installer or technician and often without a reliable supply chain for specific products. However, removal of the expense was sufficient to permit some quick changes. On our return to Auroville in 2015, we found that our former guesthouse now had a toaster, microwave oven, electric water kettle, and an electric espresso machine, none of which were possible in 2013 when we first arrived there. In addition, new air conditioners and water heaters had changed the level of comfort available in the rooms and the ability to manage it. There was also a new entertainment system, and a small electric car. The incentive to avoid excessive electricity use was removed.

While overall energy use by the guesthouse increased, the uptick is smaller than one might at first assume. The electric water kettle and espresso machine for guests supplanted an earlier system in which two large urns, one with coffee and one with tea, were supplied to guests each morning. The propane required to heat the water for these urns on a stovetop used more primary energy than electric water-heating systems do. Electrification for tea and coffee is therefore more energy efficient. The new air-conditioning and water-heater systems for guest rooms do increase overall energy usage, but this increase is modest

12 "Auroville Municipal Energy Plan," Auroville: A Universal City in the Making, last modified 23 May 2012, https://www.auroville.info/ACUR/documents/municipal_energy_plan.pdf.
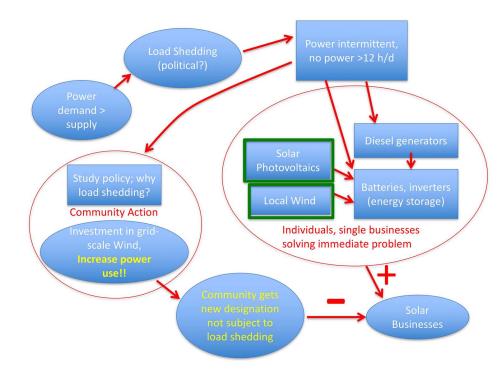
Figure 4:
Flow diagram showing parallel individual (short-term) and municipal (long-term) responses to power intermittency. Individual solutions supported a local renewable power industry (symbolized by the "+" in lower right), but the municipal approach—while providing renewable power—resulted in lost support for the local renewable power industry (symbolized by the "-" at lower right). Diagram by Carrick Eggleston.

and the source is now renewable, rather than fossil-fuel, energy. One unanticipated result of the change to wind-powered, grid-tied electricity in Auroville was that there was no longer an incentive to install photovoltaics (Figure 4). The city was now being powered by renewable energy to a greater extent than ever before, but where previously the renewable energy infrastructure was highly varied (solar cooking, solar hot water, mechanical wind-driven water pumps, biogas, photovoltaics) and local (small individual installations), now it is mostly externalized.

Hopeful Signs: Implications for the Future of Renewable Energy

In many ways, Auroville pointed the way toward renewable energy in India and provided real-world experiential knowledge that supported implementation on a wider scale. Auroville goes somewhat beyond the typical "niche" described by Geels[13] and others, for

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13 Frank Geels, "The Multilevel Perspective on Sustainability Transitions: Responses to Seven Criticisms," *Environmental Innovation and Societal Transitions* 1, no. 1 (June 2011): 24–40.

two reasons. Firstly, there are multiple simultaneous, but independent, efforts to move to-wards a sustainable energy system, from the household level to private enterprise and the wider community. This is not just a singular R&D site. Secondly, because of the privileged space Auroville occupies within the Indian government (at national and state levels), its consultants have disproportionate influence in designing policies and suggesting prac-tices. Auroville therefore affects both regime and landscape levels. One example of this is the development of grid-tied net-metering systems for rooftop solar in the state of Tamil Nadu. Auroville was the initial test/demonstration site for this initiative, using a system designed there between 2012 and 2013. Later that year, the first statewide policy was issued, with specific implementation instructions following the Auroville model.[14] In Auro-ville, and in India more generally, the shift to grid-scale renewable energy has increased overall energy use. This can be viewed as a limitation on the ability of renewable energy development to displace carbon emissions from (for example) coal-fired power plants. While renewable energy is rarely implemented for reasons of climate change mitigation, the result is in fact often mitigation of climate change drivers, but this is not always the case. Each new system transformation must be evaluated in context, and no "silver bul-lets" for carbon reduction can be assumed.

What Does It Mean to Be Modern? Evolution of Energy and Consciousness in Auroville

This experiment in community has created the tools to allow Aurovilians to dwell in a degraded landscape, highlighting how renewable energy and water systems can be integrated to provide an alternative to the fossil fuels that enabled notions of "Progress" in the production of "Modernization" as embodied in development projects. "Energy" is no more a modernizing force than is iron or water or fire or air; all can be put to techno-logical uses that increase efficiencies and mask the costs, economic or environmental, of such resource use. Fossil fuels, in their limited time as the dominant source of energy as the West rose in power, have certainly created a shortcut, a way of moving and act-ing that seems to speed up and extend our capacities as humans, per Marx, to act upon

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14 Tamil Nadu Generation and Distribution Corporation Ltd (TANGEDCO), "Memo. No.CE/Comml/EE/R&C/AEE1/F.Solar NM/D. 023/14, dt.17.02.2014," 17 February 2014, http://www.teda.in/pdf/TANGEDCO_dt_17_02_14.pdf.

nature and society. But in conversations about this,[15] reasonable questions emerge as to the symbolic and metaphorical values that fossil fuels have for modernity as a way of engaging the world. The changing energyscape of Auroville has coevolved with its diverse range of community members, who have not only converted a "ruined"[16] landscape back into one that supports life in all its forms, but created a built environment that offers different ways to imagine community, prosperity, and sustainability. The Aurovilians responded to their unique conditions, and continue to act on the land and its resources as experimentalists—agents who are not just consumers or citizens, but also producers of the energyscape as it plays out on many scales that change over time.

Further Reading

Auroville Green Practices Website. http://www.green.aurovilleportal.org/.

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Strauss, Sarah, Stephanie Rupp, and Thomas Love, eds. *Cultures of Energy: Power, Practices, Technologies.* Walnut Creek, CA: Left Coast Press, 2013.

Tsing, Anna. *The Mushroom at the End of the World: On the Possibility of Life in Capitalist Ruins.* Princeton, NJ: Princeton University Press, 2015.

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15 Strauss, Rupp, and Love, *Cultures of Energy.*
16 Anna Tsing, *The Mushroom at the End of the World: On the Possibility of Life in Capitalist Ruins* (Princeton, NJ: Princeton University Press, 2015).