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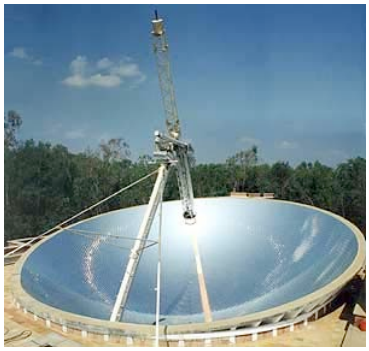
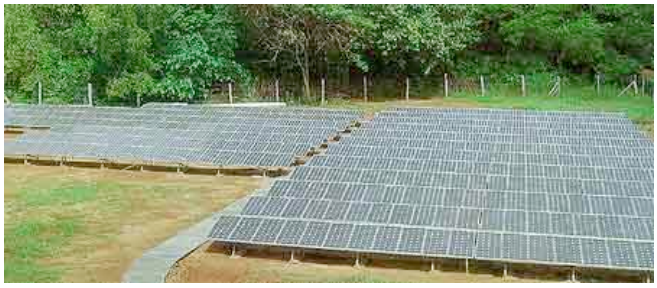
Technology and Sustainable Development
Innovative and Integrated Approaches in Emerging Countries

INDIAN INSTITUTE OF TECHNOLOGY MADRAS

Sustainable Energy in Auroville
The Vision and the Reality





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- Technology and Sustainable Development
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Executive Summary

The world consumption of fossil fuel based energy is increasing everyday. The emerging countries, on their way towards development, are taking a more and more important part in this race. Indeed, for certain organisations, the level of development of a country is measured in terms of per capita electricity consumption. On one hand, the fossil fuels are not renewable and so, are going to disappear in a more or less near future. On the other hand, they are harmful for the local environment, since their combustion emits toxic gases like Carbon monoxide, un-burnt hydrocarbons, NO_x, to quote only a few. Moreover, the fossil fuel combustion contributes to global warming with emissions of CO_2. To try to reduce such hazardous effects, the renewable energies are often seen as very promising solutions, since they use natural elements (solar radiations, wind, etc.) that are not likely to disappear and are pollution free.

The idea of renewable energy can be really sustainable only if the energy produced is used in an efficient way. In fact, using solar electricity to run an air-conditioning unit to cool down a black walled room does not really make sense. The concept of sustainable energy has then to be introduced to take into account the renewable technology to produce energy and the efficient ways of using it.

Currently, renewable energy technologies are expensive and not reliable enough to be able to replace conventional energies on a very large scale. On the other hand, to make the technology advance and to reduce the costs, more research and practical applications are required.

34 years ago the universal township Auroville, the city of the dawn, was created near Pondicherry in the South of India. The aim of this community is to achieve a higher level of consciousness through human unity. Research in different domains, such as education, economy, sciences or architecture has been very important from the beginning.

In the renewable energy field, the Aurovillians have been very active to implement different technologies, first in Auroville and nowadays, more and more outside. This unique experience, through its successes and failures, through its achievements and difficulties can really give an idea of the current possibilities of renewable energies and their various implications. Moreover, in order to give a basis for the future development of the city, a Master Plan was written one year ago. In the energy section, the first paragraph (2.16.13) mentions that, “Auroville’s vision is to become energy independent and self-sufficient, with all its energy requirements met from renewable sources”.

The idea of this one month project was to confront this ideal vision with the reality through a stakeholders review. End-users, as well as technical implementers, visionaries, town planners and architects, 38 people in total, have been interviewed.

After having interviewed so many different people the work has been to join all their different answers to try to give a general sense of what they were saying and to finally be able to give some general recommendations for further studies and further program to implement.

About the current Auroville renewable energy scenario, the opinions were quite balanced from the more renewable energy enthusiastic to the most realistic. Indeed, for some Aurovillians, the city of the dawn is not doing enough to promote renewable

energies and it is difficult to remain positive about this place, whereas for the others, the majority, what could be done and implemented was done and it is already more than anywhere else in India. This is probably true, and if some Aurovillians are really eco-conscious, it is not an imperative to come here, the majority of the people being more attracted by the spiritual side. The debate about the environmental consciousness of the Aurovillians is quite strong among them. As external observers, it can be said that this consciousness definitely exists, and is for sure higher than compared with the rest of India. The comparison with the North-European countries is probably less advantageous.

In fact, it seems that the problem in Auroville, is currently more a problem of sensitization than awareness. How to make the people act according to what they are aware of. This is especially true for the demand side. Indeed, if it is not possible to expect everybody to have solar panels in their garden, it is quite realistic to expect some rational use of the energy. But it seems that low consumption bulbs are not widely used in Auroville, at least by grid connected, and, still worse, lights stay often switched on when nobody is in a room. Some sensitization campaign should definitely be launched, as well as an “efficiency unit”, taking care of these problems and advising the Aurovillians with personally adapted solutions. This would help to close the loop of sustainable energy.

On the renewable energy supply side, there are different units dealing with solar in Auroville and they are all well known within the population. The problem is that, the new interested people do not always know where to go for advice. Moreover, during the installation phase, the different units take charge of only one part of the system. So, the entire plant is sometimes not very well designed and easy to maintain due to these different parts. A unit taking care of the entire installation and maintenance of solar systems could be a good idea.

The building problem was quite difficult to tackle, since the architects met were not very talkative about their work and even less about their colleagues. It seems that a building code is needed, to impose some solar passive architectural rules, especially for private houses. If some building recommendations currently exist, their concern is more to respect the different zones of the city and it seems that they are not always followed. Further, code should also impose solar heaters, since the technology is really simple and mature and can allow the saving of a lot of electricity.

Regarding transport, everybody agrees that it is a big problem. However, no concrete solutions seem to appear very clearly. Some initiatives have been taken by some particular people to propose solutions such as the mobility report by Helmut or solar bicycles by Carsten. But both were not taken very seriously into account and do not seem likely to be implemented. Some serious discussions have to occur soon between the different protagonists to find a quick and implementable solution. Otherwise, the motorbikes will continue their dance around the city, the pollution, the dust and the road crashes will increase, and the quietness of the city, so appreciated by the guests and the Aurovillians, will slowly, slowly disappear…

1. Introduction

1.1 Foreword

Energy, especially the electricity is a very crucial part in development. For some, the amount of kWh per capita yearly consumed is a development indicator. If the reality is more complex and the inappropriate use of energy can lead to hazardous situation, a minimum is required to insure a harmonious development of the poorest places in the world. The energy sustainability is influenced by different factors such as its source, its distribution, way of using it or the wastes generated. Every option for generating electricity affects the environment.

Today, the world energy demand is around 9376 Mtoe/year [1] and is ever growing. Much of the world gets its electricity from big inefficient and dirty power plants situated far from consumers. The distribution is done through inefficient and often unreliable national grids. Moreover, these traditional options of distributing electricity reach at first the urban areas and in the developing countries around the world, about 2 billions of people living in remote areas are still “in the dark”. These conventional options to produce electricity are damaging the air, climate, water, land and wildlife as well as raising levels of harmful radiations. The effect of electricity generation on climate change is huge. On average, one kilowatt-hour of electricity consumed is equivalent to an emission of 600 lit of CO_2.

Renewable technologies are substantially safer and will last for ever. The environmental imperative remains clear, the future must be renewable.

In India there are other reasons as well to go renewable. The Indian energy scenario is rather scary. There is an energy deficit of 8 % and a power deficit of 16 % in electrical energy supply. The transmission and distribution losses of 20-22 % and average plant load factors around 58 % only. The indigenous petroleum resources have peaked off and ratio of indigenous to total requirement has leveled off. Annual energy requirements are going up. However, the increasing demand cannot justify any additional conventional power plants due to the pollution caused by these plants [2].

The Ministry of Non-Conventional Energy Sources (MNES) estimates that India has an enormous potential for renewable energies. The ministry is now supposed to take care of 18000 remote villages which have no chance of being electrified ever through the national grid. Another 80000 villages are likely to be connected to a grid, but may not get electricity in the near future. The reason is that rural electrification corporations cannot make the grid economical as the demands are insufficient. Therefore, the role of renewable energy in India’s energy future is important.

1.2 Sustainable energy

The concept of sustainable energy means the combination of renewable sources with efficient use. In fact, it is not really worth (and sustainable) to emphasis only on the clean production while wasting the energy in inefficient devices. This concept takes into account both supply and demand side. These efficient appliances often already exist (low consumption bulbs for example) but they are not well known and represent a higher investment cost. More efforts are then needed to make these technologies cost-competitive and to increase their penetration in the market.

Though the renewable energy is the goal, conventional energy will continue to play a major role (as much as 90% of the total consumption, according to experts) for a long time to come. This is due to technology reliability, users' habits and investment costs. Therefore, the concept of energy efficiency will play a major role in sustainability.

1.3 Auroville

Just over 30 years ago, Auroville Universal Township was started with a vision to create a sustainable township. To fulfill this vision, Aurovillians are trying to find alternatives in every aspect of sustainability. Therefore, the city of the dawn has taken up everything, from environment to education, from alternative economy to natural healing systems, from alternative building technologies to spirituality, and from research on gold tiling to renewable energies. There is no other place in India or elsewhere, which does that. It was initiated and developed following the Vision of its creator, the Mother.

This vision is incorporated now in the Auroville Master Plan [3]. In the energy section, the first paragraph (2.16.13) mentions that, "Auroville's vision is to become energy independent and self-sufficient, with all its energy requirements met from renewable sources". Already a lot of work has been done in this direction.

Since the beginning, Auroville has been involved in the research and implementation of renewable energy systems. Interest in these systems developed out of sheer necessity to secure energy for living and day-to-day activities. Interested persons carried out the research for improvement of the devices, and those activities led to the formation of units involved in R&D, the manufacturing and the promotion of the different renewable energy technologies.

Today, Auroville is recognised in India as a 'testing' centre for a wide variety of renewable systems. They are responsible for the consulting, dimensioning and installation of the systems, and in most cases, they also do the maintenance and 'post-selling' service, also outside Auroville, in the whole India.

In Auroville, the density of various renewable options is unmatched in India, with around 500 kW of solar PV panels installed in an area of 20 km^2, along with more than 30 wind mills and around 20 biogas plants.

1.4 Aims and objectives

The main objective has been to perform an audit i.e. a stakeholders review on renewable energy in Auroville. The method adopted for this was interviews of the various stakeholders involved in making this vision a reality. Among the stakeholders, four groups were considered viz. visionaries and town-planners, architects, technical implementers and end-users.

The various aims can be summarized as follows:

- To get an idea of the evolution of renewable energies in Auroville.
- To see what the Aurovillians think about the present situation and what are the future plans for the city.
- To confront the vision of Auroville with the reality to see how far it has been achieved.

- To understand the obstacles in the road towards sustainability.
- To see how these difficulties were overcome and what were the strong points during the process.
- To find out what can be done to improve things further and to see how far this experience will be useful for the country as a whole and the developing countries in general.

1.5 Scope of the study

Sustainability refers to many fields. However, the present study is focused on the energy aspects of sustainability. Major emphasis is on electricity, but it also includes the energy used for transport and built environment (embodied energy) to some extent.

Within electricity, both the conventional and non-conventional sources have been taken into consideration, but focus is on various renewable energy options. The various options under study are solar, wind and biogas.

An attempt has also been made to see how far the Aurovillians are aware about the concepts and practices of energy efficiency.

2. Auroville and Renewable Energy Scenario

2.1 Renewable energy in India

India is blessed with abundant sunshine and wind, and though the government is implementing one of the world's largest programmes in renewable energy it will hardly reduce the anticipated shortfalls generated under conventional energy sources. Budgetary allocations for promotion of renewable energy are still too low (0.8% of total funds allocated to the energy sector in the eighth Five Year Plan from '92 to '97) compared to conventional energy sources that operate with huge subsidies from the government. Investment from industries in research and development of renewable energy is insufficient to make a difference both in quality and quantity. Financing and end-user acceptability are still considered major barriers. Considering all these points it is normal that the promotion and the development of renewable energy sources are still considered as a frontier adventure.

In order to counterbalance the substantial government subsidies to the conventional energy sector, the Indian Renewable Energy Development Agency (IREDA) offers programmes under which subsidies, soft loans and tax benefits are made available to renewable energy users.

Nevertheless, India is witnessing a tremendous development of renewable technologies in the last 20 years that are well engineered and well made. E.g. solar pumps, biogas plants, wood gasifier technology etc. The table below summarizes the estimated potential for renewable energy technologies in India.

Sources/systems	Potential (estimated)	Achievements (till Aug 2001)
Biogas plants (no.)	12 million	3.22 million
Improved woodstoves	120 million	33.86 million
Biomass Power	19500 MW	343 MW
Biomass Gasifiers	-	41 MW
Solar energy (total)	20 MW/km^2	
Solar Street lights	-	41,403 Nos.
Solar Power plants	-	1132 kW
Solar Pumps	-	4204 units
Solar Heat	30 million m2 collector area	0.59 million m^2
Solar cookers	-	051 million units
Wind energy	45000 MW	1367 MW
Small hydro power	15000 MW	1398 MW
Hybrid systems	-	101 kW
Ocean energy	50000 MW	-
Energy from wastes	17000 MW	1602 MW
Battery operated vehicles	-	240 Nos.
Source: MNES (2001)		

Table 1. Renewable energies in India.

2.2 What is Auroville?

2.2.1 Vision

"There should be somewhere upon earth a place that no nation could claim as its sole property, a place where all human beings of goodwill, sincere in their aspiration, could live freely as citizens of the world, obeying one single authority, that of the supreme Truth; a place of peace, concord, harmony, where all the fighting instincts of man would be used exclusively to conquer the causes of his suffering and misery, to surmount his weakness and ignorance, to triumph over his limitations and incapacities; a place where the needs of the spirit and the care for progress would

get precedence over the satisfaction of desires and passions, the seeking for pleasures and material enjoyments.

In this place, children would be able to grow and develop integrally without losing contact with their soul. Education would be given, not with a view to passing examinations and getting certificates and posts, but for enriching the existing faculties and bringing forth new ones. In this place titles and positions would be supplanted by opportunities to serve and organize. The needs of the body will be provided for equally in the case of each and everyone. In the general organization intellectual, moral and spiritual superiority will find expression not in the enhancement of the pleasures and powers of life but in the increase of duties and responsibilities.

Artistic beauty in all forms, painting, sculpture, music, literature, will be available equally to all, the opportunity to share in the joys they bring being limited solely by each one's capacities and not by social or financial position.

For in this ideal place money would be no more the sovereign lord. Individual merit will have a greater importance than the value due to material wealth and social position. Work would not be there as the means of gaining one's livelihood, it would be the means whereby to express oneself, develop one's capacities and possibilities, while doing at the same time service to the whole group, which on its side would provide for each one's subsistence and for the field of his work.

In brief, it would be a place where the relations among human beings, usually based almost exclusively upon competition and strife, would be replaced by relations of emulation for doing better, for collaboration, relations of real brotherhood."

The Mother

Auroville is a place in south India where, for more than thirty years, an increasing number of people from all over the world have been quietly and painstakingly working on the construction of a new township, a new way of living, a new way of being. Something is being attempted here for the benefit of all.

"Man is a transitional being, he is not final. Evolution is not finished; reason is not the last word or the reasoning animal the supreme figure of Nature," observes Sri Aurobindo. "There is something that he is not yet which he has to be; he is reaching always towards the something yet unrealised; his whole life and nature is a preparation, an endeavour of Nature towards what is beyond him."

Auroville is to be a major vehicle of this evolutionary thrust and, eventually, a platform for transformation.

This wide and vast objective of the township has attracted people from its inauguration in 1968 onwards. Today, the Auroville project is quite well established, having found ways of collaborating with the villages in its bioregion, with the Indian authorities, with many non-governmental organizations and world bodies worldwide.

The present 1,851 residents from some 35 nations living in Auroville (a workforce of 4,500 and 1,500 to 2,000 guests need to be added to this population) are aware that they may not yet be able to live up to the project's high aims. While holding the vision in their heads, hearts and meditations, they are spending their energies in those aspects of the experiment where they can actively work.

In Auroville particularly, there are the enormous challenges of how to

- shape, plan and build a city for an ideal society of the future
- let the indigenous population of Auroville's bioregion co-evolve along with it
- educate the young in a way that their deeper identity is allowed to remain at the forefront
- organize a collective life without authoritarian structures
- manifest beauty in all facets of living
- **consciously, wisely and justly manage the wide variety of resources available**
- heal, and to evoke healing energies
- relate to the earth in a truly appropriate manner
- artistically express newly found realities within

Underlying all this is the main challenge of *living* an actual human unity.

By their very choice of being here, the Aurovillians commit themselves to be instrumental in the creation of "a universal township where men and women of all countries are able to live in peace and progressive harmony, above all creeds, all politics and all nationalities". They are aware that "the purpose of Auroville is to realise human unity" so that, eventually, our species may progress.

2.2.2 The Township

Auroville is mainly divided into the City Centre and the Green Belt. The City Centre is divided in four zones: the Residential zone (where development is mainly limited to residential community buildings, community meeting spaces, nurseries, first aid centres, parks, playgrounds and eco-friendly parking areas), the Cultural zone (limited to institutions and research centres related to education, arts and sports, city level cultural uses including auditoriums and exhibition halls), the International zone (limited to national and international cultural pavilions, conference and exhibition halls, communication centres, visitor information centres, guest houses and restaurants) and the Industrial zone (limited to manufacturing services and other non-polluting industries, professional consultancy offices, vehicle parking, industrial display areas and R&D staff quarters).

In the City Centre they are following a centralized model of development, which draws heavily on outside energy supply for its sustenance.

Lastly, the Green Belt Zone has broadly three main categories of uses, viz. agriculture and farming, forest and land regeneration and recreation. Their development is designed to promote biodiversity enhancement, environmental management, land regeneration and water management, with technology transfer of the above activities for wider application. This will make the Green Belt not only an asset for Auroville and the surrounding villages, but also a National Resource Centre (NRC) for sustainable development. The Green Belt has evolved guidelines of its own for people wanting to build there. These guidelines indicate a will to create a self-supporting infrastructure in the field of electricity and water management. In this region they are following a decentralized model of development, where alternative energy should be used whenever possible.

2.2.3 Master Plan

Through its Master Plan, Auroville wants to break new ground in settlement-planning in such a way as to help other cities, both in India and abroad, which are

experiencing high urbanisation trends. Auroville also hopes to demonstrate how 'urban' & 'rural' areas can complementarily develop in an integral and holistic way for their mutual benefit and well-being. The town planners talk about an 'integrated' master plan, implying here that both city and environment are integrally planned for, since Auroville has come to care for its 'hinterland'.

Auroville's approach aspires to go much further. The approach of its Master Plan is to establish that the economic and human intellectual resources, which normally gravitate to urban areas, can be effectively used to spread development more evenly, and to create an equitable and economically sound society. This is, more often than not, presently not the case in regard to the way cities are planned, developed and are functioning.

The approach to planning needs to be in three stages:

Perspective Master Plan

A very broadly based plan, incorporating planning policies and general structure of land use, transportation and scale of amenities.

Development Plan

This plan builds up on the Perspective Master Plan. At this stage, the ground realities will be reviewed in detail. At this level, much more data, information and collaboration from the community will be required.

Annual Plan (Implementation Plan)

The Annual Plan, conceived within the framework of the Development Plan, will contain the details of new and ongoing projects to be implemented during the financial year.

2.3 Renewable energies in Auroville

Since the beginning, Auroville has been involved in the research and implementation of renewable energy systems. Interest in these systems developed out of sheer necessity to secure energy for living and day-to-day activities. Interested persons carried on with the improvement of the devices, and those activities led to the formation of units involved in R&D, the manufacturing and the promotion of the different renewable energy devices. Today, Auroville is recognised in India as a 'testing' centre for a wide variety of renewable energy technologies.

2.3.1 Solar energy

Energy from the sun has many salient features that make it an attractive option; these include widespread distribution, lack of pollution and virtually inexhaustible supply.

In India, under clear sky, the daily average solar energy incidence varies from 4 to 7kWh/m², depending on the location (peak will be 1kW/m² at noon). As there are 250-300 sunny days a year in most parts of the country, India receives solar energy equivalent to more than 5.000 trillion kWh/year, which is far more than its total energy consumption.

Solar energy, experienced as light and heat, can be used in various ways and for a number of applications.

The two principal technologies for its utilization are:

- **The photovoltaic (PV) route**, in which sunlight is converted into electricity.
- **The thermal route**, in which the heat produced by solar radiation is harvested and used in some ways.

The first solar panels were installed in Auroville in the early eighties. Today, Auroville has more than 150 houses fully powered by photovoltaic panels and about 50 houses that use solar power in conjunction with a grid connection. Some communities run solely on solar and wind energy. The total standalone photovoltaic energy capacity of Auroville is more than 15% of the total photovoltaic capacity in India.

Solar energy in Auroville is used mainly for home lighting systems, pumping water for drinking purposes and irrigation, heating water for domestic purposes, and food processing. Other solar applications developed are solar curing chambers for ferrocement prefabricated elements and solar concentrators.

2.3.2 Wind energy

Windmills for pumping water have been designed and built in Auroville since the early pioneering days. One of the first designs was the Cretan windmill, made of wood and cloth-sails.
Aureka, in collaboration with CSR, started work on the design of a multi-blade windmill as early as 1984. The design has evolved from the practical experience of Aurovillians gained in operating windmills over the last two decades. The AV55 can now be used for pumping water from bore wells as deep as 100m as well as for low-lift high-volume output from open wells.

Today, there are more than 30 windmills of various designs spread over the Auroville plateau for pumping water.

Generating electric power through wind is seriously hampered by the fact that Auroville does not always get the high velocity winds that prevail further south. Two wind generators, which under optimum wind conditions are capable of generating 4kW of power, are part of a hybrid solar and wind energy system that is being tested at the Visitors Centre. However, the actual output we are able to get in Auroville is much lower.

CSR-wind pumps is the unit involved in R & D. Aureka is the manufacturing unit for the Auroville wind pump AV55.

2.3.3 Energy from biowaste

CSR got involved in the manufacturing of biogas plants since the small farms operating in Auroville produced the basic input, cow dung, and were in need of energy.

Biogas designs existed and were developed in India as early as 1950. CSR's contribution in the field was an innovative combination of a renewable energy system with an appropriate building technology. The outcome was a modular prefabricated

ferrocement biogas system suitable for small scale farm operations and producing biogas in the range of 2 to 4 m^3 a day.

Advantages of prefabricated biogas plant are the corrosive resistant digester and gasholder.

Auroville Building Centre manufactures the ferrocement biogas plants even for the Andaman and Nicobar Islands. The marketing is done under Aurore Systems and Products.

2.3.4 Appropriate building technology

The term 'appropriate building technology' refers to building processes and tools that are appropriate to the climate, socio-economic conditions and natural resources of an area, and which contribute to sustainable development. In the Auroville context we have two examples of appropriate building technology, earth construction and ferrocement.

Appropriate architecture

The term 'appropriate architecture' is used for the integration into construction of all the separate technologies and disciplines involved in the research and promotion of sustainable solutions. 'Green Architecture' is another name used for this approach.

Earth construction

Compressed Earth Blocks (CEBs) are made in a manual press (produced in Auroville by Aureka) using a mixture of earth with 3-5% cement. The advantages of using CEBs for construction are that they can be made on site and the manufacture of them doesn't pollute the environment. A CEB uses between 3-5 times less energy to make than a fired brick.

In 1996, the Auroville Building Centre designed and built a cyclone- and earthquake-resistant house at the UN Habitat-2 Conference in Istanbul using compressed earth blocks.

Auroville Building Centre (AVBC)-Earth Unit is conducting regular training programmes in earth construction. The earth unit maintains a construction team and offers consultancy and design for buildings in earth.

2.3.5 Solar passive architecture

Providing comfortable buildings, while reducing the use of conventional fuels and electricity, can be obtained through solar passive architecture. The benefit of solar energy is utilized through designing energy efficient buildings.

Climatically responsive, energy efficient architecture

Auroville is situated in the hot humid zone, a zone where solar passive measures are the least effective. Natural lighting and proper ventilation, shading of the walls and good insulation of the roof are important features for naturally creating comfort zones within buildings.

Low energy content building materials

Appropriate building technologies are an overall part of passive solar architecture. Auroville Building Centre has gained expertise in two low energy content technologies: compressed earth blocks and ferrocement. Both technologies use in their category substantially less energy than the more traditional applications of fired bricks and RCC structures.

2.4 Technical units in Auroville

CSR

Auroville Centre for Scientific Research (CSR) is an international voluntary organization working towards a sustainable future in the field of renewable energy systems (wind, solar, biomass), appropriate architecture & building technologies, waste water recycling and sanitation, and the transfer of these technologies through training programs.

CSR was founded on January 6th, 1984. After the Indian Parliament passed the 'Auroville Foundation Act' in 1988, the assets of CSR were transferred to an autonomous institution, the Auroville Foundation. From April 1998 CSR was registered under two trusts, one for its research activities, Auroville Centre for Scientific Research, the other for its commercial activities, Aurore Trust.

CSR has an international staff of 9 full-time and 5 part-time qualified persons, supported by a permanent work force of 20 people.

CSR receives grants and donations for its programs and research projects from Indian and foreign governmental and non-governmental agencies, and from well-wishers worldwide. All donations from Indian citizens to CSR are 100% tax-exempted under section 35(1)(ii) of the Income Tax Act.

Research and development activities of CSR include renewable energy systems (wind, solar and biomass), appropriate architecture & building technologies (earth, ferrocement) waste water recycling and sanitation.

Commercial activities include promotion of renewable energy systems, production of cost-effective building components and manufacture of renewable energy systems

Renewable energy has been CSR's first field of research and development and India's Ministry for Non-conventional Energy Sources (MNES) has been its main sponsor in this domain.

- CSR developed and produces maintenance-free ferrocement biogas plants of two types: floating drum and fixed dome. R&D was financed by MNES.
- CSR developed India's best performing wind-pumps (5.5 m diameter wheel, 25 m high tower). CSR's wind pumps are manufactured and marketed by "Aureka", a sister unit under the Auroville Foundation.
- CSR installed a 37 kW solar photovoltaic power plant, the biggest stand-alone system in India, close to the Matrimandir. It has also installed more than 200 solar photovoltaic water pumps of at least 1kW each in Auroville and surrounding region.
- CSR is presently manufacturing some of the components of an 8-metre diameter solar parabolic concentrator that will provide heat to a 10 kW Stirling

Engine. This system was designed in Germany and will be installed at Vellore Engineering College in Tamil Nadu.

Aurore

Its activities are project development and management in the field of renewable energy.

Aureka

It manufactures windmills for water pumping, brick compressing machines and the stand for solar panels.

Altecs

It is involved in producing and marketing UPS, charge controllers, inverters and small DC converter with lamps.

Auroville Energy Products

It is specialised in solar energy products -such as in solar lamps, solar charge controllers and inverters to provide a complete solution for solar home systems-, wind energy systems - design, supply and erection of wind-diesel hybrid systems- as well as micro-hydro systems. One of its main focus points is presently the development of solar transport, starting with a simple bike.

Auroville Electrical Service

Its main activity is the maintenance and installation of the electrical grid.

2.5 Further information

For more information about Auroville: www.auroville.org

3. Methodology

To achieve the goal of having a better view of the reality of Auroville regarding sustainable energies, the following methods have been applied:

- Interviews
- Opinion invitation in AV News
- Opinion invitation in AV Net
- Auroville web site review
- Available literature review

The interviews appeared finally as the most useful tool. The invitation of opinions through the Auroville's weekly newspaper and website did not have a lot of success and at last, no answers were registered. However, according to the feedback of some Aurovillians met afterwards, it seems that the newspaper announcement was seen by quite a lot of people.

For the interviews, the people met were divided into 4 groups: Visionaries/Town Planners, Architects, Technical Implementers and End-users. Finally, 38 persons were interviewed (8 Visionaries/Town planners, 5 architects, 11 technical implementers and 14 end-users) in three weeks. A first list of interesting people to interview was proposed by Jos at the beginning of the study. This constituted the basis from where the work started. During the project duration, some other names were proposed by the interviewed people and the study went on. No real logical order was followed for programming the interviews, the majority of Aurovilians being quite busy; the scheduling was made according to their availability. The duration of the interviews varied from 20 minutes for those in most a hurry to more than two hours for the most talkative.

The contacts were mainly taken by phone, but some others were realized directly by meeting people on the spot. It appeared that the Solar Kitchen (community kitchen) at lunch time was a very good place to enter in contact with interesting people. The interviews took place in different places, offices, houses, coffee shop or other exotic places such as under a solar panel or under drying Mexican chillies. To show by example and to be coherent with the topic treated, all the commuting have been made **by bicycle**, despite a very strong sun, a temperature rarely under 35^{o}C, dusty roads and, still worst, crazy fast vehicles drivers. The total amount of kilometres covered has been estimated at about 300. The quantity of smoke and dust (due to the engine powered vehicles, in very large number in the Auroville area) breathed during the whole project is more difficult to measure.

The basis of the interview was a questionnaire prepared in the beginning of the project. Different questions were prepared for the different group of people and they can be seen in Appendix A. However, the interviews were more like discussions rather than formal questions/answers. For example, the questionnaire was not showed to the interviewees but was there to help not to forget important topics during the discussion. At the end of the work, it was hardly used, the interviewers having become experts on the topic.

The questions asked to the architects were mainly about the concepts of energy efficient buildings and solar passive. The aim was to try to check their awareness on these concepts and, most important, to see if they were implementing them in

Auroville or not. Regarding the town planners, the questions were more based on the master plan and its applicability as well as on the evolution of the concept of sustainable energy in Auroville from the pioneer years. The technical implementers were invited to talk about their work, their projects in Auroville and outside and their effort to promote the sustainable energy in the city of the dawn. The users were asked about their understanding of sustainable energy and its application in their everyday life. These last questions were also asked to the other categories, since all the people interviewed were also living in Auroville and somehow end-users. Finally, all the interviewees were questioned about their general feeling about Auroville, the Master Plan and the future, especially regarding the energy issue. The question “Speaking about energy, do you think Auroville is on the right track?” was often asked to close the discussion.

It appeared very quickly that no two interviews were similar, the answers to the same questions being very different from a person to another. On the other hand, the questions asked varied a bit from an interview to another, the interviewees’ interest being quite different and the topic treated being quite vast.

Auroville website was checked for general information about the city and the technical units involved in renewable energy. The review of literature consisted mainly on articles of AVNews and AVToday (weekly and monthly newspaper respectively) on sustainable energy. Different papers proposed by the interviewees were studied to have a better view of the global picture.

4. Results of the Survey

The present chapter presents the result of the survey for the different categories of people interviewed (Visionaries, Architects, Technical Implementers and End-Users). For each group, only the main ideas are presented, as accurately from the original interviews as possible. The general remarks about these results as well as some personal suggestions from the authors of this survey are presented in the next chapter.

For confidentiality reasons, no names are mentioned with comments about personal feelings.

Indeed, the aim of this work is not to inflame internal conflicts, but to propose general suggestions that could help Auroville on its way towards sustainability, taking into account as many different opinions as possible.

4.1 Technical implementers

4.1.1 The different units and services visited during the survey

During this one month project, the following units and services have been visited once or several times:

- AuroRE: host of this study
- Centre for Scientific Research (CSR)
- Aureka
- Altecs
- Auroville Energy Products (AEP)
- Auroville Electrical Service (AES)
- Auroville Solar Service (ASS)

Finally, Manfred was also interviewed. He doesn't really belong to one specific technical unit but his research on fossil fuel substitution fits very much in this sustainable energy survey.

4.1.2 The main technology developed in these units

A brief description of these different units has been given in the second chapter, Auroville and the renewable energy scenario. In this particular section is to develop in more details the evolution and the technical point of view.

AuroRE

The unit started in 94 as part of CSR and then became independent in 97. The major aim of Aurore is to promote renewable energy through intelligent combination of financial mechanisms. In that respect, it does not really develop new technologies, but the experience gained in the process allows it to improve the technologies.

In Auroville, a major breakthrough came when a special financial engineering concept was used to reduce the prices of solar panels for pumping purposes. The proper co-ordination of the government subsidies, financial institutions, leasing companies helped to reduce the price to $1/10^{th}$ of the market price. So, more people could afford it.

After getting enough experience in Auroville, the unit slowly started spreading out in other parts of the country. This year, there were more projects outside than inside the city of the dawn. Outside offers new set of realities. Currently, the unit is more into solar pumping systems and lighting. Last year it has started a project in Punjab for solar pumping, resulting in installation of 175 pump sets. It is currently going on, and due to its success other Indian states are now very much interested in starting similar programs. On the other hand, AuroRE is currently launching a program of solar systems rental. It has started in February 2002 in Chennai, where in Elliot beach the street sellers can hire solar lanterns for a fixed rate per night (20 Rs), having so an alternative for the polluting and costly kerosene lamps. The maintenance and the daily charging of the lanterns, is realized by a small enterprises that forms the link between the users and AuroRE.

The main technical problems have been the design of the universal join of the panels.

In the future, AuroRE, wants to improve the efficiency of old PV systems in Auroville, to participate more in the development of renewable energies in the city via meetings with other stakeholders and finally becomes a real renewable energy service provider.

CSR

In terms of number of technologies developed in Auroville it is by far the most productive. In fact, the word development is really to be taken in its first sense, since it is more an adaptation and experimentation of existing technologies that is going on at the CSR. None of these were really invented there. In fact the name Centre for Applied Research could be more appropriate.

It has officially started in 1984 and currently, about 15 staff people and 60 workers are working for it. The main technologies developed there are prefabricated ferrocement biogas plants (about 25 units in Auroville), solar cookers, solar water heaters, PV panels for pumping and electricity production and a solar bowl for steam production for the community kitchen (1500 lunches 6 days a week). Except the last one, all these technologies were implemented outside Auroville and the biogas plants and the solar cookers are now being commercialized. Nowadays, the solar PV panels for pumping purposes are taken care of by AuroRE. The technical details about the solar bowl can be obtained in [4].

Regarding solar PV, the main realisation of the CSR inside Auroville is the Matrimandir solar power plant. It is a 36.3 kW plant and was commissioned in September 1997. It is composed by 484 monocrystalline panels of each of 75 W. The plant was installed in 29 days and is the largest stand-alone photovoltaic power plant in India. It also serves as a test-ground for decentralized power generation.

In the future, the focus will mainly be on structuring the maintenance mechanism for the renewable energy systems and working as “Renewable Energy service providers” at least for Auroville.

Aureka

Aureka is a large unit headed by Robi where about 80 people are working. Different products are manufactured here such as windmills for water pumping, brick compressing machines and the stand for solar panels. Regarding sustainable

energy, the windmill part of the activities is very interesting, since it has been fully, the pump included, designed in Auroville. It represents about 15-20 % of Aureka's activity.

Robby has been in Auroville for 30 years and the idea of using wind energy to pump water came very quickly in his mind. Indeed, in the beginning the only pumps available there, were hand pumps.

In 1982 the first windmill was installed. It was very rudimentary, in wood with sails in the arms. In 1988 the first prototype of the future steal windmills was designed. It is still running in Gaia community and, with its 6m diameter, is the biggest windmill in Auroville (current windmills have 5.7m diameter). From 88, the concept is still the same but improvements have been realized, especially regarding the bearings, and some valves in the pump.

Currently, Aureka has installed about 40 windmills in 3 Tibetan refugee camps in Karnataka and between 15-20 windmills in Auroville.

Windmills really need maintenance and it needs to be done by Aureka since they have the knowledge and the experience. Once a year someone from the unit is sent to check the installations. The service is charged 400 Rs in Auroville and about 1000 Rs outside.

The main technical problems were the general reliability in the beginning (with wooden mills) and later on, the bearings. According to Robby, now the major problems have been solved[1].

Altecs

The company is involved in producing and marketing UPS, charge controllers, inverters and small DC converter with lamps. However, due to global competition it is currently working on a very small scale, mostly maintaining the systems previously sold.

Auroville Energy Products (AEP)

The unit is divided into two sections, SPV Systems and Wind-Hybrid. The first one, headed by Carsten, employs 8 people and started with solar lamps in 1996. It is currently focusing on the electronic side of solar system and also some small items like solar lanterns. AEP-SPV systems has a tie-up with a German company allowing the unit to sell and manufacture the German product. Some of the products of AEP are manufactured within Auroville in units like Aureka. Only the final electronic assembly and the quality testing is done in AEP workshop. Most of these products are sold outside Auroville, mainly in South-India and now a little bit in the North as well.

A solar bicycle has also been developed there. Carsten would like to develop a transport system in Auroville with these bicycles. The idea of project is to have a certain amount of bicycles (e.g. 20 to begin) and different places to charge the batteries (Pour Tous, Central Guest House, Matrimandir, etc…). The people will rent

[1] However, during the interviews, one user said that he had problems with the rope of his windmill. It was a problem easy to fix in one or two days but during which no water is available. According to him, this kind of problems occurs once or twice a year.

the bicycles for one day and change the batteries in these different places when it is needed. Two prototypes are now available, but AEP is waiting for the availability of finance to fully develop the idea.

AEP-SPV sytems organizes a “training programs” for maintaining solar systems, in collaboration with the Auroville Solar Service, and with the help of “Asia Urbs Conference”. These courses are mainly attended by outsiders.

The Wind-Hybrid section, headed by Jan Imhof, employs 5 people in Auroville and 4 in a small office in Calcutta. Its main emphasis is on wind with two main products: a range of 1.5 – 10 kW wind battery-chargers and a 50 kW wind turbine. For the first product, the unit bought models from different brands and dismounted them to take the best of each. AEP- Wind-Hybrid has now his own design. For the second one it has a technology transfer agreement, with an American company. It is now the official supplier of this brand in India, and he is allowed to build them. The Aurovillian unit would like to slowly, slowly replace imported part with Indian ones.

In Auroville the wind conditions are not good enough (average wind speed of 4 m/s) to be competitive versus Diesel and of course heavily subsidised electricity. For that reasons AEP- Wind-Hybrid has mainly projects outside Auroville. One big project currently going on is an island electrification with an hybrid system composed by 500 kW wind turbines and two diesel generators.

Auroville Electrical Service (AES)

It was started in 1974 by Toine. Ponusamy took over in 1992. The service has 4 main functions to perform:

- Service: Maintaining the present electrical grid (2 substations, 30 transformers,…)
- Job works: Constructing new connections (internal and external wiring)
- TNEB: Approaching TNEB for getting new services and counters and for maintenance.
- Planning: Planning of the future of AV. They want to remove all the old high tension lines and put underground cabling. Up to now it was not possible because they do not have the permission of the TNEB (they were not considered as a township)

The Service receives on average 20-25 complaints per day. Their priorities are water followed by community facilities, interruptions and finally others. The bi-monthly bill ranges from 10.4 to 40 lakhs for the whole township. The relations with TNEB are good.

In 1997, Ponusamy sent an invitation for people who were interested in learning about energy efficiency. Only 10 Aurovillians responded. He also conducted a class of electrical services for 12 students. He plans to conduct another course in June for Aurovillians.

Auroville Solar Service (ASS)

It was started in 1990 with Auroville funds on an idea of the development group. Rama, the actual director of the service started with 3 boys. The idea is to maintain the domestic batteries. The service is currently servicing about 175 locations, including solar units and backup systems (UPS). It does not deal with solar pumps (AuroRE). Its work includes checking and maintaining the batteries (including UPS),

cleaning the panels wherever possible and troubleshooting. Initially it was free, but as the number of customers increased, it became difficult. Rama had to engage more boys, but he could not ask for more money from the fund, so, now he charges a very small amount (Rs. 25-30/month) for the new customers. The service also tries to educate people about the simple maintenance so that its team does not have to come for too simple problems, especially for remote houses (green belt). They also try to make the people interested in their system. It is a large part of the success of a solar installation. Rama also conducts training programmes with Carsten (AEP) for solar technicians. Finally, the service installs the small solar home systems.

Manfred

Manfred Lehnert, who hails from Germany, joined Auroville in 1993 and is working on a variety of research and development projects. In Auroville, he is presently working on the following four projects: Solar sea water desalination, Biodegradable soaps & cleaners, Plant oil as a substitute for diesel oil and Low cost light roofing components. Regarding sustainable energy, the most important participation of Manfred is about substitution of Diesel oil. In fact, in Auroville, this substance in not only use for transportation purposes, but also for pumping and, more and more, for electricity production as Tamil Nadu Electricity Board (TNEB, the state grid in Auroville) backup. Its substitution by a renewable and "free" of CO_2 emissions source could be a big step towards sustainability and self-sufficiency of energy consumption.

One year ago, Manfred bought 5000 thousands litters of Pongam oil and started to test to run 9 engines with it. Out of this 9, 4 are running without problems. For the others, it seems, that there were not maintained properly or did not have an adequate cooling system (no radiators). For his research, he is in contact with IISc Bangalore that is currently testing some generators with plain oil, and IIT Madras to develop a simpler process to produce biodiesel.

In the future, he wants to find more engines to test, to plant Pongam trees to directly produce the oil in Auroville (theoretically, 50 hectares should be sufficient to fulfil Auroville's need) and to have a bank of alternative fuels (plain oil, biodiesel, and bioethanol).

4.1.3 Where does the money for the research come from?

CSR

According to Tency, CSR coordinator, "the budget is neither extraordinary nor fixed". They have to find every cents and therefore, to be creative. The sources of funds are the following:

- Trainings and projects for government and other organizations
- For big projects such as Martrimandir solar power plant or the solar bowl: MNES (Ministry of Renewable Energy Sources), IREDA (Indian Renewable Energy Development Agency)
- Income from their small Production Unit (Ferro cement, earth blocks), architectural office and services provider (solar water pumps in Punjab).

Aureka

Now the unit is profitable, but the aim is not to make huge profit. Money comes from the selling and the maintenance of the windmills. In the very beginning of the unit, fundings came first from Tata. Then a rich neighbour helped them to develop their first prototype of windmills and after that JDZ gave some money for the research. In the 90's they got a contract with a Dutch company, specialist in wind pump, that provided more technical advising that allowed better result with few changings.

Even if the windmills are subsidised, they are very costly, 1.5 lack Rs without subsidises. The government in Delhi can subsidise them up to 45.000 Rs and the local Tamil Nadu government up to 20.000 Rs. This price is the same for everybody (inside and outside Auroville) and unfortunately it is not affordable for the farmers. The unit is currently selling 10-20 windmills per year.

Auroville Energy Products (AEP)

The both sections started with personal investment. The SPV-Systems is not yet profitable and therefore, is still running with its manager's personal money. For the other section, according to Jan, with the different projects started, the section is now running OK.

Auroville Electrical Service (AES) and Auroville Solar Service (ASS)

The both services are running with both Auroville funding and money got from the services (installation and wiring for AES and batteries maintenance check for ASS).

Manfred

He is doing his research on his personal money and with the results of the selling of his previous research (ecological soap, etc.).

4.1.4 Main difficulties encountered to run the unit

The different unit visited mentioned different kind of difficulties faced.

About India

- Bureaucracy.
- To find good and committed people (that accept to work for several years for the same company).
- Uncertainties due to government policies regarding subsidies and taxation (especially for those working with financial mechanism to promote renewable energy).
- Renewable energy has bad name in India due to problems in quality and availability of maintenance => to promote them, you have to fight against everything.
- No level playing field between conventional and non-conventional energies. The conventional electricity is heavily subsidized.

About Auroville

- Lack of interest to try new technologies (about diesel substitution).
- No definite source of funding like a University.

- Absence of laws or any enforcing mechanism in Auroville slows down the process in the short run =>extremely frustrating.
- Loans are not possible as the unit is a part of AV Foundation and not the unit director's own asset.
- Aurovillians are difficult to convince. Sometimes is more difficult to get the permission from the Aurovillians than from the TNEB.

However, an optimistic unit director answered the question about the difficulties faced by his unit with the following: "We do not have many difficulties, it is pretty harmonious". There is still hope…

4.1.5 General remark about the technical implementers

Among the technical people interviewed different opinions came out about their unit and its role in Auroville. It seems that the majority of the persons interviewed are more interested in doing projects for Auroville than outside. The notable exception is Jan Imhoff, who almost has to find project outside Auroville, since the local condition there are not optimal for wind power generation.

4.1.6 What do the technical implementers think about the master plan and the idea of self-sufficiency?

The different people interviewed had very different opinions about this plan. None of them seems to have really collaborated to its preparation, even though 2 have admitted to have been a little bit involved at the beginning. The majority did not really read it. One person was very enthusiastic, saying that it was fully needed to transform Mother's vision (something that speak to the heart) into reality. On the other hand, one other technical implementer was quite strong with it, saying:"I do not think anything about it".

About the self-sufficiency, the great majority of the technical implementers was quite enthusiastic about this idea, admitting however that it would be very difficult to achieve. It is also important to notice that one of them thought that it was stupid to write this in the master plan and that the grid will be anyway needed, at least for backups. "The people who write such things have no idea, what they are talking about. We have to work first". The main mentioned barriers on the way towards self-sufficiency were of technical and economic orders. Moreover, most of the technical implementers interviewed were agreeing, saying that with the current technology state (and its price), it was not possible and it did not make sense (especially for the industrial zone). "The section concerning energy is a big dream. It is possible for households to be self-sufficient with renewable energies, but not for industries". One was going even further, saying that solar PV technology as it was now utilized was not a good solution, due to the lead acid batteries and their harmful impact on the environment. Almost all the technical implementers are waiting for a technological breakthrough. The fuel cell was very often quoted as a future hope (the production of hydrogen was however not often mentioned). Biomass utilisation has also been sometimes cited either in combination with a microturbine or a boiler for a classical Rankin cycle. On the other hand, Manfred's works on substitution of Diesel have not been mentioned by any other technical implementer.

On the other hand, the process of wheeling[2] was quite often cited. For some it is the only solution to become self-sufficient for other it is only a compensation solution:" The idea is to compensate conventional energy with non-conventional energy. This is not a way to become independent but it is to temporally compensate our grid consumption".

Regarding this idea of self-sufficiency, different people spoke about a better use of renewable energies, by using mini-grids to connect the different units. This could be applied even now in order to have a more efficient use of the renewable energies. The selfishness of certain Aurovillians who do not want to share was pointed out by one technical implementer. The lack of coordination between the different units concerned was often cited. The idea of starting at a small scale (one community for example) was pointed out by one of the interviewees. To get the permission of energy exchange with the TNEB (indispensable if mini-grid is decided), a general plan approved by the government is necessary.

Finally, for the technical implementers, the concept of self-sufficiency is very much related with the efficient use of energy, and thus sustainable energy. And this should begin now, since a lot can be done already now in this respect [5]. Different solutions were proposed by the technical implementers to increase Aurovillians'awareness.

Ways like publication of articles in AVNews, on Avnet or organisation of workshops were often pointed out. Some people were proposed the creation of an "efficiency unit" that could advise the Aurovilians, on better and more efficient appliances. Some interviewees were going even further, saying that this unit should start a review of each house in Auroville and propose concrete solutions.

During this study, the idea of the "efficiency unit" was proposed to the electrical service. However, they argued that they were already doing a lot and that again a lack of coordination with the other concerned units was not helping. Nevertheless, the electrical service was totally agreeing about the usefulness of such an "efficiency unit", that could be the result of a venture between different services within Auroville. On the other hand, the electrical service has a fully equipped (with electrical appliances, watt meters,…) classroom. Courses on energy efficiency and awareness raising can be conducted there. The electric service director, Ponusamy, said that he will organise such a course for the Aurovillians next June.

4.1.7 Is Auroville on the right track regarding sustainable energies?

In this section, the aim is to try to summarise the different personal opinions pointed out by the technical implementers.

All the technical implementers interviewed during this study were saying that the Auroville was on the right track regarding renewable energy. "Auroville is on the right track. It is challenging." The quantity of work realized and the number of installations in Auroville was often pointed out to push this affirmation. "The density of solar panels in Auroville (about 250 KW in a 20 km^2 area) is the highest at least in India" or "The amount of work and energy put in the renewable energies does not exist

[2] The principle is to have wind turbines in a place where there is a good wind (near Kanyakumary, South India, for example) and to produce there the same amount of energy consumed in Auroville.

anywhere else in the world". Even though, they were quite optimistic, the technical implementers kept also mentioning that not enough was done. "A lot is done in Auroville but you can never do enough" or "There is still a long way to go." This contradictory feeling was well summarized by on of the interviewees:" The situation of the renewable energy in Auroville is very remarkable but far from the objective".

So, how can the situation be improved in the future? Different options and hope were proposed. It was first question of the level of awareness in Auroville. This level was judged as being quite good by the majority: "Auroville as a whole has a lot of consciousness for renewable energies, much more than outside". However, during the discussions, this general statement was very often balanced by the diversity of the Aurovilians. "Some people in AV are aware of renewable energies, but there are also many that do not even think about it", or still stronger, "Auroville is a collection of strong individualists. There are lots of things happening with renewable energies (solar bowl, windmills,…) at the same time, but not together". The idea of some motivated people pushing for the whole community was well summarized by an interviewee: "The concept of renewable energy has evolved organically in Auroville. It was mainly because of passionate people working for it without expectations for monetary gains. They are the precursor on behalf of the whole community."

To raise the awareness of those who need it, most of the people interviewed thought of awareness campaigns through newspaper, website or workshops. The laws imposing use of renewable energies were not seen at something possible to implement. "Laws do not work; the only way is to convince people". Some more pessimistic people think that Auroville is not that different form outside and that change in the behaviour will not happen before something really strong happens outside. "Nobody wants to be told how to live. Some people in Auroville think that without motorbikes you cannot live. You cannot force them. It will probably not change before something happens outside".

The example of the green belt was often quoted as a very positive sign of the willingness of the Aurovillians. In fact, in this part of the township, the inhabitants have signed an agreement of none use of the TNEB. It works but it seems difficult to impose this for the whole community. Indeed, the people living in the green belt have decided to live a simpler life, which in not the case of the "city" inhabitants. Because, even if "the aim of Auroville is to demonstrate that a different life is possible", a lot of people do not want to live without fridge, TV or washing machines which is very difficult to sustain with renewable energy only. "The ideal of Auroville is also an ideal of beauty; to have a well washed and ironed shirt is also very important in Auroville". Moreover, the people in the green belt have maybe more a technical spirit and are interested to maintain properly their solar system and understand how it works. This maybe not the case in the "city" part, where the people want only to push a button to see their appliances working.

For some technical implementers, another hope relies in the lack of reliability of the TNEB. Since the grid suffers from very frequent power cuts, the renewable energies can bring a solution. If they are used only as backup, the quantity needed is less and then the investment becomes more affordable. This could be a way to start the implementation more renewable units.

About the investment cost, it seems that it is really a barrier for a lot of people. In that respect, the hope relies in better energy policies of the Indian government, with a higher cost of electricity (especially for the farmers) and intelligent subsidies

programs for the renewable energies. In that respect, one interviewee was very optimistic: “Is Auroville on the right track? Auroville is a very small community. India as a whole is on the right track!”.

4.2 Visionaries and Town Planners

This group of people includes some of the town-planners who are working actively in the development of the city, as well as some external consultants or persons who have been attached to the Auroville project for a long time. The aim of the interviews was to get an idea of the evolution of Auroville, their opinion about the present situation and to know more about future plans for the city.

4.2.1 Past and present of Auroville

“The situation in Auroville is far from being the ideal picture that someone may get from our website”. However, the general feeling among the interviewees was that in Auroville they are trying to do their best. Besides the difficulties in obtaining funds, two main ‘social’ reasons have been pointed out for the slow development of the city.

First, is the individualistic spirit existing among the population. At the beginning, very few people were living in this place and the individual initiatives as well as the creation of new units were welcomed. From these pioneer years, Aurovillians still have the habit of doing all the things by themselves without the help of the outside. In the current state of things, with a growing population, the mentality has to change and the inhabitants should evolve from independent ‘islands’ to a more collective approach.

Many things are happening in Auroville in bits and pieces, but there is no systems approach. “There are pockets of excellence scattered in Auroville” said Prof. B. Mohanty. But it’s necessary to use them in the city in a holistic way. People who are aware try to do something, but very often, they do not implement the right solution because they do not have the means or because they cannot see the problem in its whole complexity and they implement only local solutions. “For planning perspective one should look at the whole chain. If Auroville wants to be a sustainable township, it must begin to look at the problem as a whole.” That means that Auroville has to think as a city and not as individuals. Times have changed, the Aurovillian experience is known abroad and now they could experiment more technologies with the help of other institutions, including, according to one town planner, partnership with multinationals.

The other reasons pointed out why Auroville is developing so slowly is the absence of laws together with the very diverse backgrounds existing here. It is one of the main principles of the city, and since the population has so diverse backgrounds and so different ideas (this is one of the advantages of this place according to many), the decision making process is very often slowed down. “The Absence of laws or any enforcing mechanism in Auroville slows down the process in the short run. It is sometimes extremely frustrating but on the other hand very exiting”.

Since nothing can be imposed, the best and sometimes, the only way of making people aware of some subject is information through the AV news, workshops, conferences, etc.

4.2.2 Meaning of the Master Plan

The Master Plan is a legalised expression of Auroville's vision. It exists since 1996, but it was only written in 2001 because of two main reasons. First, it is a legal requirement of the 'Auroville Foundation Act' and secondly, it represents a legal instrument in order to safeguard the lands still not owned by Auroville from the speculations. The Auroville Master Plan (Perspective: 2025) was written by G. Dattatrey, a retired urban planner. The plan has already been accepted by the government of India, but it still needs to be approved by the Tamil Nadu government, state where Auroville is located. It is only a perspective master plan that must be seen as a road map that will help for the transformation of the vision into reality. It needs to be followed by sub-plans of shorter duration as well as specialized plans as for example an energy plan, water plan or transports plan.

One external interviewee criticized the top-down approach of the Mater Plan especially regarding the energy section. He sees in this type of approach a lack of data for making previsions. He thinks that a bottom-up approach is necessary here, but it is not possible currently due to the lack of basic data. The top-down approach was right at the beginning. However, now the population is growing, as well as its needs, so that this approach is not the best. In fact, while planning a town, a combination of top-down and bottom-up approach is needed along with continuous feedback from the community. A bottom up approach should be preferred with first a clear definition of the needs.

4.2.3 Is Auroville on the right track regarding sustainable energies?

Most of the town planners interviewed agreed in saying that there is a high level of awareness regarding renewable energies in Auroville, but that people are not really sensitized, they do not act consequently. The level of awareness is not enough to push people to change their habits. The commitment among the current population should increase. A specialized unit should be created to really sensitize people, to make them aware of the impact of their habits and to give them the whole picture as well as some constructive propositions. It is the only solution, since there is no critical mass and the Aurovillians are too busy in their everyday life to act by their own. Concretely, this should lead to a drastic reduction of consumption, since a lot can be done in that way. For example, if someone has a solar panel, he thinks about reducing the consumption. If it is the grid, one just plugs everything possible.

The renewable scenario in Auroville is lead by a few motivated people. A minority has done a significant work regarding sustainable energy in Auroville. This resulted in a few isolated initiatives, but not in a community level action. The main reason for this is the diversity of backgrounds and aspirations. There are many different ideas, but no consensus.

However, one of the advantages of this place is that the population is very open to these ideas and is willing to support this type of energy. A large majority considers themselves as eco-conscious, but argue that the main problem is money. Some Aurovillians see the connection to the TNEB as something inevitable because alternative energies are still to expensive.

The first comers had a high level of commitment. This is no more the case for many of the newcomers. However, the level of eco-consciousness is also a question of personality and not of time spent in Auroville.

4.2.4 Future trends

This section summarizes the main directions that the interviewees have pointed out for the future of the city.

Energy

The energy self-sufficiency of Auroville will be possible in the long term. Before its achievement, there will be a long period during which hybrid systems with the TNEB as backup will be necessary. At present, there are still technical and financial barriers for renewable energies. However, with the technological advancement, renewable energies will be used more and more instead of the grid until the self-sufficiency is reached.

The first step to go towards this goal is energy conservation measures. These measures have to be implemented by awareness, not by laws. The electrical unit of Auroville has to take the lead to make the people aware. After an efficient use of current devices, the awareness should be pushed towards the use more efficient devices. The last step of this way towards self-sufficiency is renewable energy. These steps should be codified in the energy plan that will be prepared. However, it seems that the focus right now is more on restructuring the grid infrastructure than on renewable energy sources.

Sustainable energy is clearly related to efficient use of energy. People, even governments, have tendency to look only at the supply side, at short-term, fragmented but easy solutions. However nowadays, one has to look at the demand as well as at the supply side. First, one has to clearly define what the needs are. Then, the supply side is important as well as the environmental impact, once the demand is well defined. It is necessary to look at the whole life cycle from production to utilization as well as the environmental impacts. Today, decentralized power generation, utilizing an appropriate technology is more desirable.

Even in Auroville different decentralized power plants could be implemented using different technologies (biomass, solar, wind…) according to the local potential. Instead of having only the TNEB grid, it would be a better option to have small decentralized power plants adapted to the environment (e.g. where biomass is available, generate the energy in this way) and thereby, create small grids. Auroville would be the right place to implement such a network. A proposal that is still under discussion is the project of the wind farm in the south of India. For a better match between supply and demand an integrated resource planning should be implemented in order to optimize the consumption and to define the real needs. Mini grids should be used to avoid the transmission losses. All this should be taken into account in the urban planning phase. The city planning should be done in a holistic way and the buildings and communities should be placed according to the available resources in each zone.

In this context, the Alternative Energy Group (Jos, Hemant, Carsten, Matthias, Mohanty, Ponusamy, Toine…) has been created a short time ago and is starting to meet regularly. By the end of 2003 the first energy development plan will probably be ready. In the context of the Asia Urbs project, Auroville has signed a contract for the next 8 years.

Transport

According to the planners and visionaries, the generalized opinion is that transport is currently a big problem and that all traffic should be non-polluting in the city. The city centre should definitely be kept free of polluting vehicles. The emphasis is first put on having non-polluting public transport and then non-polluting private vehicles. A detailed transport management plan will come in the future. However, there is no time frame for it.

In reaction to the transport section of the master plan, which he found unsatisfactory, Manfred has proposed the *Auroville Mobility Concept* [6] written by the traffic planner Hans Billinger. The aim of this report is to work out with more details the mobility parameters of the Master Plan. Based on the Master Plan's general considerations on traffic, especially the aim of giving preference to non-polluting movement, a network of roads and pathways has been proposed. Furthermore, it gives an important role to the public transport in Auroville. Since it is the result of some discussions with an outside fellow, it does not correspond to the vision of the Aurovillians. Some people may like it, and some may not.

The external interviewees agree in saying that the extended use of mopeds and motorbikes in Auroville is the result of the lack of sensitization in this respect.

Building Codes

As mentioned before, one of the main characteristics of Auroville is the absence of laws or rules. However, the idea of building codes came out quite often during the interviews with the planners and visionaries. The objective of these building codes could be to give some guidelines to be followed in the construction process according to the concept of energy efficient building. These building codes are something that is supposed to evolve with time. Water conservation is the first field where regulations will appear, since water scarcity is at present the most important limitation for further development of Auroville. Solar water heaters, dry toilettes, etc. are expected to be included in these building codes in a further stage. The discussion about these codes has not even started and the planners and visionaries do not know how people will react to such imposition. But essentially, there is no choice for these building codes. However, if these codes cannot be imposed (following the main principle of Auroville), people will need to be convinced that it is in their best interest, so that these rules will be accepted by the community.

Currently, a commission evaluating the building projects already exists. However, the plans do not have to fit with written laws. The commission ensures that the projects are conform with the general idea of the city (the planning of the four zones, etc.). However, it seems that this commission has not a real power and that some projects have been realised without its authorization.

Influence in the surrounding villages

According to one town planner, up to now the surrounding villages have benefit of Auroville in the form of jobs, education and health facilities. But from now, there will be more focus on the co-development of these villages.

4.3 Architects

Some of the architects working for the design of the public and private buildings of the city have been interviewed. The aim of the interviews has been to see what they think about the necessity of some building codes and if they apply energy efficient building techniques.

4.3.1 Energy efficient building

It is a fact that the climate in Auroville is the worst that can be found from the architectural point of view. In summer there are almost no temperature variations between day and night, and along the seasons, the climates can pass from hot dry to hot wet. Therefore, it is difficult to build energy efficient buildings. Furthermore, according to one architect interviewed the appropriate building materials are not always available in Auroville. Some of the rules to take into account are the orientation of the building, the use of appropriate building materials, the positioning of the windows, cutting the sun radiation, ensuring good natural ventilation creating differences of temperatures into the spaces and taking care of the slope of the roofs. However, one architect mentioned that more attention should be paid at the local architectural traditions because very often these traditions and beliefs are based on practical considerations.

Awareness of the concept of energy efficient building exists among the architects and they try to apply it in their buildings. They explain all these principles to their customers, but finally they are not always implemented. It is not a problem of money, since energy efficient does not necessarily mean more expensive, but sometimes the aesthetic aspect plays an important role.

Finally, it is difficult to have a global view of this topic in Auroville. First of all, it seems that there are some personal conflicts among the architects. The harmony was not the impression felt. Secondly, it is difficult to have a clear idea of the real application of this concept in Auroville. For example, a famous architect spent a long time describing all the possible techniques she knew, but at the end she could only give one example of a single house where she had implemented them.

Another interviewee pointed out that energy efficient building is not the only way to sustainability. “One should adapt oneself to the local conditions.” This means working less in summer, adapt the schedules to the climate, etc.

4.3.2 Meaning of the Master Plan

According to one of the interviewees, more architects should have been involved in the Master Plan.

4.3.3 Is Auroville on the right track regarding sustainable energies?

For the architects, the level of awareness in Auroville is quite high compared with the rest of India. But people do not act according with this awareness, since it is still possible for them to pay the electricity bill.

4.3.4 Future

Water is the big problem for the development of Auroville. A more efficient water harvesting should be accomplished. This is the big challenge for the future and for

the growing of the community. The solution should be to stop building aseptic tanks and use compost toilettes (which doesn't need water).
Each community is building its own infrastructure regarding electricity, water distribution, waste water treatment, etc. but, there should be a general plan for the city, so that it could be done in a more efficient way.
According to one architect, a prevision of 50,000 inhabitants in AV is unrealistic, mainly because of the problems of drinking water. In a first stage, 10,000 inhabitants should be envisaged for the next 10 or 20 years and once this objective is achieved, more growing could be planned. At present, even if there are around 1800 Aurovillians, there are also 1500 to 2000 guests and a workforce of around 4500. This floating population should also be taken into account while planning the various facilities.

Transport

One of the interviewees thought that the centre of the city should only be accessible for two wheelers vehicles (cycles and motorbikes). Since the city is still under construction, the centre should be accessible to trucks only some hours per day. The ideal would be small roads in the centre with only space for two wheelers (polluting or non-polluting).

Building Codes

According to an architect, in terms of bioclimatic factors such as energy, water and waste, Auroville needs some regulations or rules. Some general guidelines could be given for an efficient building. However, it has to be taken into account that the appropriate building materials are not always there.
On the other hand, there are some architects that think that rules are not necessary because there need to be place for creativity.

Surrounding villages

It is not possible that Auroville remains an island. It has to develop taking into account the surrounding villages (co-development), which will only grow and grow as the city develops further. At present there are around 4500 workers coming every day to work in Auroville. They will never become Aurovillians and they do not have the rights of the Aurovillians. "You need them, but you do not want to see them" said one of the interviewee. Finally, they cannot take advantage of many of the facilities existing in Auroville.

4.4 End-users

4.4.1 Motivations

The most notable thing about the Aurovillians is that they at least know the environmental problems and are willing to implement the renewable energy options when it is possible. However, the level of awareness and degree of willingness to adjust differs quite a lot. Consequently the extent of actual actions also changes significantly. It is also important to notice that one person interviewed mentioned that she had seen more environmental awareness in her country in Europe than in Auroville.

The communities in the green belt have their own guidelines regarding energy. In fact they signed an agreement not to have any grid connections and it is not likely to change in near future. However, for the city area the grid is omnipresent. For any new structure, grid electricity is the most convenient and the cheapest option available.

Many people fear that since now Auroville is a nice place to stay, many of the newcomers do not have the same motivation as the pioneers. According to many interviewees, the consumer mentality is creeping in Auroville. Thus, a majority is now looking for more and more comforts, which solar or wind cannot provide.

There are obviously a few people who think that using renewable energy is an important consideration.

4.4.2 Advantages

The environmental benefits are obvious. The mental satisfaction of having a green source of energy is also important for many of the Aurovillians. However, the most important advantage for the users seems to be the freedom from TNEB that solar or wind offer. For many of the Aurovillians renewable energy means less power cuts and a better control on their energy needs.

Some Aurovillians thought that it will soon become a cost-competitive option, as the price of electricity is bound to rise. Currently, it is kept low artificially by means of government subsidies. It has a great political advantage, but sooner or later this will change. Already there is a pressure on the state government from central government and World Bank to charge the electricity for farmers (it is free till today). At this moment the difference in conventional and non-conventional energy will not be very high. Furthermore, Auroville is already paying a very high cost as it is identified as a foundation.

For some interviewees, solar or wind pumps are better as compared to the noise and smoke produced by diesel engine.

One interesting advantage quoted by a community user is that it means more quiet surroundings. Since his community is currently dependent fully on solar, there are no TVs or big sound systems in the community. Therefore, the surrounding is kept nice.

Other interesting advantage quoted was that the renewable energy sources help them to keep in tune with the climate, which is considered to be good spiritually.

4.4.3 Difficulties

Cost and system limitations

The most important difficulty often pointed out is the high initial investment. This, according to experts, will continue to be a problem at least in the near future. In fact, very often the investment cost was quoted first. “Unless the money comes, we are on the old track.” A lot of people did not even think of the adjustment. However, one optimistic user said, “The solar installation is costly, but affordable if you want to do it.”

Solar is a bit unreliable during the rainy season. There is also some time of the year when there is no wind (for the windmill). However, it is not so much a problem in

systems that are well designed and well maintained. But otherwise it can lead to major problems. One user said that his community has experienced water shortage for as much as 3 months a year due to this problem. So, people hesitate to relay on these systems for the entire year.

Pumping water seems to be a major item of consumption, especially for the farmers. Surface solar pumps can lift water only from a depth of 7-8m, whereas the water table in most of Auroville is very low. Considering the current water consumption pattern, experts fear that it will become even worse in future. Therefore, they either need a submersible pump (even more costly) or another booster pump running either on wind or diesel. Many of the people are using their solar pumps either in combination with another pump or for lifting water from one storage to another.

Adjustments in lifestyle

Very frequently the high cost results in adjustments in the lifestyle. For some theses adjustments are a welcome change as they see it as a way of spiritual growth. As an important architect said (and many share this opinion) “Renewable energy does not mean just replacing the source of energy, it means reducing the need. It means reviewing your lifestyle.” And in fact, many people, especially in the green belt, are trying to live simply sometimes even without fans. A “green belter” concluded the interview with a remark, “Sustainability is all about life style”.

However, for majority of the population, it is too much of adjustment. Most of them need more electricity. Therefore, the cost of solar system to fulfil all their needs is very high.

Maintenance

According to some people, the batteries are a major nuisance for the environment so that they don’t want them. They also need regular maintenance and this can become problematic if the user is not interested in doing the basic. Although the “AV Solar Service” maintains the batteries very well, it expects some interest from the users. The recurring cost of the battery replacement every five or six years is also a very costly affair. The low quality of the batteries can be a drawback in India if the brand is not chosen carefully.

The electronic parts in the system like charge controllers are costly and many times, quite problematic. Different brands are available and the temptation is high for the users to buy the cheapest (unreliable) products.

According to some users Windmills give more problem than solar (dwell not good, lubrication, bearings under dimensioned, etc…) and they need more maintenance. However, for some they are “perfect”. The experience for biogas is similar. The people who have cattle usually have biogas plants. Most think that these plants work very well, but some of the communities have problems to maintain them. Solutions are always easy to find.

Failures

It is important to notice that some users decided to go for renewable but stopped in the middle of the way. Especially, the case of a community that bought 96 panels of 50 Watt but then decided that it did not make sense because of the need of energy (for appliances like fridges, washing machines etc) and so the number of batteries

required was very high. “These lead acid batteries do not make sense. Where is the ecology?”

When asked about having a hybrid (TNEB-solar), he was not quite convinced about it. “Hybrid till what end?” he asked.

So, they kept the panels in their boxes for several years before selling them back to the CSR (that had provided them). The same history happened in another community about a wind generator that was installed by AEP but never run, since the inhabitants had decided in the mean time to go for the grid connection.

4.4.4 Future of sustainable energy in Auroville

According to most of the users interviewed, becoming self-sufficient in energy will take a lot of time. It seems difficult especially for heavy uses (like industry and devices like washing machines). It will be possible when new technologies become available, which are feasible technically as well as financially. Many people pointed out fuel cells as the next generation technology.

Most of the users interviewed said that the majority of the population is really active in this aspect, but a small amount of people are really concerned about renewable energies. These people will make a difference. However, some people also feel that Auroville is doing enough in this aspect and slowly things will happen.

Some interviewees feel there should be a general policy coming from the planners and then accepted and applied by the community. On the other hand, some feel that regulation can be good in the case of energy but can also be used badly for other purposes. It can be used as a backdoor for laws in future. So, it is better not to go for it.

Some people think that the consumer mentality will not change unless there is something drastic, unless “their backs are against the wall”. However, some are more optimistic and think that more and more information through AV Net, AV News, and various workshops, seminars etc. can make a lot of difference.

It is interesting to note that almost every user thinks that the potential is there. Moreover, there are also a lot of motivated people and a lot of running systems that can be examples for others. However, a few said that regarding sustainable energy, Auroville was on a wrong track.

4.4.5 General

Transport

The major mode of transport for most of the Aurovillians is a moped or motorbike. Some people do use cycles but their proportion is comparatively smaller. Though most of the interviewees thought that transport was a major problem, no clear solution was proposed by the end-users. One of them had this very poetic exclamation: “Motorbikes are a painful necessity here”. Compared to the initial period, life style has changed in Auroville. People are very busy (more meetings) and need more mobility. So motorcycles became more convenient. Cycle is not taken into account seriously now. The evidence is that nowadays money first goes for roads than for the cycle paths.

The people coming from European countries find this climate too hot and humid. So, cycling here is too difficult. Motorised transport is obviously faster and more comfortable. Some users think that they are too busy to use bicycles. “You know, I do not have time to cycle. Who has time? ”. For some it is the best means of transport as it gives them a lot of freedom to move around. For young people it is not really a necessity but more a question of fashion.

One interesting initiative was the solar bicycles developed by Carsten. However, they are very costly because some of the spare parts are imported. The autonomy offered by them is very small (10-15 km). So, they are not popular. For the moment, this is also due to a lack of infrastructure (see section Technical implementers). However, one interviewee commented that if they can become fashionable, then everybody will but one.

One farm has decided to buy mopeds with treys for transporting their produce (for delivery). According to them, sharing the vehicles with other farms can be a good idea and it is feasible.

Building

The common Aurovillians do not seem to be very much aware of the concept of energy efficiency building. They trust the architects to take care of it. However, some people like Stephane are well aware of this fact and they have implemented it in their homes.

Master plan

Common Aurovillians doid not seem to know much about the master plan. Some have gone through it and found it a good idea. Some thought that it would help to organise the city. One Aurovillian even had this very strong affirmation: “Currently, there is sort of a mafia in Auroville and the master plan is good in that sense to put back some order. It could help to fight against some “Aurovillian lobbies”.”

Some think that the master plan is an imposed idea. The city should be allowed to grow organically. So, for them the master plan is not a step further.

4.4.6 Having a solar system in Auroville

Finally, in this section the different problems occurring in Auroville with the domestic solar installations will be summarised.

For a user, to install a solar system is quite complicated, due to the different units and services dealing with solar energy. If these different entities are well known in Auroville, the question remains: who to contact? Moreover, it seems that there is a clear lack of coordination between the different people (coming from different units) installing the various parts of the installations (panels, batteries, inverters, wiring,…). Nobody takes the responsibility of the whole system. This was pointed out especially by the people in charge of the maintenance. One of them said:” It is difficult to maintain the solar systems because they have been installed by different people”. The same person was even speaking about “messy systems” in some cases. To emphasis the lack of coordination between the different units dealing with solar energy, it is interesting to notice that nobody really knows the total solar power installed in Auroville. Three different technical implementers gave three different answers. The range given was between 200 and 500 kW. On the other hand, the

only written document on this topic that could be found during this project, although it was not taking into account the solar pumping systems “transformed” in batteries charger, was mentioning 65 kW.

On the other end, the users can be also blamed sometimes. In fact, it seems that, once the panels have been bought (huge investment), certain users want to economise on the other parts, sometimes on batteries or inverters and very often on wiring. It results in bad functioning systems, difficult to maintain and that do not give satisfaction. It contributes then to give a bad name to the reliability of the solar systems. The maintenance is also a very important part for a well functioning solar system. If a service exists for that purposes in Auroville, it seems that sometimes the users are not interested to do the basic of the basic, which is a bit discouraging for the maintainers. Moreover, the users’ ideas often change and if in the beginning they think to be able to leave with a few electrical appliances they need change after sometimes. This fact was pointed out by a solar implementer: “Very often, customers change their mind after a very few times and want a bigger system”. It can also maybe due sometimes to a lack of technical advice. Regarding advices, another technician also mentioned that sometimes the users are more interesting in listening to relatives who are supposed to have some knowledge in that topic rather than official Aurovillians specialists.

The range of size of the personal installations in Auroville is quite large from some tens watts to some kilowatts for the biggest. The most modest installations, when used as unique energy source, allow running some efficient lights and a sound system or a laptop from time to time. For some people met during this project, this is sufficient. On the other hand, the larger systems permit fans, kitchen devices, computers, printers, scanners, small fridges etc.

About the installation visited, it was noticed, that to work properly, a solar system has to be well designed and maintained. It doesn’t seem to be always the case in Auroville. In fact, two situations are faced: individual or community systems. The first one is easier to manage since only one interest is involved. However, it is not so simple and some problems may occur (see above).

For community systems, the problems are the same but they are multiplied by the number of different users taking power from the same installation.

For this study, two different communities fully self-sufficient regarding energy production were studied more in details.

The first one is a great success. It had been planned from the beginning as an eco-friendly community. Currently, the electricity is produced by solar PV panels, the water is pumped by a solar pump and a wind mill, water is heated by a solar heater, and last but not least, the cooking is done with biogas. The electrical energy available is enough to power some low consumption bulbs, some computers and small sound systems and occasionally, a fan. The habitants are very committed to their community. There were some problems at the beginning, but according to a community member, not more that was expected. The system was designed according to the community needs and all the people had agreed, so that no sizing problems were encountered afterwards.

On the other hand, another Aurovillian community claming to run only with renewable energy is not a real success. First of all, they use LGP for cooking purposes, so in that sense, they are not fully self-sufficient. Except this, the

technologies used are the same than for the previous example. But the problem is not this one. The original idea of this community was launched by some friends and was to build a real eco-friendly community, where the motivated people and not those who can afford a solar system would live. The project was funded by future inhabitants' personal money as well as by donations. The problem is that from the beginning it did not work out very well. Maybe the original design (especially of the solar system) was not satisfactory or the expectations were higher as what was really available.

The result has been that from the beginning, 10 years ago, the inhabitants have pretty much changed. The initial people involved with the idea left the community and nowadays the inhabitants are not committed to the community neither to the solar system. Nobody really cares about the others and adapts his appliances to the real capacity of the system that probably no one really knows within the community. The result is a very unreliable power system that cuts off very often at night. This should never happen with a well designed and used installation. For this unreliability reason, more and more people are pushing for a TNEB connection or a generator. It has not happen yet for a reason of lack of money. It is also interesting to notice that the real unreliability of the system depends very much on the people speaking: for some it is quite OK, for others is just impossible whereas others do not care since they have their own small home solar system kit for their basic needs.

On the technical point of view, according to a solar technician, the system was very badly installed from the beginning. Especially the wiring was done by at least 10 different people. Currently, it seems that only a few people are really interested in doing things to increase the situation the others thinking that solar is hopeless and it is definitely worth to go for an external source of energy. The people interested in the current system do not really have the technical ability to maintain the system properly.

5. Recommendations and general comments

This chapter wants to be more subjective than the precedent and the idea is to give our personal point of view about everything we have been listening to during this month. Furthermore, some suggestions or ideas given by the interviewees and that seemed interesting to us will also be pointed out. Although one month is too short to do an exhaustive study, it can be considered enough for a first approach and still remain objective in the analysis. The comments are divided in four main sections energy, transport, planning and general. This could be the starting point of further longer studies or implementation programmes. They are just the impressions of some students who spent one month here and talked to a lot of people....

“Breath, smile and move slowly”, said one long term guest. It is something to think about, since in Auroville one may have the feeling that people are taking more and more the bad habits of the stressed Western people.

5.1 Energy

As mentioned before, the concept of sustainable energy is not only related to renewable energies, but also to a more efficient use of it in the day-to-day life:

Sustainable energy = Energy efficiency + renewable energy

Therefore, some suggestions are given in both aspects.

Energy efficiency

- In order to raise awareness and sensitization in energy efficiency among the population and as a first contact of the end-users with the concept of sustainable energy, a unit should be created to advise people on how to live in a simple and efficient way (it could be the Efficiency Unit). “There should be an effort to encourage people to live simply, modestly and with a good use of resources”, said one of the interviewees. The aim would be to act as information service on energy efficient practices in the day-to-day life. The energy efficient practices could be in a first time the avoiding of wastage (switch off the light while nobody is in the room) and then a slow moving towards efficient appliances. In this context, the Electrical Service told us that they are willing to organise an awareness campaign and that a course on energy efficiency will be organised in June. The idea of such a unit was suggested by several interviewees.
- This same “efficiency unit”, or another could make the link between the customers and the different renewable energy units in Auroville. It could also help first, to increase the coordination between the different units and secondly, to make the end-users clear about who is doing what in the city
- Concerning the current energy units, efforts are needed in defining the tasks of each unit clearly and informing the Aurovillians about the result. It would be a good idea to create a central maintenance unit, in charge of all type of maintenance in the renewable energy systems, or at list for the solar plants, installed in the city. Surely, this would simplify the task for the technical units, increase the efficiency of the service and extend the life of most of these systems.

- During the interviews, a lot of people spoke about the problem of water, which worried them more than energy in itself. In fact, the relationship between water and energy is really strong, even if the majority of the people are not aware of it, since energy is needed to pump the water, to filter it, etc. A general awareness campaign, including the surrounding villages, could be implemented concerning the subject of the water.

Renewable energy

- In general, no one seems to know the exact amount of PV power installed in Auroville. Ideas are varying between 200 kW (Carsten) to 500 kW (Hemant). The only written document that has been found is Rama's list of battery systems, which includes solar PV and UPS systems but not pumping systems use to charge batteries. According to this list, the total solar PV power installed is about 65 kW, (figure that seems too low). Since the city will only grow in the future, it is now the moment to decide how to document the renewable energy systems. If the idea of decentralized power plants goes forward, it can really be useful to have somewhere written where and what is already installed in Auroville. For sure, it needs some effort and time from the concerned persons, but it is something that seems to be necessary, so that it can be consulted by planners and all the people involved in the development of the city.
- A great part of the Aurovillians thinks that renewable energy systems are expensive. In order to take a maximum profit of the installed infrastructure, there should be a general policy concerning renewable energies coming from the town-planners. This policy should be accepted and applied by the community in order to succeed. The idea of mini-grids with decentralized power plants including renewable energy generators can be the direction for the future in Auroville.
- In the same direction, a survey of the electricity consumption and the load pattern in the city should be implemented before to go further in the planning of the future energy grid of the city. The study should include the type and the quantity of appliances that are being used in each household in Auroville, their consumption and load pattern. The next step should be to suggest more efficient ways of using these appliances (tricks to diminish the daily energy consumption in a simple way) and when possible to substitute them for more efficient (low consumption) devices.
- During this study, our feeling was that very few people knew about Manfred's work with plant oil (Pongan seeds) for substitution of diesel. Or at least, this solution was never quoted as a future hope. We thought that it was very interesting and promising, and that there was a need to put more efforts in this work as well as in making people aware of it. For this, more tests are needed and Manfred is waiting for open minded engine owners. The awareness programme can be taken up by the proposed "efficiency unit".

5.2 Town - planning

At present, town planners are very busy defining the next phases of the master plan. Several studies are on the way, in order to define the development plan in each sector (water, energy, sewage, etc.). Probably, before going further in the development, some of the following comments should be taken into account.

- Maybe the time has come for Auroville to have an external audit to know where Auroville is. The aim should be to do an environmental impact assessment as well as an economical, social and energy review of the city. This study should be done by someone from the outside, which could see the entire project objectively. This should be seen as a way to confront Aurovillians with the reality, which is often the unique way of being aware of the real situation and to get the push to introduce changes.
- More effort should be done in improving/increasing the coordination between the different units. We have often had the feeling that each unit is doing its work individually, without taking into account what others have already done, particularly regarding solar energy. Moreover, more coordination should exist between building services engineers, structural engineers, architects and end users in the construction process of new buildings.
- The influence of Auroville in the surrounding villages has been very big, but much effort should be done in helping the villages to co-develop with Auroville. These villages should be taken into account in the further planning and development of the city. In case of electricity, if Auroville decides to go for underground cables or not to use TNEB anymore, the surrounding villages will be greatly affected. In that case, it is necessary to consider the problems of the villagers.
- All the external 'consultants' think that AV is not doing enough regarding RE. (see section of town planners)
- For Prof. Mohanty, sustainable energy is clearly related to efficient use of energy. People have a tendency to look only at the demand side, at short-term, which is a fragmented but easy solution. Nowadays, it is necessary to look at the whole life cycle including demand side, supply side as well as the environmental impacts at each stage. This will be especially true in Auroville, where decentralized power plants will be the tendency for the future.
- According to Prof. Chaman Lal Gupta, "Effectivity is doing the right thing in the right way." Maybe Auroville should work with more effectivity.

5.3 Transport

After one month ridding around on a bicycle, we confirm that transport is a big, big problem in Auroville! All the Aurovillians are aware of it and agree in saying that something has to be done. However, the most surprising is that people think of solutions in the long term only (e.g. public transport when the city will reach the critical population necessary to make it useful, reliable and profitable).

We think that something should also be envisaged for the intermediate phases. Sri Aurobindo said "We should not worry because we have eternity, but we should not tarry because we have infinity to do." Some solutions that could be implemented and that could be even used once the city is completed are:

- Electrical vehicles, like the REVA cars (we know that there is already one in the city!), or any other type of non-polluting vehicles that could be shared among the community inhabitants for long distance displacements.
- If it is not possible to get rid of polluting vehicles instantly, one idea could be to share polluting transport vehicles among users, as it was suggested by a farmer.

- To share non-polluting vehicles inside the city (Carsten solar bicycles, for example) with a good infrastructure (places to charge or change the batteries, parking for these vehicles, etc.).
- Reducing the distances within the different places in Auroville can also be a solution to reduce mobility problem. This should be taken into account during the planning phase. Currently, “Pour Tous II” (shop and financial service) is being built near the solar kitchen to create a concentrate pole of interest.

Of course, these solutions need an initial investment and are more expensive than using a motorbike. However, as Aurovillians are too busy to cycle, but aware of the problems created by their “painful necessities”, they might agree with this additional effort. Certainly, it is unbearable to use bicycles when one has 5 appointments in the same day each one in one part of the city. But to go only from home to work, Aurovillians could think twice before taking the motorbike... And mediated this quacker saying: “the more hurried I go, the further I get behind”

Furthermore, a new guest/student/newcomer coming to Auroville and seeing all the motorbikes on the Solar Kitchen or Bharat Nivas, will first think of buying/hiring a mopped. The idea of trying to cycle will not even traverse his mind. Showing by example is the best way of making people aware... During the week of the Earth Day, Helmut presented his proposal for a mobility plan. It included public transport and non-polluting vehicles and surprisingly, at least for us, once the conference finished, he took his big polluting motorbike to go home!

5.4 Architecture – Building

Building codes for construction in the city will probably appear in a near future. It would be a very good idea to integrate the solar passive and appropriate building technologies in them. Each architect is aware of the concept of energy efficient building, but they are not always sensitize about it and they give priority to the aesthetic side.

Why solar heaters could not be included in buildings from the beginning? For example, the Israeli government made a law forcing each new household to have a solar heater and it has been a great success. Currently, more than 95% of the houses are equipped with such device and this allowed great energy savings for the country.

5.5 General comments

- During the interviews, the degree of awareness of the Aurovillians regarding renewable energies has often been compared with the existing in the rest of India. This is a very easy comparison, since in India this awareness is very less. Of course, in this case, Auroville will always ‘win’. However, statistics says that around two thirds of the Auroville population is westerner. So, the level of awareness existing here should be better compared with the one existing in western countries. In this case, we are not sure whether the comparison would be advantageous for Auroville. Moreover, one Aurovillian clearly told us that she had seen more awareness in her country in Europe than here in the city of the dawn. Maybe it is not correct to talk about awareness, but about sensitization. Aurovillians are aware, but do not really act.

6. Lessons learned from the Aurovillian experience regarding renewable energies

For 34 years, Auroville has been very active in the field of renewable energies. The survey realised during one month in the city of the dawn permitted to give some general propositions for the township to try to help it on its way towards sustainability. It is also interesting to see what the Aurovillian experience can bring to developing countries and to what extend it can be reproduced. The experience acquired during this long period of time should help to provide some guidelines for renewable energy projects in India and elsewhere in the poorest country of the world. The aim of this chapter is to try to give some general ideas with the help of the successes and failures in the surrounding villages.

However, it is important to mention that the Aurovillian experience is very complex, due to the different people and ideas present there and it cannot be summarized easily, even if only the renewable energies are taken into account. Therefore, only some general remarks will be given here.

First of all, it seems that in Auroville, the renewable energy experience is not fully sustainable, at least from the financial point of view. Indeed, the great majority of the people who have a solar system paid it with their own money. Most of the renewable energy plants' owners are coming from developed countries and thus paid their systems with the money earned in the west. In fact, the monthly maintenance received by the Aurovilians working for the city (about 4000 Rs) allows them to live (survive) but not to afford huge solar plants. It is also important to keep in mind that the government subsidies were a real breakthrough to increase the number of renewable units in Auroville.

This means that for common people in developing countries it is very difficult to afford such a system. A good utilization of different subsidises, if available, can help. However, at least in India, the subsidy system is quite complicated and so the help of some specialists is a necessity. "AuroRE systems" in Auroville can provide such services. Most of the time, it seems that even an intelligent combination of the subsidies (if ever they exist) is not sufficient to make it affordable to common people, even less to the poorer sections. An external input of money is then really required most of the time. This can come from a government willing to promote clean technology, or an NGO.

Auroville Village Action Group has been working in the surrounding villages for the last 10-15 years. Two years ago, they tried to implement scheme proposed by HUDCO (Housing and Urban Development Corporation). The purpose was to create a model village using various building and renewable energy technologies, but it didn't work out. At first HUDCO was supposed to give full funding, but finally then they wanted the village to give half of it (17.5 lacks), which was impossible.

To reduce the financial barriers, the solution of renting some solar devices for a certain time can also be interesting. This experience just started in Chennai and is about to start in Pondicherry with solar lanterns for street sellers. In both cases, AuroRE is at the origin of the project (c.f. survey of technical implementers). Since it seems to be a success, other similar ideas could be implemented elsewhere and not only in developing countries.

However, along with money, some other very important considerations have to be taken into account.

Indeed, another very important conclusion that the Aurovillian experience can bring, is that a renewable system really needs to be taken care of. It can not be imposed without the full approbation and understanding of the final users. All of them, for example, should be aware of the appliances that can be used with the system. It is very important that everybody trusts each other within the community. In Auroville, the problems with the solar system often hide deeper difficulties in the group of people. On the other hand, the users, at least one of them, need to have some technical background to understand the system and take the responsibility to ensure its proper use. The maintenance can be done regularly (once a month) by an external service provider (technician). The best solution is that the maintenance is done by the same person who installed it. Regarding the installation phase, it is quite an important operation that should be taken care of by only one person or organisation. A total package of the installation, including good quality panels, batteries, wiring, UPS, inverter if needed, etc…, should also be proposed to the customer so that the temptation of economize on certain part is avoided. Finally, the installer should also advise the customer on low consumption appliances to close the loop of sustainable energy.

Another option, in order to avoid problems within the community can be the use of individual solar devices, such as lanterns, etc. In this case, each one is responsible to manage his own system properly and can not blame the neighbour in case of power cuts.

Awareness and sensitization of the users is also very important. In the villages surrounding Auroville, there are quite a few misunderstandings about renewable energy. Villagers think that the panels won't work in winter, or the biogas needs a lot of maintenance etc.

It is important to take into account the views and needs of the users. In a village, concrete house is a status symbol. So, even though local materials are energy efficient, the villagers who have money don't even think about these alternatives. So, it is necessary to raise the consciousness of the villagers to increase the technology penetration.

There are also some practical problems in a village which are neglected many times. In the villages surrounding Auroville, the fear of theft was a drawback for solar systems. Furthermore, according to the villagers compressed earth blocks attract ants and the base of these walls becomes wet during monsoon. Ferro-cement roofs are said to leak and to need a lot of maintenance. There can be other reasons of the failure of the technology like improper setting of the ferrocement channels. However, it must be kept in mind that even one failure can prove to be major setback for the technology in a rural surrounding. Some biogas plants were installed in Auroville surrounding villages with government subsidies. However, due to some reasons (no one knows why) they failed and now it has become difficult to convince the villagers to try it again. So, it is necessary to implement these projects with extreme caution and proper follow-up. A good supporting service which the villagers can depend on for aftercare can be a determining point for the success of the technology.

Last but not least is that the users should feel the need for these technologies. This will not happen on its own. Attempts are necessary to create consciousness. Otherwise it can lead to failure. In Tamil Nadu, for example, the electricity is free for farmers. So, they will not feel the need of an alternative energy source. Since all the villages surrounding Auroville are electrified, it is very difficult that the rural people will look at renewable options on their own.

To summarize, finding money to implement a renewable system is not everything. The awareness and participation of the users in the decision making process as well as good supporting system is also very important. It is the key factor for the success of a renewable energy project.

7. Personal experience

Auroville is a unique place in the world, and even if we like it or not, it is just a great experience to see what it is and what is going on there. After that, one can have his own feelings about this place, which can also be balanced. If up to some extent one can have the impression of entering a sect in the beginning, especially through the website, it is not really the feeling after having spent some weeks there.

The impression at the beginning was to have reached a holiday resort in South-India. The number of westerners and the habits they brought (music, clothes, etc.) were increasing this feeling. However, after having spent 5 weeks in a technical unit, we can say that this impression was not fully true, since a lot of westerners are working quite hard for the betterment of the city.

These interviews, first of all, have been a fantastic way to discover Auroville from the inside and to realise the diversity of people living here. None of the interviews were the same, and the difference in answers for the same question was quite incredible. Even if the subject treated was the renewable energies, the discussions very often were reaching general aspects of life in Auroville and feelings about the world and its problems.

The impression is that some westerners took with them their working habits from abroad and did not really adapt to the local rhythm. It is amazing to see how the Indian people can remain quiet in stressful situations whereas the people from abroad want to manage all the problems at the same time. Moreover, the working schedules in the Aurovillian units are not really adapted to the local climate. In CSR for example, the workers and the staff people are on the spot from 8am to 5pm with one hour break for lunch 6 days a week. Better results could be achieved with a longer break after lunch to rest when the temperature reaches extreme.

The “village spirit” was also sometimes felt quite strongly. Auroville being quite a small community, almost everybody knows each other and the gossips are not rare. Moreover, according to one interviewee, some people were probably afraid to answer our opinion invitation on AVnet, because other Aurovillians could have read their feelings. This is a bit surprising for a community that wants to reach human unity.

We were also quite shocked by the gap between Auroville and the surrounding villages. Some villages or settlements are even sometimes in the middle of the city of the dawn, a bit hidden and can be discovered near some shortcuts through the forest. The impression is the cohabitation of some quite high-tech buildings with some poor traditional huts on a very small area. So what? Auroville is not a development NGO and its aim is to help itself to develop and reach a higher level of consciousness. But can this aim be achieved if Auroville stays an enclave in the middle of a poor neighbourhood? And what about the fact that these people are fully needed for their labour force to help the city to develop? The discussions we could have with some Aurovillians regarding this topic were very interesting and their opinions, as always, were quite different. For one, the case is similar to the foreign workers without legal documents in Europe. There are needed but we do not want to see them and to offer them the same facilities we have. Other Aurovilllians had more balanced opinion, saying that thousands of villagers have now a regular income for them and their families. The real impact of Auroville to the local villagers is, however,

difficult to assess. Current data should be compared with data before the beginning of the Aurovillian experience and also with data of other places in India. Among our group, we could not agree about a common idea on this topic, one being quite enthusiastic about the place and its impact on the surroundings, the two others being less positively impressed. It might be because of the difference in expectations from this place.

From the technical point of view, we also learned a lot about solar PV technologies. If this world was a bit unknown for us at the beginning, we have now a much better idea about the possibilities offered by such systems. Jos took really a lot of time to explain us the different aspects of the solar PV technology, never counting his time and energy. Moreover, above the technical aspects, he had a lot of human experiences to share with us, experiences gained with some years spent around the world to fight against misery, hunger and wars. Our discussions about the world and being in general were always long and fascinating, never boring.

The contacts with the great majority of the interviewees were very good. Only a few people really showed us that they were not really interested in giving their opinion and part of their precious time. Other than interviews, the informal contacts we could have with other people were rather with other guests than with Aurovillians. In fact, the city is quite spread out and no real central meeting point exists. Moreover, the Aurovillians are living permanently with a lot of guests. It is like a very touristy city and the questions asked by the outsiders are somehow always the same. The Aurovillians are therefore quite used to the guests and their interrogations about the city, and so, are not running after them to answer their questions. But anyway, most of the guests met were also very interesting, with a lot of experiences to share, stories to tell, etc. The lunch at the Centre Guest House was often lasting quite a long time, spiced with Indian epics and Swiss policies stories, whereas at night the ice-cream at the coffee-shop was always the opportunity to start never-ending discussions under the stars about our future or life in general...

For the two European members of the group, this stay appeared like some weeks out of India. It was sometimes good to get out of Auroville, to come back to India, to eat again some Indian food, etc. For the Indian member of the group, it was like a discovery of a new culture, a sort of a trip abroad without taking the plane. In 5 weeks, her progress in eating with fork and knife was quite impressive.

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9. Annexe - Questionnaire

9.1 End Users:

9.1.1 Practices

Energy

- Where does the energy you use everyday come from?
- Is there a renewable part?
- Do you know about the different Auroville technical units?
- Are they useful for you (installation and maintenance of your systems)?
- How is the whole system managed within the community?
- Do you try to reduce your energy consumption in your everyday life? How (bulbs/recycling/water....)?
- What do you think about hybrid system (solar-(bio)diesel / TNEB..)?

Buildings

- Have you ever heard about solar passive (efficient energy building)?
- If yes, have you tried to follow some of these rules in the construction of your house?
- If no, why?

Transport

- What are the means of transport you use? Why?
- Do you think alternatives are possible?
- Are you interested in electrical vehicles?
- How often do you travel by plane?
- For which purpose (holidays, work or need to earn some money abroad)?
- Have you ever thought of the environmental impacts of such flights?

General concepts on sustainable development and Auroville

- Do you know something about Auroville Master Plan? Especially regarding energy issues?
- What does it mean for you? What do you understand by sustainable energy?
- Do you think Auroville is doing enough regarding renewable energy?
- How do you judge your personal contribution?
- Do you think Auroville is on the right track?
- Do you know anything about “ecological footprint”?
- Who else do you think would be interesting to interview?

9.2 Town planners/Visionaries (including external consultants for the electrical network planning of Auroville):

- How the idea of energy independence has evolved from the beginning?

The master plan

- Who wrote it (especially the energy part)?

- How do they calculate the consumption at the end of the second phase (in 2.6.16)?

- What is the 'conservation measures' mentioned in 2.6.16? How will they be implemented (in absence of laws)?

- Is it really possible to become one day self-sufficient (especially with 50.000 habitants)?

- Are there any guidelines for the end-users?

- What do you mean by demand side and supply side management?

Transport

- What has been done till now about transport (from 1968/ planning policies 2.5.5)?

- Is there a detailed "transport management plan"?

- What are the alternatives to oil consumption for transport?

- Has the transport problem been taken into account in the urban planning?

- Something has been planned for the intermediate phases?

Buildings

- What about energy efficiency of buildings?

- Are there some rules / guidelines been proposed for the architects to follow?

General

- How can awareness being transformed into sensitization (in the absence of laws)?

- Has something changed in the attitude of the newcomers compared to the pioneers?

- Do you think Auroville is on the right track?

- Can the Aurovillian experience regarding renewable energy be reproduced elsewhere?

- Do you think it is a good example for the surrounding villages?

- Who else do you think would be interesting to interview?

9.3 Architects:

Energy efficient building

- Are you aware of the concept of energy efficient building?
- What do you think about the implementation of this concept in the Aurovillian buildings?
- What are the plans for the future (regarding energy efficient building)?
- Any guidelines will be written?

Air conditioning

- What do you think about air conditioning?
- Are there any alternatives?

Transport

- In the urban planning, has the transport problem been taken into account (in the beginning/now)?

Master Plan

- What do you think about the master plan (section regarding energy)?
- Were you involved in its preparation?
- What is your role in the urban planning?
- What is your role in the building process?

General

- Do you think Auroville is on the right track?
- Can the Aurovillian experience regarding renewable energy be reproduced elsewhere?
- Do you think it is a good example for the surrounding villages?
- Who else do you think will be interesting to interview?

9.4 Technical implementers:

The technical unit

- What kind of technologies your unit has developed?
- Are they used commercially (in Auroville or elsewhere)?
- What is your role in the installation and maintenance of renewable energy systems for the Aurovillian communities?
- Where does the money for the research come from?
- What are the difficulties you face?
- Is your unit well known in Auroville?

The Master Plan

- What do you think about the master plan (energy section)?
- Were you involved in its preparation?
- How will it be implemented?

General

- Do you think Auroville is on the right track?
- How can the Aurovillian experience regarding renewable energy be reproduced elsewhere?
- Do you think it is a good example for the surrounding villages?
- Who else do you think would be interesting to interview?