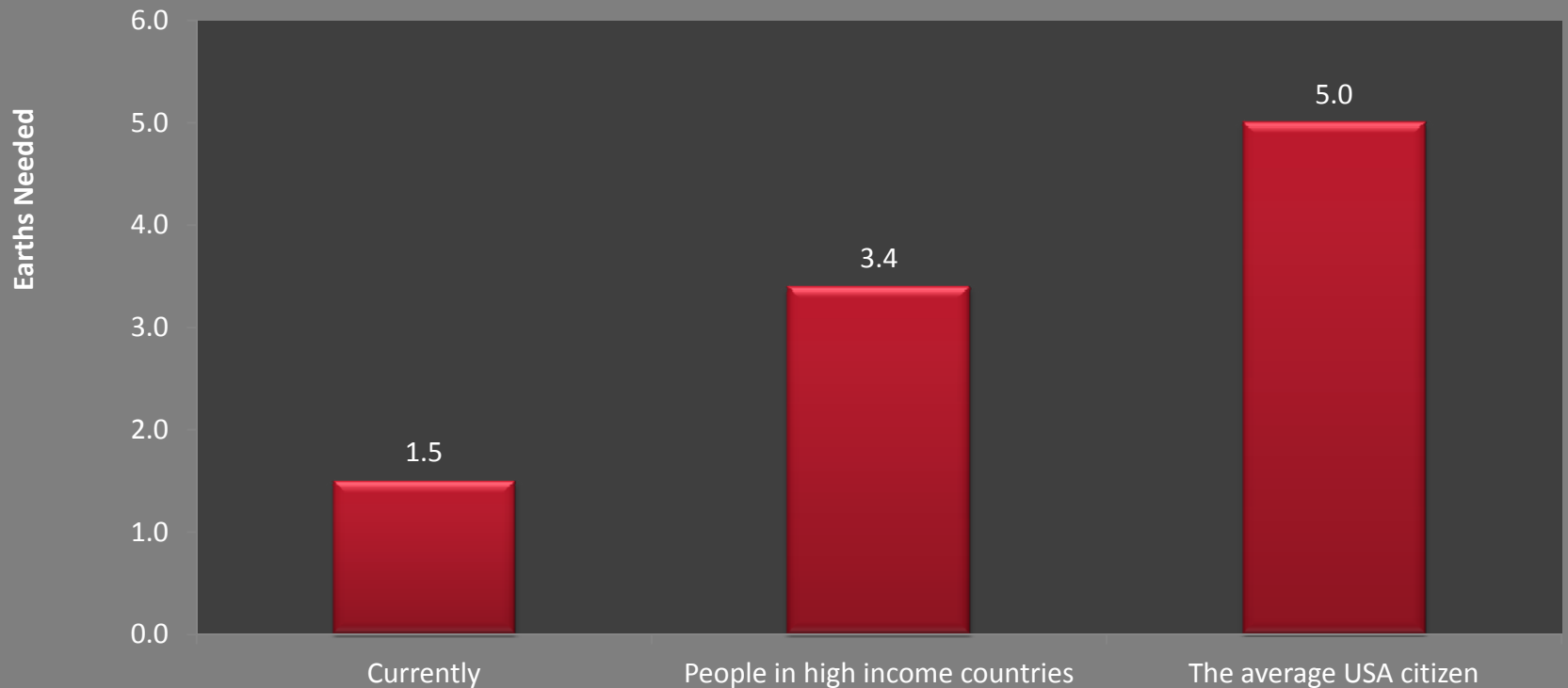# Sustainable Energy Solutions and Distributed Generation
for Tamil Nadu

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Auroville Consulting
14-12-2013

Why Sustainable Energy Systems?

1. Limited quantity of Fossil Fuels;

2. Energy security (local instead of centralised / external systems)

3. Global warming (fossil fuel burning = carbon dioxide concentrations rising = carbon dioxide increasing the greenhouse effect = increasing average global temperatures.)
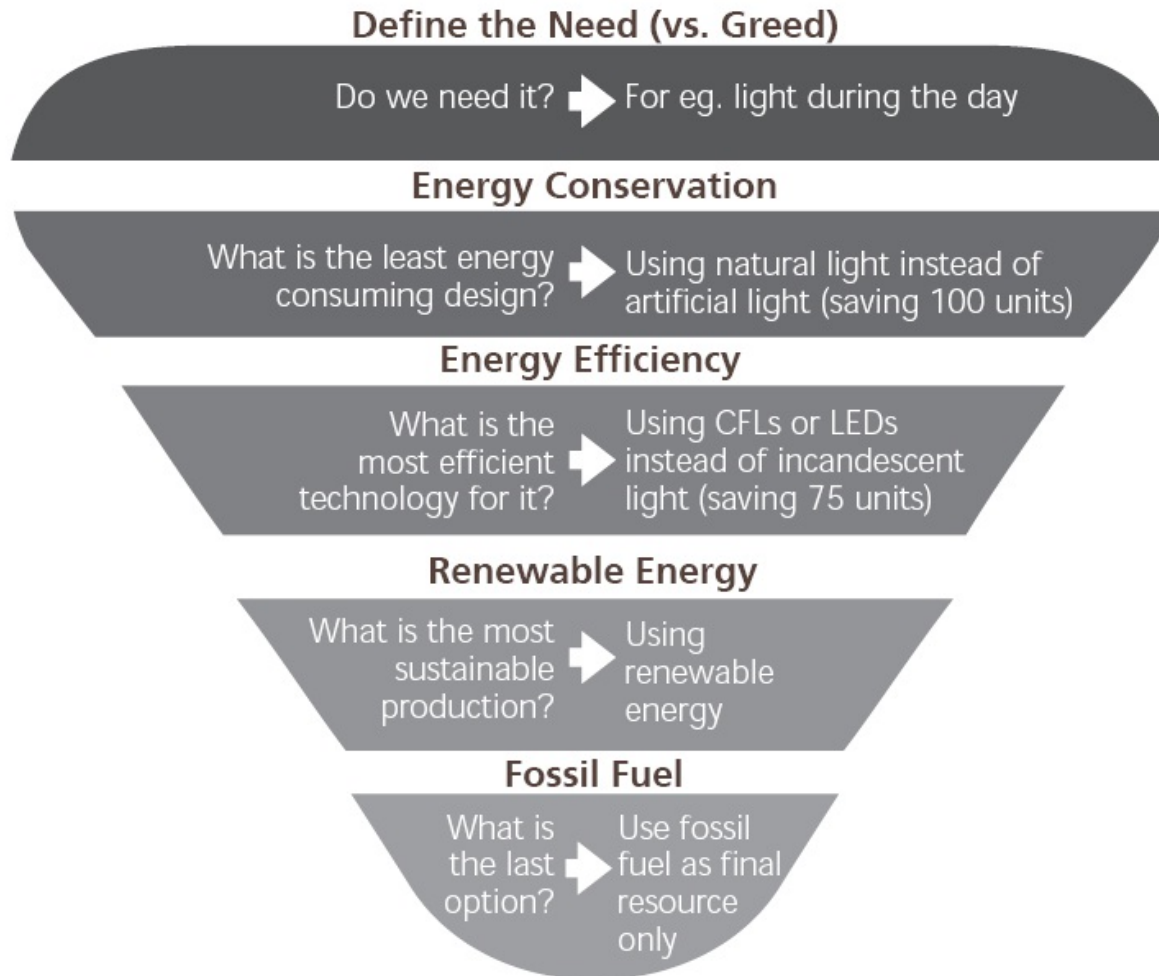
4. Pollution of the environment

Number of earths needed if everyone consumed like. . .

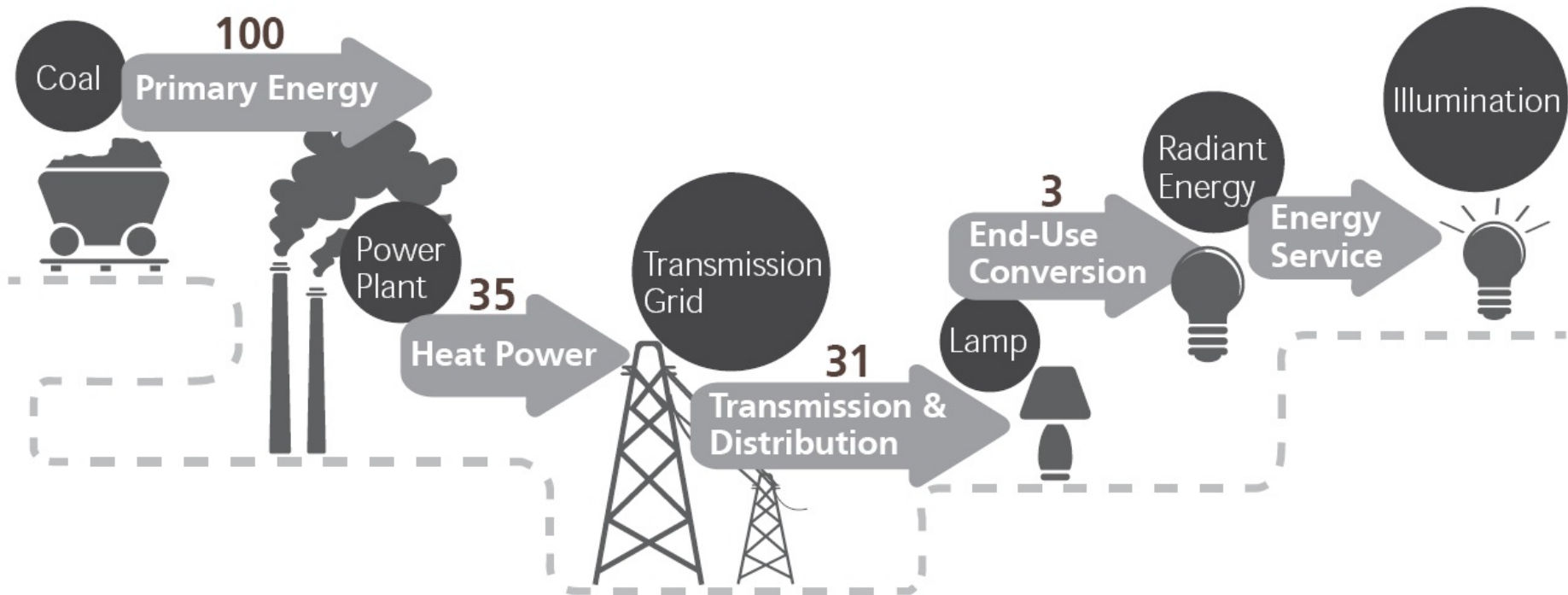"Can we *conceivably* live sustainably?"

Consumption	Sustainable Production

The Energy Pyramid

Define the Need (vs. Greed)

Do we need it? ➡ For eg. light during the day

Energy Conservation

What is the least energy consuming design? ➡ Using natural light instead of artificial light (saving 100 units)

Energy Efficiency

What is the most efficient technology for it? ➡ Using CFLs or LEDs instead of incandescent light (saving 75 units)

Renewable Energy

What is the most sustainable production? ➡ Using renewable energy

Fossil Fuel

What is the last option? ➡ Use fossil fuel as final resource only
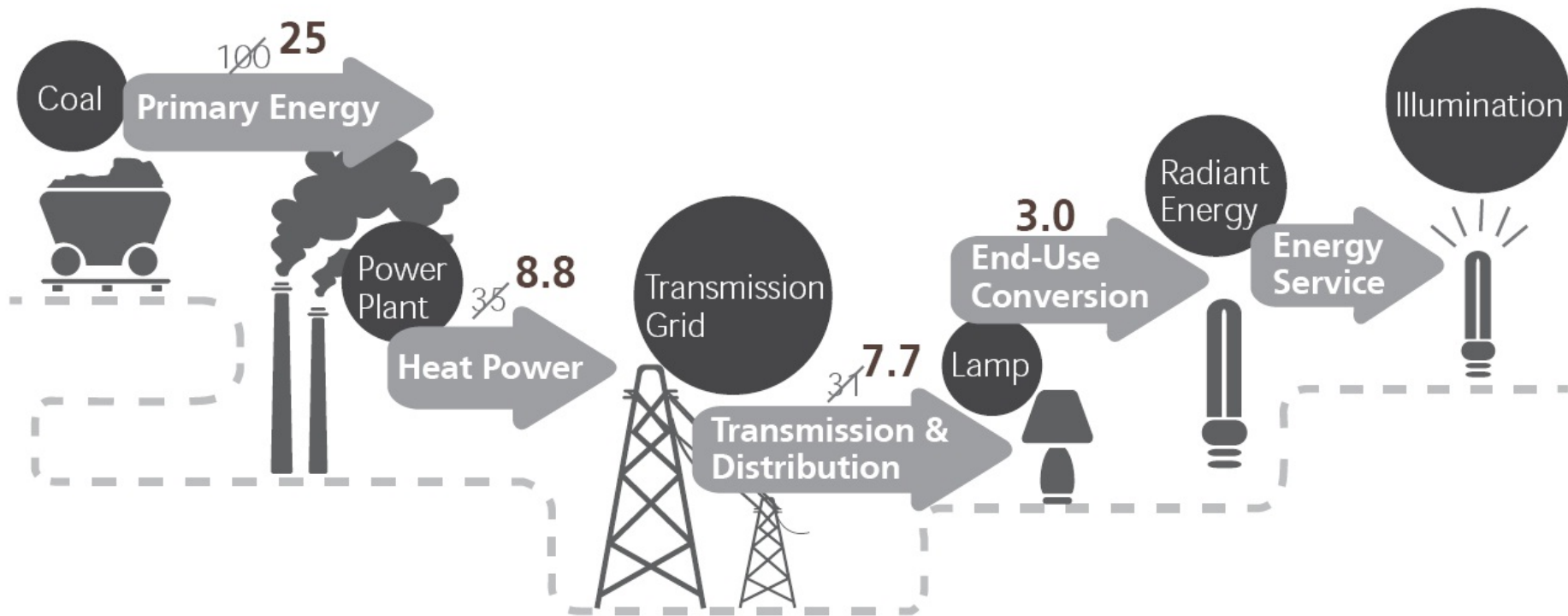
Source: Sustainable Urban Energy: A Sourcebook for Asia
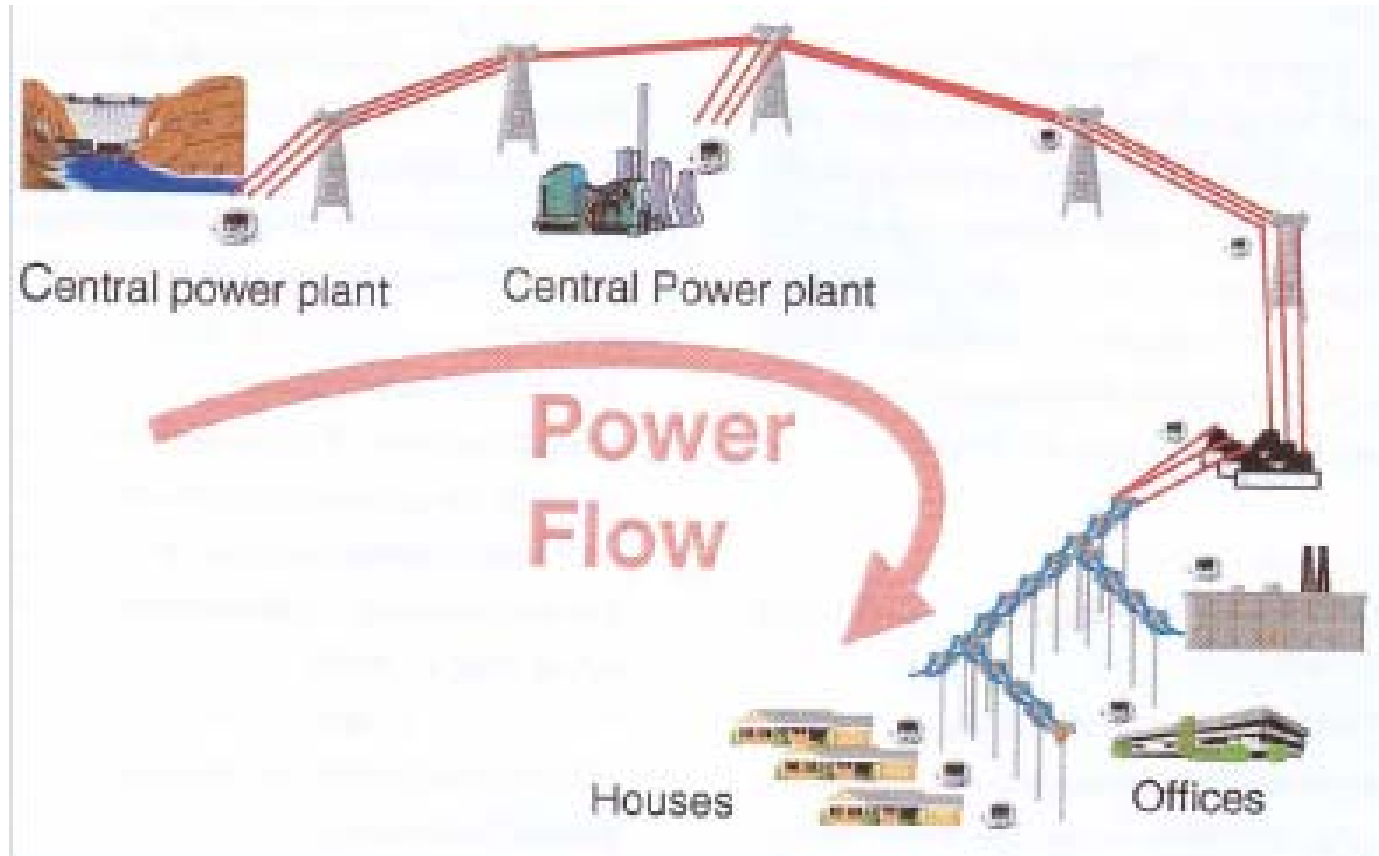
Energy Saving

Source: Sustainable Urban Energy: A Sourcebook for Asia

Energy Saving

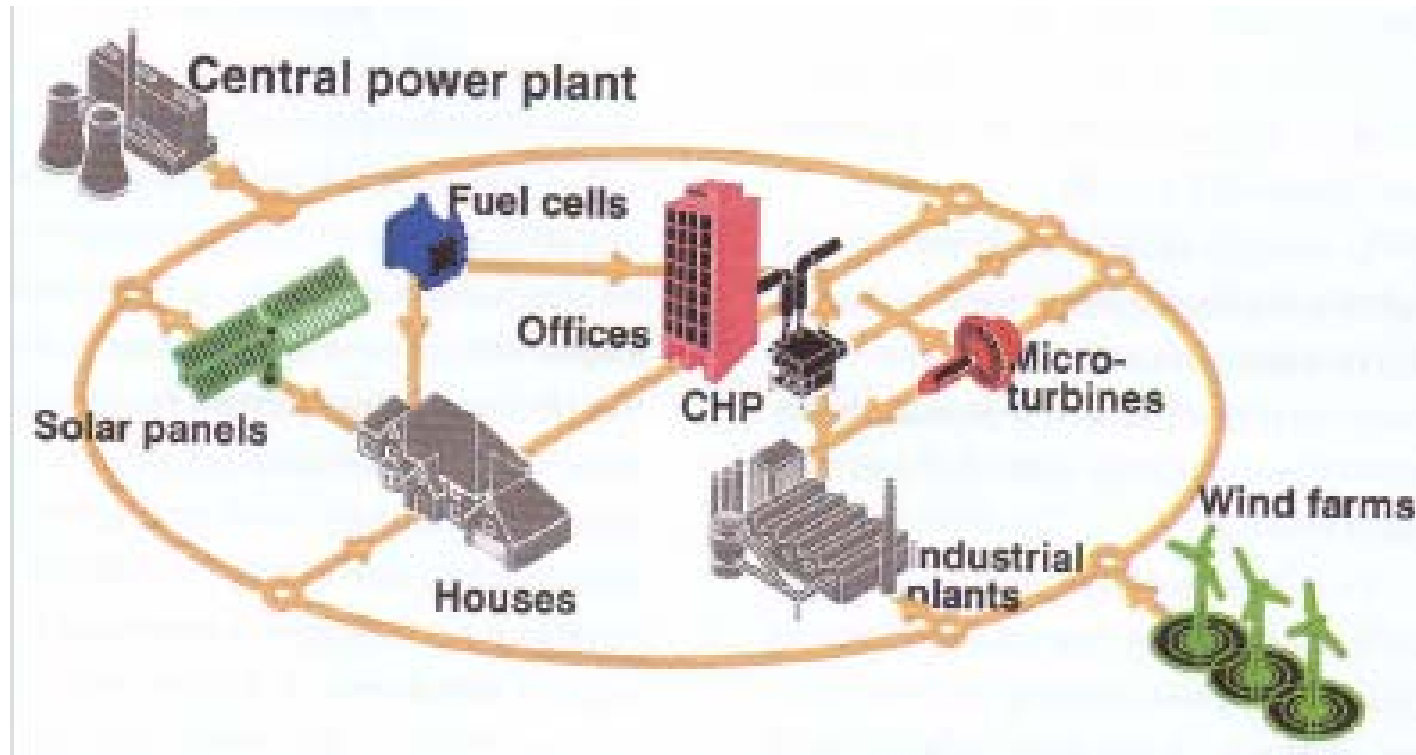Source: Sustainable Urban Energy: A Sourcebook for Asia

Renewable Energy Grid Penetration and the Smart Grid….

Distributed Generation

– Every consumer can become a producer (a "*prosumer*") of renewable energy

– Use *SmartGrid* technology to optimize grid performance

Renewable Energy Grid Penetration and the Smart Grid….

Rooftop Solar and Wind – World-wide

Every Consumer can become a *Prosumer*

Renewable Energy Grid Penetration

Sustainable Electrical Energy for Tamil Nadu

— Set, and implement, concrete and measurable energy conservation and energy efficiency targets for all consumer segment

— Make the electrical grid stable and reliable in both the urban *and* rural areas. Do this by adding on a war footing the required capacity, taking into account the present shortfalls and future demand

— With a stable grid that is available 24 x 7, grid-connected renewable energy penetration can be enhanced and the burning of fossil fuels can be drastically reduced

Sustainable Electrical Energy for Tamil Nadu

— Develop the renewable energy sector with a long term vision of full replacement of non-sustainable energy sources with sustainable and renewable energy sources. We need to do this whole-heartedly and we need to do it *now*

— Remove the barriers that prevent the wind energy sector from tapping the huge wind potential in the state

Sustainable Electrical Energy for Tamil Nadu

— Make grid-interactive rooftop solar PV an essential component of the solar energy program so that distributed generation becomes a reality and a movement by the people for the people

— The Tamil Nadu Solar Energy Policy 2012 provides for rooftop solar net-metering and this needs to be complemented with a feed-in tariff mechanism to further drive the rooftop solar PV segment with its huge potential and numerous advantages

Sustainable Electrical Energy for Tamil Nadu

— Enhance the north-south electrical grid interconnection capacity so that we get a truly national grid that has diversity of energy sources and diversity of demand patterns

— Add intelligence to the grid (the "smart grid") to ensure that the renewable energy contribution can keep on increasing

— Invest in smart energy storage systems including pumped storage hydro electricity to further enhance the renewable energy contribution while managing seasonality

Sustainable Electrical Energy for Tamil Nadu

— Pay for renewable energy on the basis of realistic feed-in tariffs that make renewable energy investments viable without long term reliance on capital subsidies and combine this with a soft loan mechanism.

— Until renewable energy costs are at par with conventional energy costs, fund the feed-in tariffs with a state-level green cess or from a revenue component built into the electricity tariffs;

Sustainable Electrical Energy for Tamil Nadu

— Provide rural feeders with 24 x 7 grid supply while having rural areas produce all the energy they consume from renewable sources

— Bidirectional rural feeders and solar villages will become drivers of inclusive socio-economic development
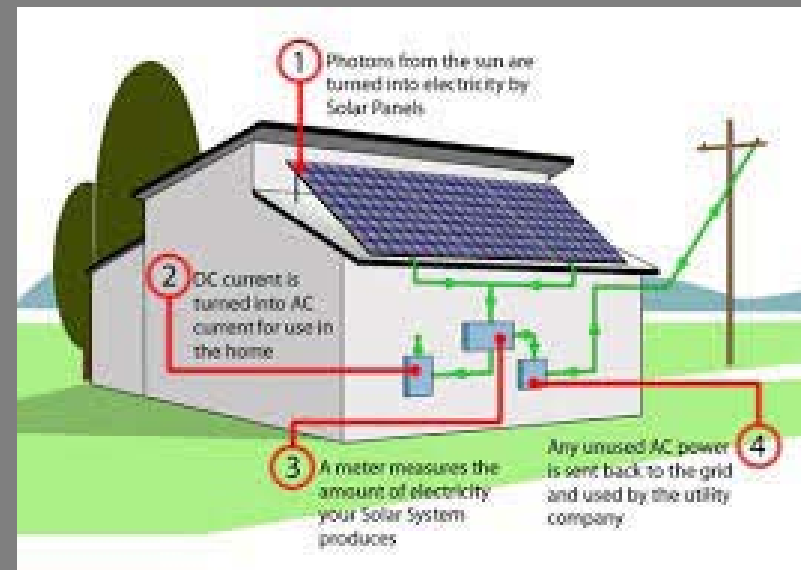
The Solar Village

In villages the open-to-sky area per capita is much higher than in the urban areas

Therefore rural areas lend themselves well for the generation of solar energy on rooftops or on (waste) lands in excess of the average per capita consumption

Components: 1. PV array, 2. SUNNY BOY, 3. SUNNY ISLAND, 4. Batteries, 5. Diesel generator, 6. Wind turbine system

The Bidirectional Rural Feeder

The proposed Solar Villages will have grid-interactive solar plants to generate all power consumed

Rural electricity feeders will become *bidirectional*: they feed into the grid during the day and take from the grid in the night

In order for this to work, rural feeders have to be given 100% (24 x 7) grid availability

A paradigm shift for rural Tamil Nadu

With the solar electrification of rural Tamil Nadu, a paradigm shift will be achieved in the way we manage rural electricity feeders.

Presently rural feeders are the first feeders to be switched off when there is power shortage.

In the Solar Villages approach, rural feeders become priority feeders since they evacuate solar power into the state grid.

How it works

TANGEDCO could use day time (conventional) power to feed offices and industries in the urban areas since villages generate their own power from the sun.

In the night when most offices and industries are closed, the villages draw a part of the energy that they exported to the grid during the day for their own usage.

Distribution Network

kWh

Solar Panel(s)

DC

AC

Solar Grid Inverter

Consumer Loads
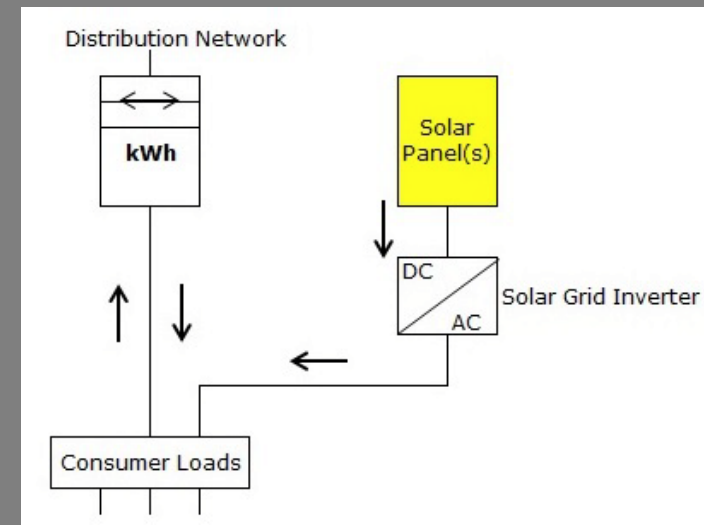
P = V x I

Power is voltage multiplied by current (P = V x I).

During the daytime, the villages provide the "I" and TANGEDCO the "V".

During the night time TANGEDCO provides the "V" and "I". However the "I" was generated by the village in the day time.

The Numbers

Assume a village with a population of about 2,000 persons, comprising 500 families

Assuming that each family consumes 4 units (kWh) per day an average daily solar generation of 2,000 kWh is needed

This requires a total solar PV capacity of 500 kW. The capital cost will be about Rs. 6 core, or Rs 1.2 lakh per family.
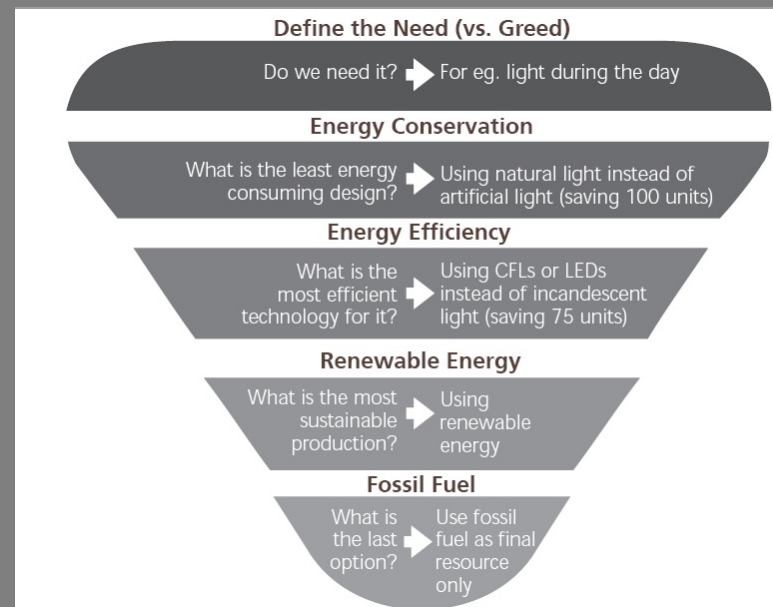
Funding

A pilot / demonstration project may be funded by the state government

For the long term implementation of solar villages funding can come from the private sector with a feed-in tariff mechanism ensuring that such funding is viable and thus attracts the required large scale investments.
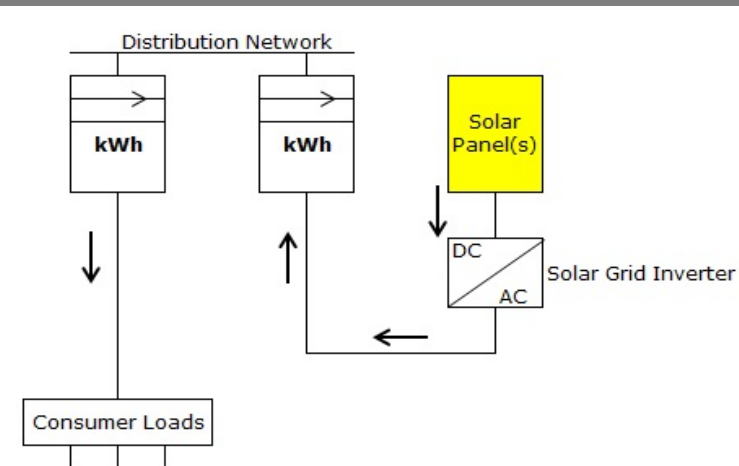
Energy Efficiency and Conservation

The Solar Village project will include energy audits and energy efficiency initiatives, including replacement of inefficient lighting with LED lights and replacement of inefficient (agricultural) pumps.

Define the Need (vs. Greed)
Do we need it? ➡ For eg. light during the day

Energy Conservation
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Energy Efficiency
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Renewable Energy
What is the most sustainable production? ➡ Using renewable energy

Fossil Fuel
What is the last option? ➡ Use fossil fuel as final resource only

Benefits

- A paradigm shift in the way the state grid is managed. Instead of considering rural areas as a burden and subjecting rural feeders to heavy load shedding, rural areas will become net exporters of renewable energy with 24x7 grid availability;

- With uninterrupted electricity supply in the rural areas, economies in these areas will grow, become more diversified and will reduce the migration to urban areas;

- There will be significant improvements in the education in rural areas when 24 x 7 grid power is made available to all homes, schools and colleges;

Benefits

- The electricity grid will become more stable and a higher level of energy security is achieved;

- The environment is protected with a higher contribution from renewable energy sources.

Auroville Example

Home with a stand-alone solar PV system of 1.5 kW and a grid-connected (import-export) system of 1.7 kW at Auroville, India
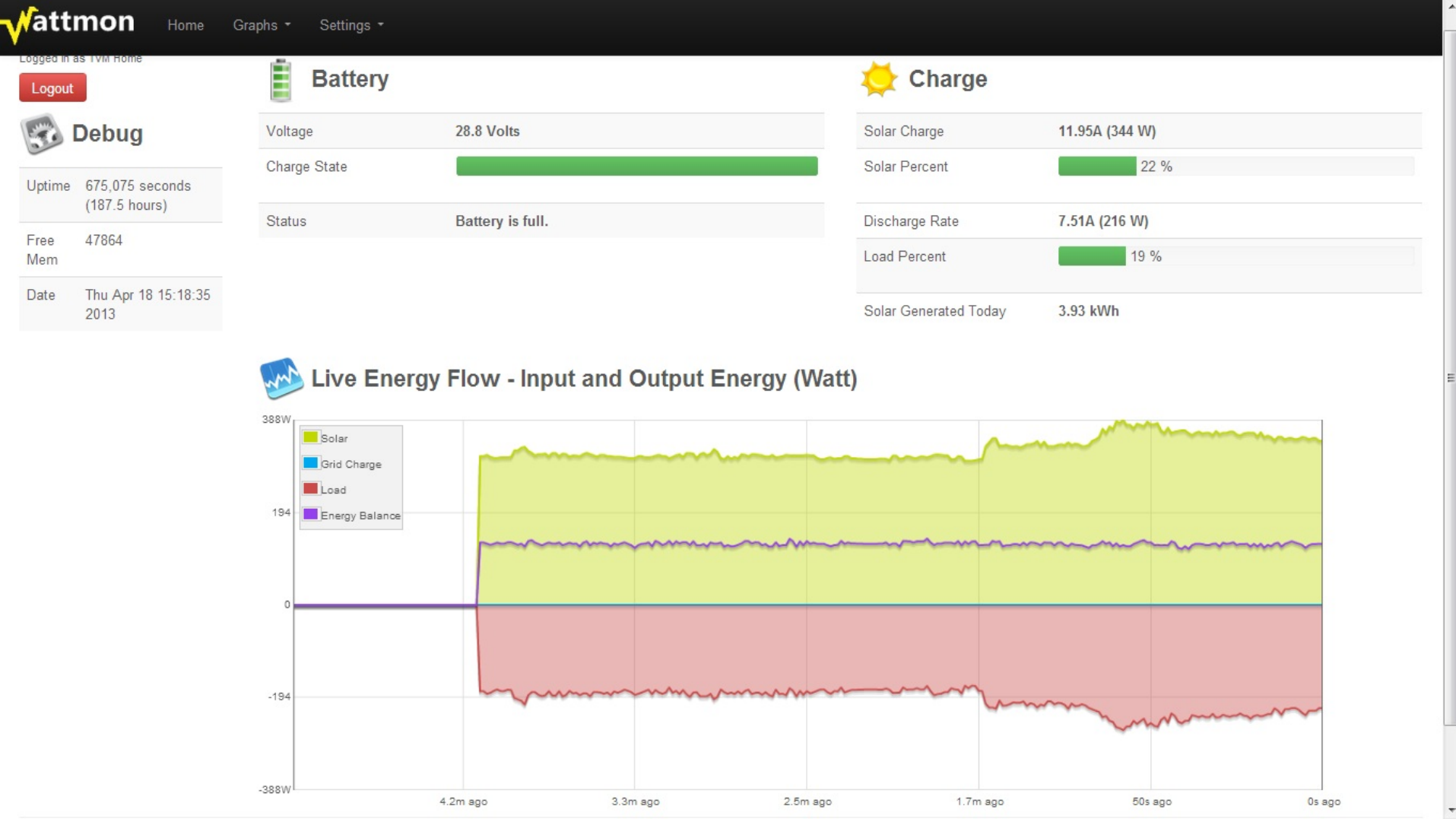
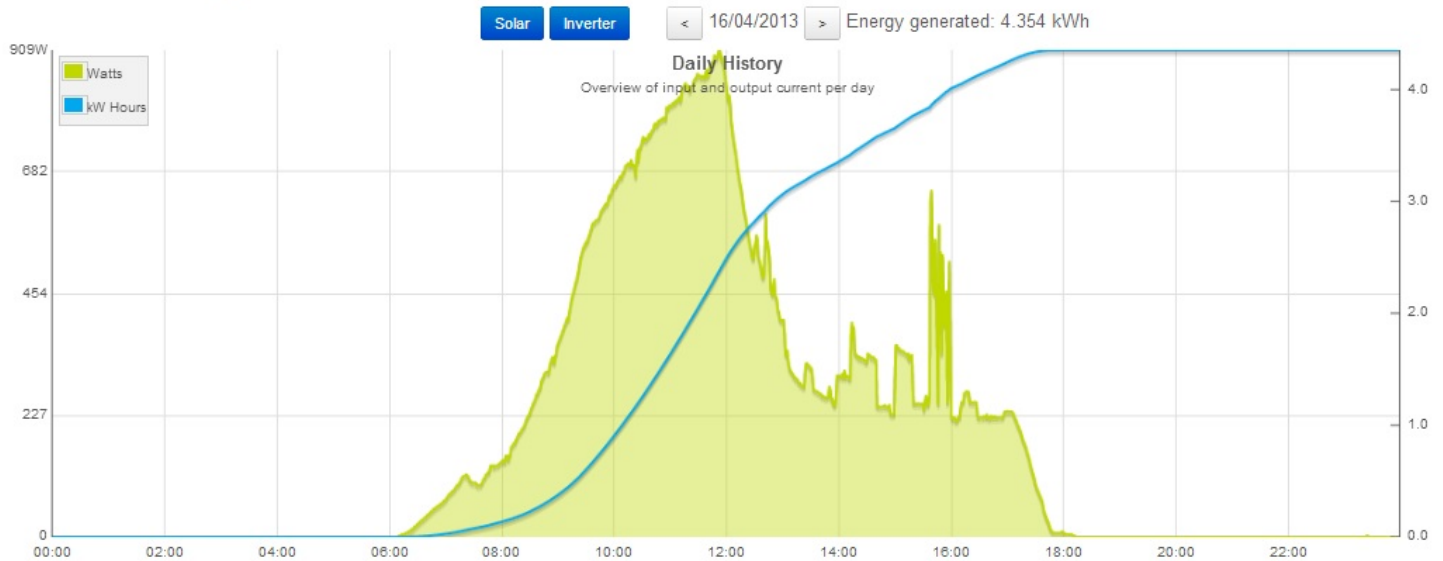# Stand-alone system

Stand-alone Solar Inverter

WattMon Screen

WattMon Screen

Grid-connected system

Import-export meter

15 kW Grid-connected

Stand-alone Rooftop Solar PV Single Line Diagram

Solar Panel(s)

DC Isolator

Solar Charge Controller

Battery Bank

Stand alone Inverter

AC Circuit Breaker

Solar Generation Meter (optional)

Consumer Loads
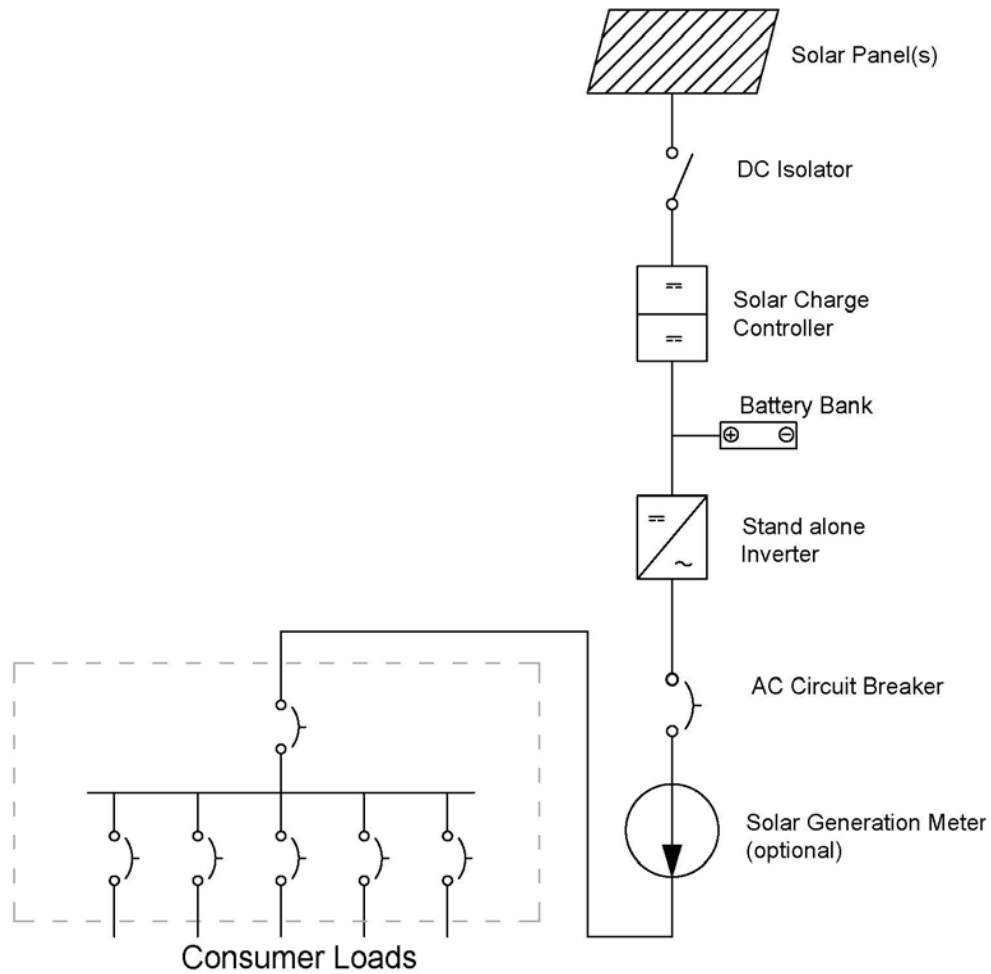
Grid-Interactive Rooftop Solar PV Single Line Diagram with net-metering

Distribution Network

Solar Panel(s)

AC

Discom Solar Service Connection Meter
(Bidirectional kWh)

kWh

kWh

Solar Generation Meter (kWh)

DC Fuse(s)

DC Combiner box

DC

Consumer Service Connection Main Switch

AC

DC Isolator / Circuit Breaker

DC Distribution box

DC Surge Protection Device

AC

AC

Solar Grid Inverter

Consumer Distribution Board

AC

AC Surge Protection Device

AC Distribution box

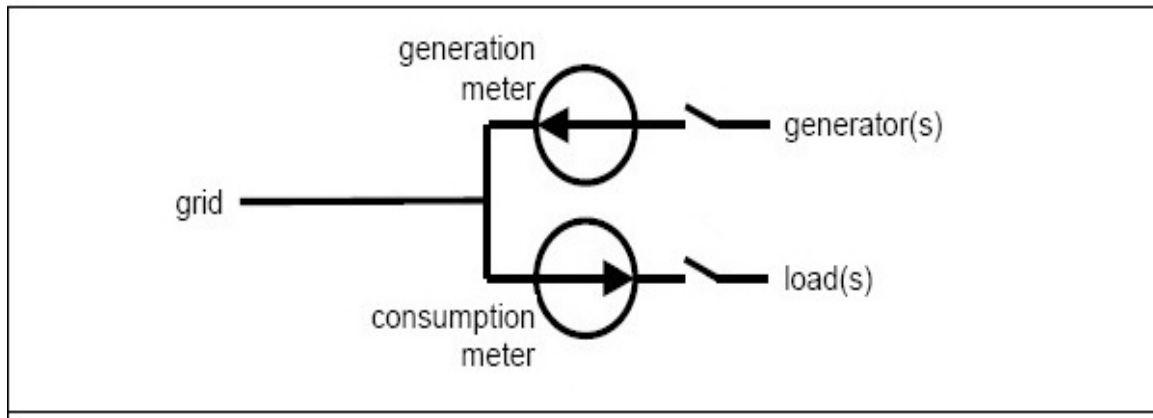AC Isolator / Circuit Breaker

Consumer Loads

Grid-Interactive Rooftop Solar PV Single Line Diagram with a feed-in tariff mechanism
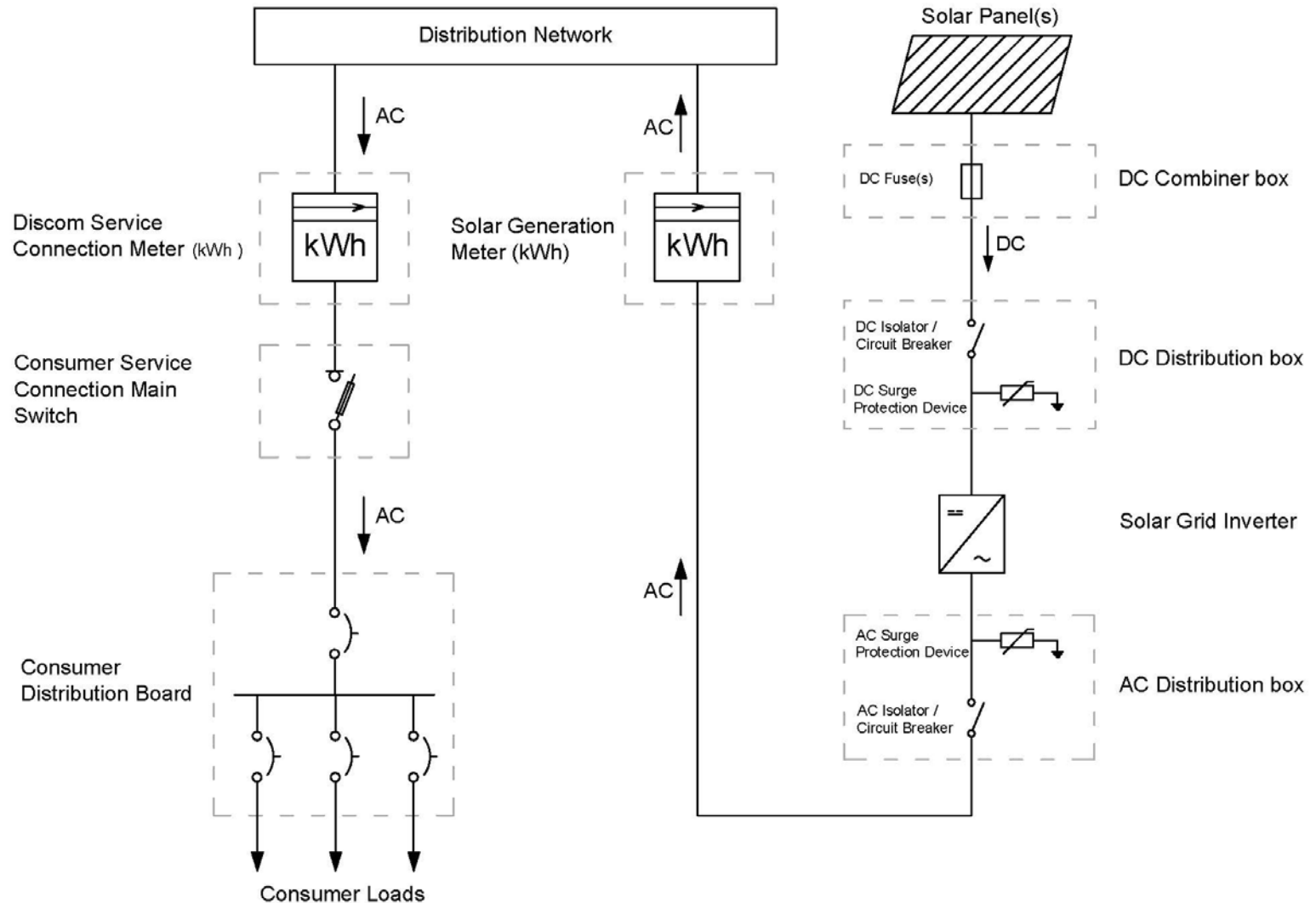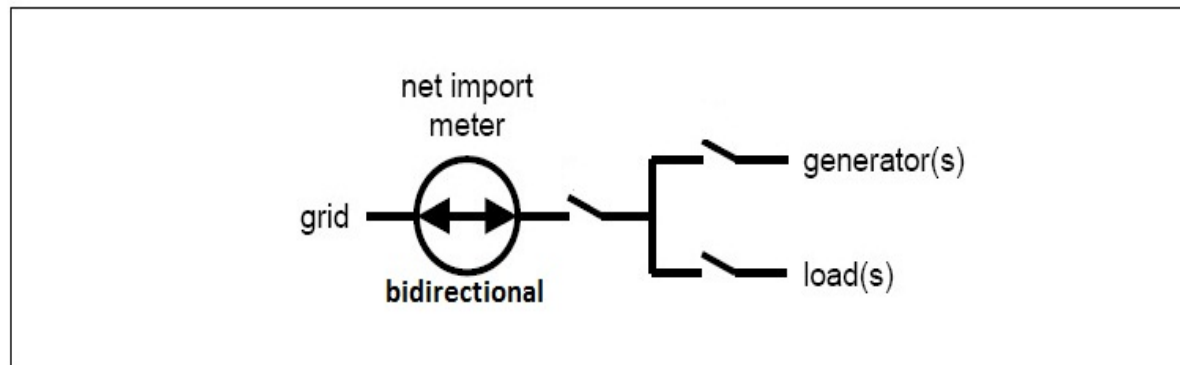
Net-metering and Feed-in Tariffs

Feed-in tariff mechanism

Net-metering

The Economics of net-metering

- Net-metering becomes economically viable when the cost of solar energy is equal to, or lower than, the cost of conventional energy.

Thank You

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