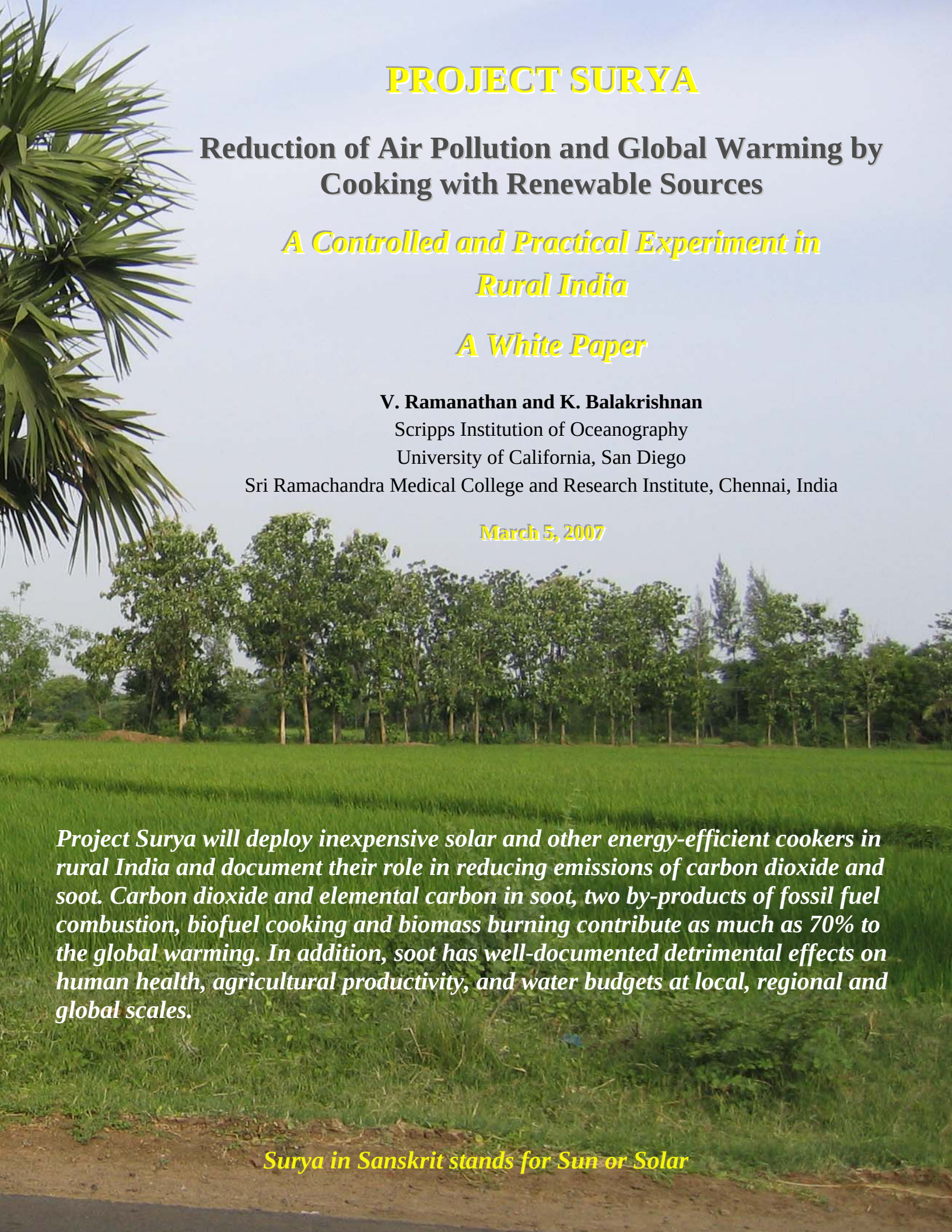

PROJECT SURYA

Reduction of Air Pollution and Global Warming by Cooking with Renewable Sources

A Controlled and Practical Experiment in Rural India

A White Paper

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March 5, 2007

Project Surya will deploy inexpensive solar and other energy-efficient cookers in rural India and document their role in reducing emissions of carbon dioxide and soot. Carbon dioxide and elemental carbon in soot, two by-products of fossil fuel combustion, biofuel cooking and biomass burning contribute as much as 70% to the global warming. In addition, soot has well-documented detrimental effects on human health, agricultural productivity, and water budgets at local, regional and global scales.

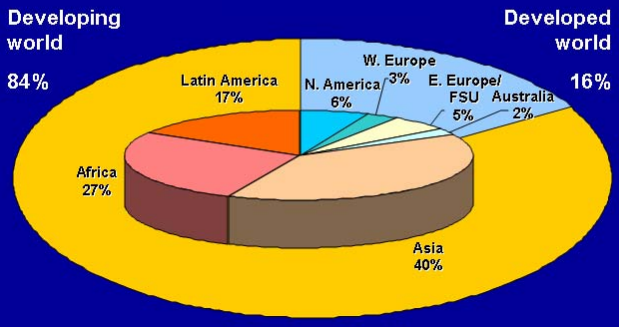
Surya in Sanskrit stands for Sun or Solar

Global Warming: Imagine One Trillion 1500-watts Light Bulbs, Always On

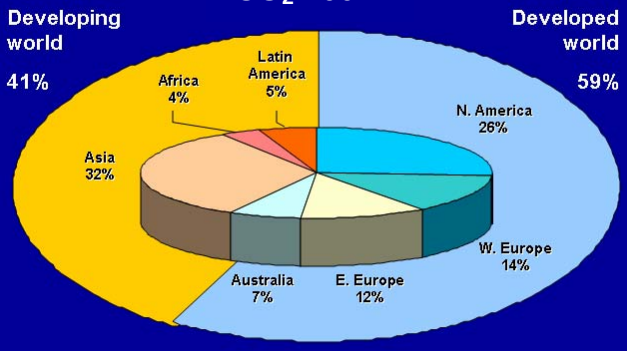
"Warming of the climate system is unequivocal..." IPCC (2007)[1]

Total World Emissions

EC 1996[2]



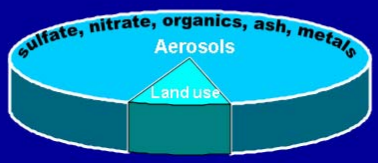
CO_2 2002[3]



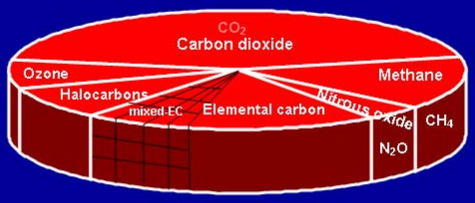
Global Radiative Forcing[7]

Pre-Industrial- 2004

Cooling agents[1,5]



Heating agents[1,4,6]



The cooling and heating pie charts are taken from Ramanathan (2007)[7] using data from sources shown above.

The infrared heat trapped by greenhouse gases such as carbon dioxide, methane, nitrous oxide and halocarbons plus the solar heat trapped by elemental carbon is equivalent to the heat output from burning one trillion light bulbs (distributed over the globe) of 1500-watts power each, every second of the day and night, throughout the year[7]. It is no surprise then that this enormous heat trapped by pollutants has led to the unequivocal global warming witnessed during the last 100 years or more.[1] The warming is certain to increase in the coming decades since the world's energy demands are expected to increase by about 60% by 2030.[8] Currently, the developed world accounts for 70% of the global energy demand. This will shift in the future since two-thirds of future growth is expected to occur in developing nations.[8] Project Surya is an attempt to develop and implement sustainable alternatives for mitigating future increases in the heating of the planet, while at the same time alleviating debilitating side effects of cooking with biofuels on health, water and agriculture.

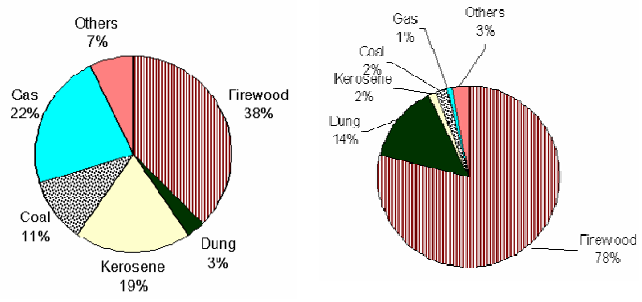
Goal and Uniqueness of Project Surya for Global Warming Mitigation

Carbon dioxide and elemental carbon (EC) in particle (aerosol) form in soot are the two largest agents of global warming (pie charts above). The main goal of Project Surya is to reduce future emissions of carbon dioxide and EC. Biomass burning and biofuel cooking are the major sources of EC emissions in India and other developing nations. The current international emphasis in global warming mitigation is on carbon dioxide, whereas the main focus of Surya is on EC, for reasons given in the next few sections. With respect to air pollution reductions, the main focus worldwide is on reducing sulfates, a strong cooling agent. The pie-charts

of warming and cooling agents shown suggest that, if the cooling aerosols are reduced without a concomitant reduction in warming agents such as EC and carbon dioxide, global warming will accelerate. Project Surya is unique in this sense, in that it attempts to reduce air pollution and improve the well-being of humans and ecosystems, without accelerating global warming. We should caution, however, that EC aerosols are also sometimes coated with organics. These organics, depending on their chemical composition and size, can either enhance the heating by EC or can reflect sunlight and offset the warming of EC. It is for this and other reasons that Project Surya will deploy sophisticated air pollution instruments to document the nature of particles and gases released into the air.

Indoor Air Pollution: Health Impacts

About half of the world's population, and 75% of households in India, use biofuels and biomass, including wood, charcoal, crop residues and dung, to prepare food and heat their homes.[9] More than 70% of India's population lives in rural areas. Cooking accounts for about 60% of the overall energy and 80% of the non-commercial energy used in rural India. More than 90% of the cooking is done with fire wood and bovine dung, i.e, cow-dung[10] (also see pie chart below).



Urban India (28% of Population) Rural India (72% of population)

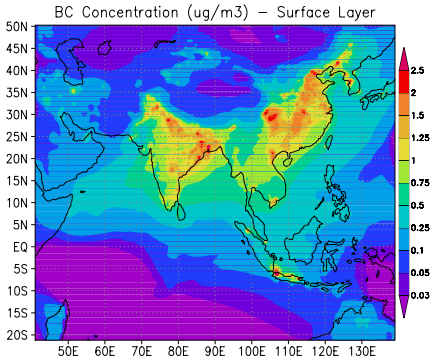
Primary Sources of Energy for Cooking in India[11]

Cooking fires, often open fires in enclosed spaces, lead to both indoor and outdoor air pollution, with detrimental consequences for local health. Several international studies have documented that indoor air pollution leads to 400,000-550,000 premature deaths in India from acute lower respiratory infections and chronic obstructive pulmonary disease.[12] Air pollution-related premature deaths can be as high as 2.5 million according to another study (Pachauri and Sridharan, 1998)[12].

The burden falls disproportionately on women and children, who inhale soot and other particles from smoke released by the burning of biofuels.[13] The health impact of India's cooking fires is not unusual in the developing world: solid fuel use accounts for 4.8% of Sub-Saharan Africa's disease burden, 2.5% of the disease burden in China, and just under 1% of the disease burden in the poorer Latin American countries.[14]

From Local to Regional Impacts: Global Dimming

The soot from indoor smoke ultimately escapes to the outdoors and combines with soot from outdoor air pollution (fossil fuel combustion) to form atmospheric brown clouds (ABCs). ABCs envelope most of India and the Indian Ocean with a dense layer of brown clouds consisting of copious amounts of tiny particles of sulfate, nitrate, soot and fly ash, among many other pollutants (see Figure).



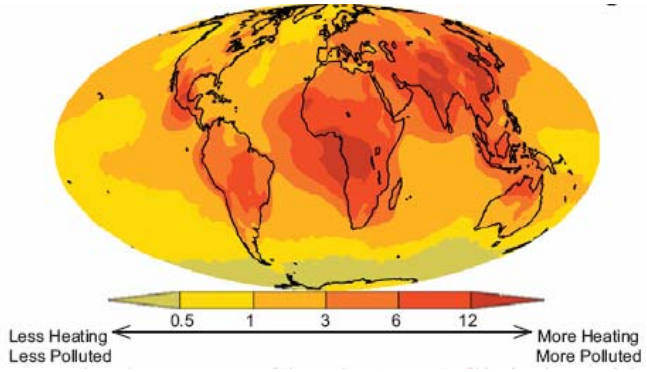
Distribution of elemental carbon content of soot in Asia. Ramanathan et al[4]

Soot and other particles in ABCs lead to a large reduction of sunlight at the ground and, in addition, lead to large atmospheric solar heating.[15,16] The dimming by soot also has other major environmental impacts, including slowing down the monsoon circulation and leading to stronger inversions[16] (see Table on Environmental and Human Impacts on India). An integrated climate-agro-economic

modeling study has shown that surface warming due to greenhouse gases and reduction of monsoon rainfall due to ABCs have adversely impacted the rice harvest in India by as much as 14% since the 1950s.[17]

Amplification of Global Warming: Atmospheric Heating by Elemental Carbon

Brown clouds are not limited to South Asia.[6,7] Atmospheric solar heating by soot, next to carbon dioxide, is a contributor to global warming and, more locally, to melting of Himalayan glaciers. Over the last 10 years, we have completed a series of investigations which have pointed out that absorption of solar radiation by soot leads to atmospheric warming over most regions of the world, particularly the tropics, thus contributing to global warming.[6,15,16] Project Surya will lay the foundation for reducing soot emissions in other regions of the planet. Clearly, reduction of soot emission will have a major positive impact at the local level (reducing fatalities among women and children in villages and cities); at the regional level (avoiding potential negative impacts on monsoon and glaciers that feed rivers like Ganges and Brahmaputra); and at the global level (reduction of global warming). It is hard to think of another environmentally damaging compound that has such far-reaching consequences.



Atmospheric Brown Clouds Are A Global Problem[6]

Environmental and Human Impacts on India[1,16,17]

Impact Parameters	*Carbon Dioxide*	*Elemental Carbon*
Temperature, Surface	Warming	Warming, during wet season; cooling during dry season
Temperature, Atmosphere	Warming	Warming
Monsoon Circulation	Intensify	Weaken
Precipitation	Increase intense rainfall	Reduction
Heat Waves	Increase frequency	Minimal effect
Himalayan Glacier	Melt and retreat[18]	Melt and retreat
Low Level Inversion	Minimal effect	Increase strength during dry season
Rice Production	Decrease (2 million tons)	Decrease (5 million tons)[17]
Other agricultural production	Decrease in some crops and increase in others	Reduction
Human health	Expected, but not quantified	0.5 million (see WHO and Smith from Ref. 12) to 2.5 million deaths annually[19]

Lifetimes are Different: Policy Implications

The lifetime of carbon dioxide gas in the atmosphere is on the order of 100 years or more. On the other hand, the lifetime of elemental carbon and other particles in ABCs is about a few weeks. Thus, ABCs will respond very quickly to reductions of emissions and changes can be documented more easily. If EC reduction is undertaken on a global scale, it can give us a decade or two to come up with viable and sustainable alternatives for fossil fuel combustion. It is important to note that a few decades from now, CO_2 increase will become the dominant driver of climate change. As a result, efforts to reduce CO_2 emissions should not be delayed.

The Human Dimension

The objectives of Project Surya are three-fold, listed below in the order of their importance:

•To eliminate the detrimental health effects of indoor smoke;

•To reduce the negative effects of elemental carbon in ABCs on the summer monsoon rainfall, Himalyan glacier retreat and agriculture;

•To mitigate the global warming effects of CO_2 and elemental carbon.

A Pilot Study: Periyar PURA

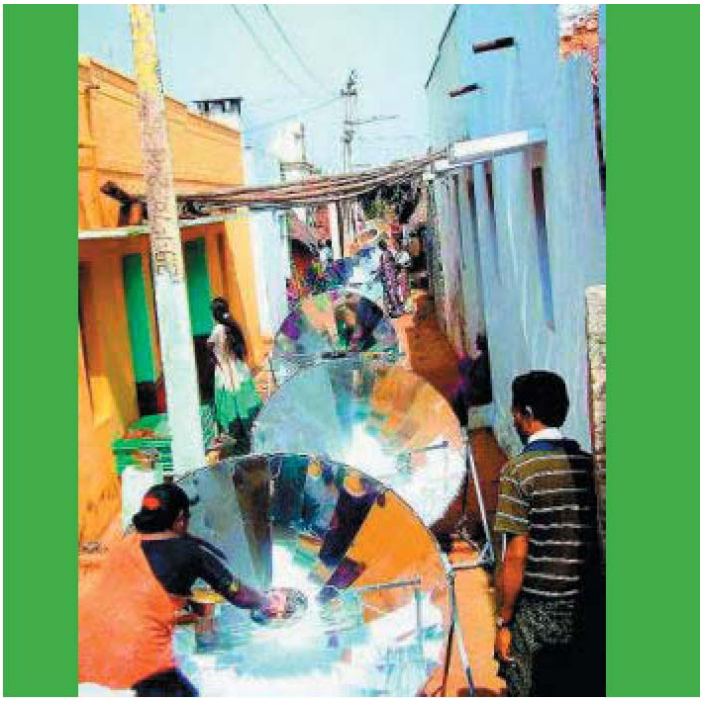
We have identified a region in the South and are considering others including the heavily polluted Indo-Gangetic Plains (IGP) region. The regional variation would ensure that we are able to learn about technology introduction in variety of settings, which will be important given India's cultural diversity. We intend to start the project by working with 65 villages (with about 6500 homes) in the Periyar PURA (Providing Urban Amenities to Rural Areas) region in the Thanjavur and Pudukkottai districts of Tamil Nadu. (www.periyarpura.org). The PURA area is roughly a circular area of approximately 1500 square km. Most households in the area use wood for cooking, at a rate of about 5 kg per day. Village infrastructure and income levels appear representative of the larger area. The villages are currently connected via a wireless network to a central hub at a local women's engineering college, the Periyar Maniammai College of Technology for Women (PMCTW). The region also has the kind of local partners and strong social network that we will need for Phase One of the project. Local NGO and academics have already gathered some baseline socio-economic data for the area. PMCTW students and faculty would be able to help with introducing and monitoring the introduction of the new cooking technologies. We have established contact with the leadership of a well-organized federation of Women's Self Help Groups that could potentially help us network with women in the villages to disseminate information about the cooking methods. Working in the Periyar PURA will also help the project gain some degree of national recognition. The PURA model has been championed by President Abdul Kalam, and the Periyar area has been recognized as one of the leading examples.

Periyar PURA (www.periyarpura.org)

Solar and Other Back-up Smoke-Free Cookers

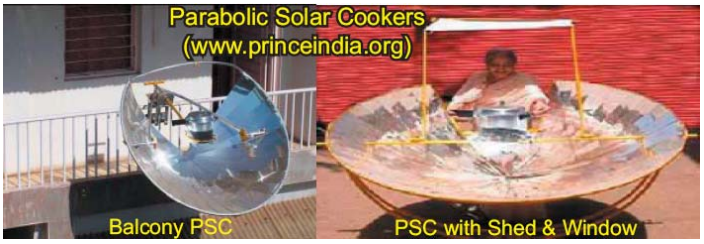
There have been some success stories with smoke-free village experiences in India. Examples include two projects in Bysanivaripalle of Kurabalakota mandal, and Singamanu Buruju of Thamballapalle mandal, both in Andhra Pradesh (south India). The eco-conscious residents of the electrified village went in for the first biogas plant in the region two decades ago. The deployments were meant for energy security and promotion of renewable energy. The officials of the Non-Conventional Energy Development Corporation of Andhra Pradesh (NEDCAP) did not need to put in much effort to motivate them to go solar. The village saves 72 tonnes of firewood, or 5,832 kg of LPG, cutting carbon dioxide emissions to the tune of 104 tonnes a year, according to NEDCAP (http://www.nedcap.org/).

We will replace the conventional cooking practices (burning of wood, cow dung and crop residues) with solar cookers (when sunlight is available) and other energy efficient back-up cookers during evenings, nights, cloudy and rainy days.



Various technological options proposed for substituting firewood burning with green, smokeless renewable technologies are already available:

Parabolic domestic cookers: These cookers are parabolic dish cookers of about 1.4 m diameter popularly referred to as SK14 and cost about $100. They are advertised as able to cook rice for a family of up to ten people in about 30 minutes. Manual tracking of the sun is required every 20 minutes. In most of the cases food is cooked in this time. With respect to safety issues, glaring can distract the operator if he is standing very close to the cooker. Use of dark goggles is recommended. Even though no cases of burns have been reported, use of gloves is recommended. Normally goggles and gloves are standard accessories supplied with the solar cookers. The cooker is on four caster wheels and can be transported short distances easily, especially for moving inside the house at night in theft-prone areas.



Parabolic community dish cookers: These new dish cookers are 2.3 m in diameter, and cost about $500. They are made by PRINCE group in India, among others. These dish cookers are capable of cooking meals for around 40 students in one hour and are recommended for use in schools where mid-day meal is served.

Biogas plants and burners: To supplement operation of solar cookers, biogas plants are recommended. Biogas will be required for cooking during evenings and nights and on cloudy days, as well as for cooking operations like frying, bread making, etc. which are difficult on solar cookers. One unit can serve four families comfortably and costs about $1000. Family-size (2-4 m^3 gas per day) biogas plants have been disseminated and popularized in India, China and many other countries (Bhat et al., 2001). Over 3 million biogas plants have been built in India alone.[20] Local artisans and fabricators can be trained for constructing the biogas plants and fabricating floating drums. In the rural area of Sirsi, in Uttar Kannada district (south west of India), 3718 family-size biogas plants were built between 1985 and 1999. Operating at a 100% success rate as of 2001[10], these biogas plants were built by local rural contractors and artisans.

We are not restricted to the above cookers and are open to other type of cookers and burners that reduce emissions of soot, smoke and greenhouse gases. We will consult with the Ministry of New and Renewable Energy (http://mnes.nic.in/) to explore other

alternatives as well as subsidies for the solar cookers, biogas plants and other alternatives

The above examples illustrate that technological options and solutions are available to switch to soot-free cooking and reduce emissions of soot from biofuel cooking. The methodology for deploying the cookers will include the following:

• Conducting surveys of eating habits, estimation of energy requirement in cooking with existing fuel like firewood etc. Actual trials are to be taken for sample houses.

• Conducting energy survey to assess availability of raw material for technologies like biogas, smokeless wood stoves etc.

• Meetings with local leaders of the villages and demonstrating them alternate green technologies like different designs of solar cookers, biogas plants, smokeless stoves etc. Getting feedback regarding the suitability of the technologies for the local needs and acceptance of the technologies by the beneficiaries.

• Implementation of the green technologies acceptable to the people in the command area. Conducting training programs for installation, operation and maintenance. Forming core teams and imparting training to them for repairs and maintenance. We will use a variety of incentives and educational outreach to ensure that burning of wood, crop residue and cow dung will be avoided in the study area.

A Scientific Experiment: Documentation of the Mitigation

First, six months prior to the deployment of the alternate cookers, we will install instrument towers at the boundaries of the selected region to document the concentrations of particulates and soot content and solar radiation at the surface (to document the dimming effects). There will be 4 such (see photo of

ABC observatory, Maldives[21]

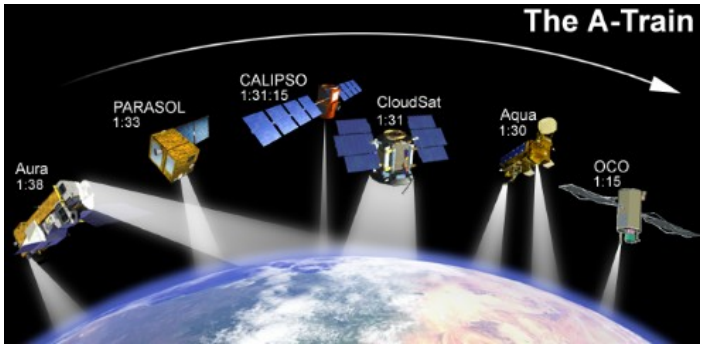
Maldives ABC observatory) instrumented tower (about 10 meters high) on the north, south, east and west boundaries of the selected region (see locations in map). We (VR) have extensive experience in developing and building such air pollution-brown cloud observatories in the Indo-Asia-Pacific region, as part of the UNEP sponsored ABC program (http://www-abc-asia.ucsd.edu/). Next, we will install inexpensive instruments indoors to monitor the indoor air pollution in selected homes. If this is not feasible (due to cost or societal inhibition) we will have a mobile instrumented van that will sample about 20 homes at random each day. While many of the instruments will be obtained in the US, the scientific data collection and analyses will be conducted by scientists in India. Once Surya is funded, we will develop a science team of Indian scientists similar to the ABC-Asian science team.

Engaging Village Children in Data Collection

One of the objectives of Project Surya is to engage the village children in collection of data. For example, children will be involved in collecting data such as weight of bio-fuels used each day, duration of cooking, and the time of the smoldering fire. This data collection will be for the first 6 months period before deploying the alternate cookers. After deployment, they will be encouraged to document the time take for the new cooking, the down time for the devices and the additional maintenance required for the new cookers.

Future scientists, doctors and environmentalists:
The PI (VR) was originally from a rural area like the above in S. India

We will conduct two kinds of monitoring after the introduction of the alternate cooking methods. Air quality measurements will continue at least a year after installation of alternate cooking methods. The controlled region and the surrounding villages will also be monitored using air pollution instruments on satellites (A-Train satellites by NASA as well as Indian satellites).



The scientific measurements will document the actual reduction in soot emission resulting from replacement of the traditional cooking practices. We will quantify the reduction in consumption of biofuels (wood, cow dung and crop residues) and estimate the reduction in soot emission. The impact on global warming, however, depends on the atmospheric (outdoor) loading of elemental carbon which will be monitored by the instrument towers and satellite observations. The tower observations will be used to calibrate the satellite data which in turn will be used to look at the impact on the entire Periyar Pura region and regions outside of its boundary. We have models to take this data and estimate the reduction in global warming potential of soot. Replacement of bio-fuels with solar or bio-gas will not have any net appreciable impact on CO_2 reduction. However, by steering the villagers away from fossil fuel, Surya will inhibit the conversion to fossil fuel at a later date, when economic conditions permit the access to fossil fuels. Subsequent analyses of the results will include economic impact of the proposed technology replacement; and its impact on brown clouds, human health and agriculture. Investigators of agriculture impacts will be brought into the project once it is underway.

We are also discussing the possibility of collaborating with the One Laptop per Child Initiative (www.laptop.org) to engage local children in tracking the energy use habits in the villages.

Documenting Health Impacts

Incomplete combustion of biomass fuels in inefficient stoves within poorly ventilated spaces results in emissions of respirable particles, gases (such as CO and NO_X) and many volatile and non-volatile organic compounds, including carcinogens such as benzo[*a*]pyrene, formaldehyde, and benzene. Average indoor concentrations of PM can be as high as several mg/m^3, with peak concentrations an order of magnitude higher. Women and young children are at the highest risk of exposures. Assessments of the burden of disease attributable to use of solid fuel use in India have put the figure at 3–5 percent of the national burden of disease. The strength of evidence for the estimated burden is the strongest for incidence of chronic bronchitis in women and acute lower respiratory infections (ALRI) in children. Contributions to other adverse health outcomes such as asthma, tuberculosis, cataracts and adverse peri-natal outcomes are likely to be significant as well.[6] Recently, The International Agency for Research on Cancer (IARC) has concluded that indoor emissions from household combustion of biomass fuel (mainly wood) are “probably carcinogenic to humans (Group

2A)".[22] Although a large body of epidemiological studies have contributed to understanding health risks related to biomass fuel use, few provide quantitative exposure data. Most studies in the region have used reported "solid fuel use" as a proxy indicator of exposure. More recently, large-scale studies carried out in Southern India across multiple exposure configurations, in addition to quantifying multiple pollutants, have provided considerable understanding of spatial, temporal and other determinants of population exposure related to solid fuel use in the region. [23]

Assessing intervention effectiveness: From a policy standpoint, although it is health effects that drive concern, it is too late by the time they occur to use disease rates as an indicator of the need for action in particular places. In addition, because these diseases have other causes as well, it is difficult and costly to conduct careful epidemiological studies to quantify the disease burden due to indoor air pollution, and to distinguish it from the burden due to other common risk factors. Improved knowledge of exposures then becomes a useful tool for determining effective intervention options. Therefore, we propose to build the evidence for expected health improvements in the first phase through documentation of exposure reduction and subsequently through reduction in incidence and severity of diseases.

Exposure reduction: We (KB) have considerable previous experience in population based exposure assessment methods. Using a combination of area and personal sampling devices together with detailed time-activity records, exposure reductions can be convincingly demonstrated. We will also deploy direct read-out devices with a detailed observational diary entry in a sub-set of households to gain an insight into exposure attributions from individual household activities as well as understand socio-cultural determinants likely to be important in sustainability of interventions. Biomarkers of exposure and early biological effect monitored in a sub-set of individuals will provide evidence for reduction of body burden.

Physician with village children

Health Improvements: We (KB) have used cross-sectional and longitudinal health monitoring methods in rural households extensively to establish the baseline situation with respect to indoor air pollution related health end-points. Some of these include recording self –reported symptoms, performing on-site serial lung function tests and physician assessments for ALRI/ Asthma/ COPD. While some outcomes will require considerable follow up during several phases of the intervention, an acute outcome such as children's ALRI is easily amenable to assessment within a period of a year or two. More complicated assessments such as lung function improvements, recording of adverse pregnancy/low birth-weight outcomes can be piloted during the initial phases with plans drawn up for follow up epidemiological surveillance. We will engage in extensive capacity building of local health professionals to recognize, evaluate and manage the

health hazards related to indoor air pollution. Wherever feasible, the Comparative Risk Assessment (CRA) protocols of WHO will be used in to calculate burden of disease burdens (if for e.g. the proposed interventions reduce exposures to the counterfactual levels used in the CRA procedure).

Impact on Local, Regional and Global Society

The fourth assessment by the Intergovernmental Panel on Climate Change (IPCC), a UN body, has recently released a policy-makers summary of the science of climate change. This report concludes that the planet has witnessed an unequivocal warming of the global climate during the last century. The panel also predicts that the warming during the next century is likely to be 3 to 6 times the warming experienced during the last century.

- **Global Scale:** The results of Project Surya by mitigating the emission of elemental carbon, a major warming agent, and by steering a large group of Indians, 20,000 during its initial phase, away from fossil fuels, would contribute towards reducing future increases in CO_2 and will have fundamental policy implications for the entire planet. Two years after initiating the demonstration project in Periyar Pura, we will investigate the scope and cost for scaling up Surya for the entire sub-continent and compare it with the costs of adapting and coping with the climate changes due to the brown clouds and global warming.

- **Regional Scale:** By reducing emissions of EC, we will reduce the effects of brown clouds on the deceleration of the monsoon, increase rice production in regions with rain fed cultivation; We will reduce the effects of EC in the accelerated retreat of Himalayan glaciers with feed major rivers such as Ganga (Ganges) and Brahamaputra.

- **Local Scale:** Our expectation and hope is that the immediate benefit will be felt by the rural population involved in this project. This includes reduction of air pollution related diseases and deaths; reduction of drudgery for women and children with respect to fire wood collection and cooking inside smoke filled huts and homes; educating the next generation of rural children on modern and eco-friendly use of energy; and education and training in scientific data collection.

Challenges and Opportunities Ahead

Promoting Sustainable Development in Rural Areas of Developing Nations

We recognize the significant challenges that lie ahead Surya for it to become a success story and be incorporated in other rural regions. We are motivated to meet these challenges, in part due to the health effects of indoor air pollution, and due to the great opportunities for scaling-up Surya to an entire sub-continent. Our vision is that, when it is scaled-up, Surya will become an integral part of a global solution for preventing dangerous climate changes decades from now. In order to meet the challenges of making Surya into a practical reality, we foresee the following five elements to be important ingredients of the Surya implementation plan[24]:

- A people-centered approach which recognizes the individual, her or his family and the village community and respects their culture and religious practices. The first step of this approach is to involve the inhabitants in all stages of implementation and avoid at all costs, top-down approaches. We will seek the help of NGOs who work on rural development and issues related to children and women.

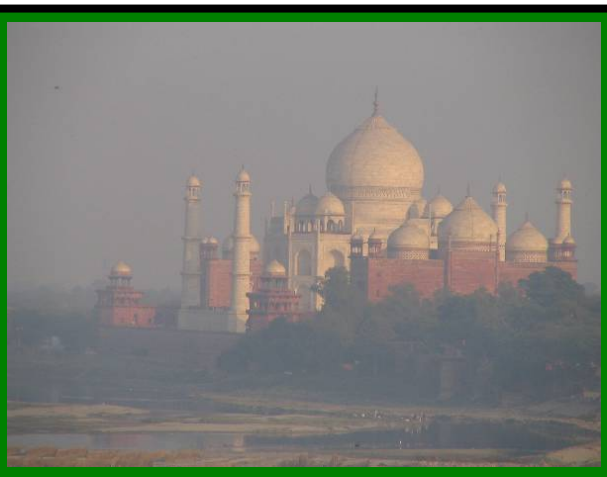
- Provide accessible and relevant information for motivating the inhabitants, e.g., information and documentary on the health impacts of indoor air pollution; and discuss with the population about new income opportunities, e.g, the time saved

from collection of daily supply of firewood and preparation of bovine-dung cakes, can be used for gainful employment.

- Empower the community with skills and the ability to act on the information and sustain the changes, e.g, providing the solar cookers and bio-gas plants free of charge and the training to use it; engaging village children in data collection; capacity building by entraining students from rural colleges in collection of data for scientific evaluation.

- Creating an enabling environment to support and facilitate change. This would involve working with the village leaders, local and state governments prior-to and during implementation. The ultimate expectation is that the benefits derived from Surya, if documented in a scientifically defensible manner, will lead to policy changes.

- Entrain social science students and teachers in local colleges to collect data that can be used to evaluate Surya. We will involve social scientists and NGOs experienced in implementing new technologies in rural India and in evaluation of its effectiveness, to develop criteria which will allow Surya to choose between different technologies and approaches for future developments.



Taj Mahal

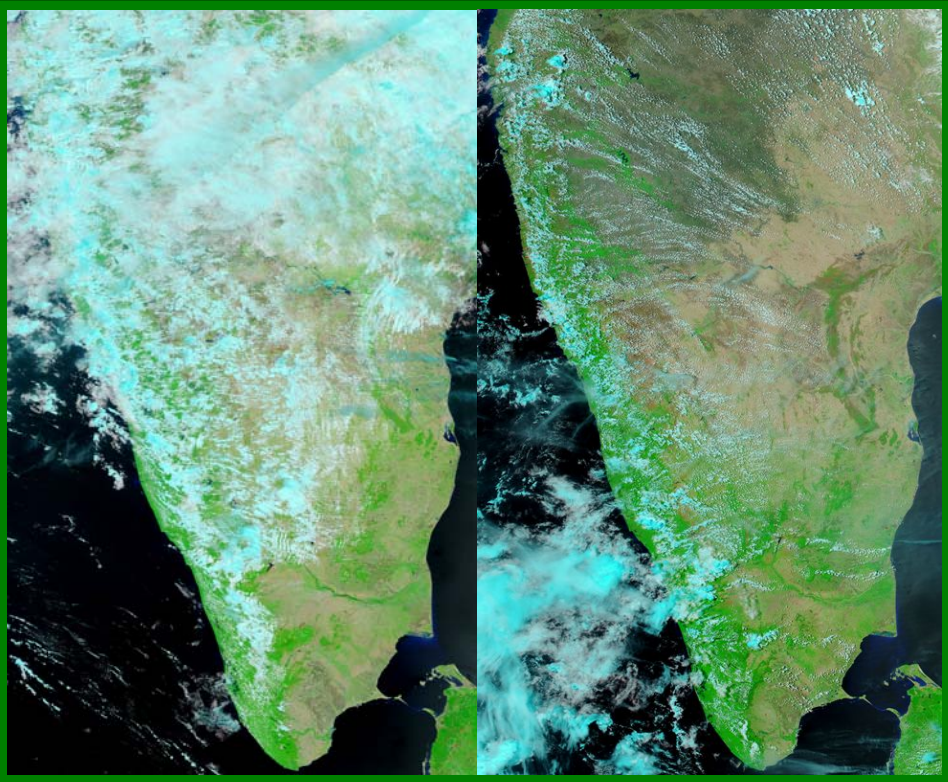
http://www.hat.net/album/asia/india/05_cities_and_maharajas/29_agra/041227161734_taj_mahal_in_polluted_haze.jpg

Mt. Everest

Himalayas

Aerosol Pollution over Northern India

http://rapidfire.sci.gsfc.nasa.gov/gallery/?2001338-1204/India.A2001338.0505.1km.jpg



Monsoon Flooding in India

Image on the left taken August 7, 2005, and image on the right taken June 15, 2005 just before the rains started. Both images are shown in false color so that water is dark blue, clouds are white and light blue, vegetation is bright green, and bare ground is tan.

NASA Images courtesy the MODIS Rapid Response Team at NASA GSFC
http://earthobservatory.nasa.gov/NaturalHazards/shownh.php3?img_id=13026

Collaborators

Principal Investigator: Dr. V. Ramanathan is a distinguished professor of climate and atmospheric sciences at the SIO, UCSD. He chairs the UNEP sponsored Atmospheric Brown Clouds (ABC) project (http://www-abc-asia.ucsd.edu/) with international participants from China, Germany, Japan, Korea, India, Maldives, Sweden, Thailand, and USA. He has written over 150 papers on global warming and air pollution including their effects on the monsoon and agriculture; and served as one of the lead reviewers for IPCC 2007. He has been recognized with several national and international awards, including election to: The American Philosophical Society, The National Academy of Sciences, The Pontifical Academy of Sciences, Academea Europea and The Academy of Science for Developing Nations (TWAS).

Co-Investigator: Dr. Kalpana Balakrishnan is a Professor and heads the Department of Environmental Health Engineering at Sri Ramachandra University, Chennai, India. She has been a lead investigator in numerous collaborative environmental health research projects focusing mainly on exposure and health risk assessment for air pollutants in the ambient, indoor and occupational environment. She has served the IARC, WHO and The World Bank on multiple short–term technical assignments including being a member of the WHO working group on setting guidelines for Outdoor and Indoor Air Quality. She also directs post-graduate and doctoral training programs in environmental health at her institution.

Potential Participants: We have benefited by discussions with the following, who are likely to join the team when Surya is funded:

-Dr. Jessica Wallack, assistant professor of political economy at IRPS, UCSD, will assist with our efforts to learn about technology adoption by collecting and assessing feedback about the suitability of technologies for local needs. Jessica's research, teaching, and consulting focuses on the factors that create successful interaction between entrepreneurs, NGOs, corporations, and governments in creating and implementing public policy. She will be based in India at the Center for Development Finance, Chennai, Tamil Nadu, for 2007-8.

-Dr. Prasad Kasibhatla is an Associate Professor of Environmental Chemistry in the Nicholas School of the Environment and Earth Sciences at Duke University. His work focuses on understanding the human impact on atmospheric chemical composition and on modeling techniques to quantify atmospheric emissions from fossil-fuel/biofuel combustion and biomass burning on global and regional scales.

-Mr. Jagdeesh Puppala is Chief Executive of the Foundation For Ecological Security (INDIA). FES works work towards the ecological restoration and conservation of land and water resources, in the uplands and in other eco-fragile, degraded and marginalized zones of the country, and to set in place the processes of coordinated human effort and governance to this end. FES works in several agroclimatic regions in the states of Orissa, MP, Rajasthan, Gujarat, Karnataka and Andhra Pradesh. FES is interested to provide the field platform for Surya and provide opportunities for bringing to surface the field knowledge for policy action.

India Outreach

-Srinivas Sukumar of Calit^2 is the strategic manager of International Relationships.

-Dr. M.C. Madhavan, Professor of Economics and Asian Studies Emeritus, San Diego State University has had extensive background in working on development issues as assistant secretary of the Economic Committee of the World Bank.

- Prof A. Chandak of Prince India provided the input on solar and biogas cookers mentioned in this white paper. He is an Assistant Professor in Mechanical Engineering, S.S.V.P.S. B.S.D. College of Engineering, DHULE and Director of PRINCE (Promoters & Researchers In Non Conventional Energy), a voluntary group working under a charitable organisation Jankibai Trust, Dhule. INDIA

Participating Institutions

Scripps Institution of Oceanography (SIO)

SIO is one of the oldest, largest, and most important centers for climate and marine science research, graduate training, and public service in the world. Research at Scripps includes climate changes on global and regional scales, global ocean climate observations, air pollution, atmospheric brown clouds and environmental sustainability.

http://sio.ucsd.edu/

Sri Ramachandra University (SRMC)

SRMC is a leading medical university in Southern India. With 9 constituent colleges, a 1500- bedded tertiary care hospital and state of the art basic science and clinical research facilities, SRMC is well recognized for it's role in providing education, clinical services, research and community extension services in virtually all major disciplines of health care.

http://www.srmc.edu/

California Institute for Telecommunications and Information Technology (Calit^2)

Calit^2 is taking ideas beyond theory into practice, accelerating innovation and shortening the time-to-product development and job creation.

http://www.calit2.net/

The Energy and Resources Institute (TERI)

TERI tackles and deals with the immense and acute problems that mankind is likely to be faced with in the years ahead, on account of the gradual depletion of the earth's finite energy resources which are largely non-renewable; and on account of the existing methods of their use which are polluting. TERI is actively working on dissemination of energy efficient technologies in the rural areas to mitigate the negative impacts of indoor air pollution due to use of kerosene and biomass. TERI is interested in taking the concept of Surya forward.

Contact: Dr Hafeez Rehman, Director, Action Programmes, TERI, New Delhi - 110 003.

http://www.teriin.org/about.php

Project Surya Office: Center for Clouds, Chemistry and Climate at SIO-UCSD (C^4)*

Project Assistant: Vanessa A. Balta Cook (vbaltacook@ucsd.edu); 858-534-8815

*C4 is also the science secretariat for Project ABC, sponsored by UNEP.

Denver Brown Cloud

The well-known visible haze of pollutants photographed in March 2004 by P.I. V. Ramanathan

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