

Annexure- A

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The manual can be downloaded from <http://www.inforse.org/asia/>

A1: Information on energy contents, conversion and light efficiency

| Energy Contents | | | |
|----------------------|------|---------|--|
| Wood | 4.5 | kWh/kg | Dry soft wood with less than 15% moisture. Hard wood: 15% higher |
| Dung | 3 | kWh/kg | Dry dung cake, wet dung lower |
| Straw | 4 | kWh/kg | Dry straw from cereal |
| Charcoal | 7 | kWh/kg | Typical |
| Kerosene | 10 | kWh/ltr | |
| Diesel | 10 | kWh/ltr | |
| Petrol | 9 | kWh/ltr | equal to about 12 kWh/kg |
| Gas (LPG in bottles) | 12.7 | kWh/kg | |
| Coal | 6 | kWh/kg | Hard coal, typical. Brown coal and lignite are lower |

| Conversion factors | |
|---------------------------------|----------|
| 1 kg oil equivalent | 10kWh |
| 1000 Btu (British thermal Unit) | 0.293kWh |
| 1 MJ (Mega Joule) | 0.28kWh |

Various sources of light for use in a village

| Light efficiency and consumption, typical | Wick lamps | Hurricane lamps | Pressure lamps | Gas lamps | Light bulbs (incandescent) | Halogen lamps | LED (white) | CFL lamps | Light tubes |
|---|-------------|-----------------|----------------|------------------------|----------------------------|---------------|-------------|-----------|-------------|
| Efficiency, lumen/w | 0.1 | 0.15 | 1 | 1 | 6-18 | 14-25 | 22-38 | 40-60 | 50-60 |
| Efficiency, relative | 0.2% | 0.3% | 1.7% | 1.7% | 10-30% | 23-40% | 37-63% | 60-100% | 80-100% |
| Light given (lumen) | 15 | 30 | 1400 | 200 | 500 | 400 | 100 | 550 | 1800 |
| Power consumption (Watt)** | 150 | 200 | 1400 | 200 | 40 | 20 | 3 | 9 | 36 |
| Consumption, 4 hrs* | 0.06 ltr k. | 0.08 ltr k. | 0.56 ltr.k. | 0.13 m ³ b. | 0.16 kWh | 0.08 kWh | 0.012 kWh | 0.036 kWh | 0.14 kWh |

* 4 hours are typical daily consumption for most lamps for household use, k=kerosene, b=biogas with an energy content of 6 kWh/m³

Sources: ESD - <http://www.eurorex.com/ugtoges/light.htm>, and Danish information on efficient lighting

** The power consumption are examples, other wattages are also available for most lamps

A2: Examples for Chapter 2.2 – 2.5

| Present energy consumption | families | Use/family | | Use/year | Energy content | Energy use/year |
|------------------------------|----------|------------------|-----------|----------|----------------|-----------------|
| | number | kg/day | kg/day | kg/year | kWh/kg | kWh/year |
| Families in village | 50 | | | | | |
| Wood | 50 | 4 | 200 | 72000 | 4.5 | 324000 |
| Dung | 30 | 2 | 60 | 21600 | 3 | 64800 |
| Agri-waste/Straw | 25 | 1 | 25 | 9000 | 4 | 36000 |
| Gas bottles (14,5 kg/bottle) | 5 | 0.04 | 0.2 | 72 | 12.7 | 914 |
| | families | no./month | Use/month | Use/year | kwh/battery | kwh/year |
| Batteries D-Size | 50 | 2 | 100 | 1200 | 0.025 | 30 |
| Batteries AA-size | 50 | 2 | 100 | 1200 | 0.005 | 6 |
| | | | | | | |
| Grid electricity use | families | kWh/month | kWh/month | kWh/year | | kWh/year |
| Household use | 5 | 25 | 125 | 1500 | | 1500 |
| | | kWh/month | | kWh/year | | kWh/year |
| Clinic & office | | 75 | | 900 | | 900 |
| Village grinder | | | | 400 | | 400 |
| | | | | | | |
| Oil/kerosene use | Number | ltr/family/month | ltr/month | ltr/year | kWh/ltr | kWh/year |
| Household kerosene | 45 | 2 | 90 | 1080 | 10 | 10800 |
| Village grinder | | | | 1000 | 10 | 10000 |
| Tractor | 1 | | | 6000 | 10 | 60000 |

| Costs of various energy forms | | | | | | |
|-------------------------------|---------------------|------------|--------|------|----------|------|
| Batteries, D-Size | | 20Rs/piece | Local* | 25% | Bought** | 100% |
| Batteries, AA-Size | | 15Rs/piece | Local* | 25% | Bought** | 100% |
| Grid electricity | | 12Rs/kWh | Local* | 0% | Bought** | 100% |
| Firewood | | 1Rs/kg. | Local* | 100% | Bought** | 10% |
| Dung, agri-waste | non, it is not sold | | Local* | | Bought** | 0% |
| Bottled (LPG) gas | | 20Rs/kg. | Local* | 0% | Bought** | 0% |
| Kerosene | | 25Rs/ltr | Local* | 0% | Bought** | 100% |
| Diesel | | 25Rs./ltr | Local* | 0% | Bought** | 100% |

* Fraction of income that stays in village as profit, payment for collection of wood etc.

** Fraction of fuel that is bought, the rest is just collected and used without payments

| Division of electricity consumption into end-uses | | | | | | | |
|---|-------|----------|--------------|---------|------------|-------|-------|
| Electricity (kwh/y) | Light | Radio/TV | Refrigerator | Grinder | Water pump | Total | Costs |
| Batteries | 18 | 18 | | | | 36 | 42000 |
| Households with grid* | 1168 | 332 | | | | 1500 | 18000 |
| Clinic etc. | 500 | | 400 | | | 900 | 10800 |
| Agriculture (grinder) | | | | 400 | | 400 | 4800 |
| Total | 1686 | 350 | 400 | 400 | 0 | 2836 | 75600 |

* Light for households with grid: Each household has in average 4 lamps 40 W each used 4 hours/day

| Energy Balance Present situation | Fuel (kWh/year) | | Electricity | | | Total | Efficiency | | End-use (kWh/year) |
|-------------------------------------|--------------------|----------------|-------------|------------------|--------------|-------------------|------------------------------|-------------|-----------------------|
| | Wood | Dung/waste | Gas | Diesel/kerosene. | | | Fuel | Electricity | |
| in kWh/year | | | | | | All source | | | All uses |
| Stove, type 1 (wood) | 324,000 | | | | | 324,000 | 12% | | 38,880 |
| Stove, type 2 (dung/waste) | | 100,800 | | | | 100,800 | 11% | | 11,088 |
| Light | | | | 10800 | 1,686 | 12,486 | 0.3% | 12% | 235 |
| Radio/TV | | | | | 350 | 350 | | 50% | 175 |
| Refrigerator | | | | | 400 | 400 | | 50% | 175 |
| Village grinder (agriculture) | | | | 10000 | 400 | 10,400 | 15% | 60% | 1740 |
| Water pump | | | | | | 0 | | | 0 |
| (other) | | | 914 | | | 914 | 50% | | 457 |
| (other) | | | | | | 0 | | | |
| Tractor (agriculture) | | | | 60,000 | | 60,000 | 20% | | 12,000 |
| Total | 324,000 | 100,800 | 914 | 80,800 | 2,836 | 509,350 | | | 64,750 |
| Costs | 7200 | 0 | 1440 | 202000 | 75600 | 286,240 | Rs/year | | |
| Cost/household excl. Agri. | 144 | 0 | 29 | 540 | 1200 | 1,913 | Rs/year in average | | |
| Costs that stay in village | 7200 | 0 | 0 | 0 | 8400 | 15,600 | Rs/yr that stay in village** | | |
| Work in village | 100 | 30 | 0 | | | 130 | Work in hours/day*** | | |
| CO2-emissions | | | | | | | CO2 emissions kg/y | | |

Tables for chapter 2.3

| "Business as usual" future energy consumption | families | Use/ family | Use/day | Use/year | Energy content | Energy use/year |
|---|----------|------------------|-----------|----------|----------------|-----------------|
| | | kg | kg/day | kg/year | kWh/kg | kWh/year |
| Wood | 50 | 4 | 200 | 72000 | 4.5 | 324000 |
| Dung | 30 | 2 | 60 | 21600 | 3 | 64800 |
| Agricultural waste/Straw | 25 | 1 | 25 | 9000 | 4 | 36000 |
| Gas bottles (14,5 kg/bottle) | 5 | 0.04 | 0.2 | 72 | 12.7 | 914 |
| | families | no./month | Use/month | Use/year | kwh/battery | kwh/year |
| Batteries D-Size | 50 | 1 | 50 | 600 | 0.025 | 15 |
| Batteries AA-size | 50 | 1 | 50 | 600 | 0.005 | 3 |
| Grid electricity use | families | kWh/month | kWh/month | kWh/year | | kWh/year |
| Household use | 50 | 25 | 1250 | 15000 | | 15000 |
| | | kWh/month | | kWh/year | | kWh/year |
| Clinic& office | | 75 | | 900 | | 900 |
| Village grinder | | | | 400 | | 400 |
| Water pump | | | 30 | 360 | | 360 |
| 4 street lights, 50 W, 12h/d. | | | 72 | 864 | | 864 |
| Small cold storage, 1 kWh/d | | | 30 | 360 | | 360 |
| Oil/kerosene use | Number | ltr/family/month | ltr/month | ltr/year | kWh/ltr | kWh/year |
| Household kerosene | 0 | 2 | 0 | 0 | 10 | 0 |
| Village grinder | | | | 1000 | 10 | 10000 |
| Tractor | 1 | | | 6000 | 10 | 60000 |

| Division of electricity consumption into end-uses | | | | | | | |
|---|--------------|-------------|--------------|------------|------------|--------------|---------------|
| Electricity (kwh/y) | Light | Radio/TV | Refrigerator | Grinder | Water pump | Total | Costs |
| Batteries | 18 | 0 | 0 | | | 18 | 21000 |
| Households with grid | 11680 | 3320 | 0 | | | 15000 | 180000 |
| Clinic etc. | 500 | 0 | 400 | | | 900 | 10800 |
| Agriculture | | | | 400 | | 400 | 4800 |
| Common facilities* | 864 | | 360 | | 360 | 1584 | 19008 |
| Total | 13062 | 3320 | 760 | 400 | 360 | 17902 | 235608 |

* In this case street lights, cold storage, water pump

| Future "Business as usual" energy balance | | | | | | | | | |
|---|-----------------|----------------|------------|---------------|---------------|----------------|-------------------------------|--------------------|---------------|
| kWh/year | Fuel (kWh/year) | | | | Electricity | Total | Efficiency* | End-use (kWh/year) | |
| | Wood | Dung/waste | Gas | Diesel/ker. | | | | All sources | Fuel |
| Stove, type 1 (wood) | 324,000 | | | | | 324,000 | 12% | | 38,880 |
| Stove, type 2 (dung/waste) | | 100,800 | | | | 100,800 | 11% | | 11,088 |
| Light | | | | 0 | 13,062 | 13,062 | 0.3% | 12% | 1,567 |
| Radio/TV | | | | | 3,320 | 3,320 | | 50% | 1,660 |
| Refrigerator | | | | | 760 | 760 | | 50% | 380 |
| Village grinder (agriculture) | | | | 10000 | 400 | 10,400 | 15% | 60% | 1,740 |
| Water pump | | | | | 360 | 360 | | 75% | 270 |
| (other) | | | 914 | | | 914 | 50% | | 457 |
| (other) | | | | | | 0 | | | |
| Tractor (agriculture) | | | | 60,000 | | 60,000 | 20% | | 12,000 |
| Total, energy | 324,000 | 100,800 | 914 | 70,000 | 17,902 | 513,616 | | | 68,043 |
| Costs, total | 7,200 | 0 | 1,440 | 175,000 | 235,608 | 419,248 | Rs/year | | |
| Cost/household, excl. Agr. | 144 | 0 | 29 | 0 | 4,616 | 4,760 | Rs/year per family in average | | |
| Income in village | 7,200 | 0 | | 0 | 4,200 | 11,400 | Rs/yr that stay in village** | | |
| Work | 100 | 30 | | | | 130 | Work in hours/day*** | | |
| | | | | | | | CO2 emissions kg/y | | |

* Electric efficiencies are relative to best available technology.

** It is estimated that 20% of battery costs are going to local shop/seller in the village

*** It is estimated that it takes 1/2 hour to collect one kg firewood and 1/2 hour to collect and dry one kg cow dung

Tables for chapter 2.5

| Future "pico-hydro -chulha" energy consumption | families | Use/ family | Use/day | Use/year | Energy content | Energy use/year |
|--|----------|------------------|-----------|----------|----------------|-----------------|
| | | | | | kg | kg/year |
| Wood | 50 | 2.7 | 135 | 48,600 | 5 | 218,700 |
| Dung | 0 | 2 | 0 | 0 | 3 | 0 |
| Straw/Agri-waste | 0 | 1 | 0 | 0 | 4 | 0 |
| Gas bottles (14,5 kg/bottle) | 5 | 0.04 | 0.2 | 72 | 13 | 914 |
| | families | no./month | Use/month | Use/year | kwh/battery | kwh/year |
| Batteries D-Size | 50 | 1 | 50 | 600 | 0 | 15 |
| Batteries AA-size | 50 | 1 | 50 | 600 | 0 | 3 |
| Picohydro-electricity use | families | kWh/month | kWh/month | kWh/year | | kWh/year |
| Household use | 50 | 10 | 493 | 5,912 | | 5,912 |
| | | kWh/month | | kWh/year | | kWh/year |
| Clinic & office | | 42 | | 500 | | 500 |
| Village grinder | | | | 3,600 | | 3,600 |
| Water pump | | 30 | | 360 | | 360 |
| 4 street lights, 15W, 12h/d. | | 22 | | 259 | | 259 |
| Small cold storage | | 30 | | 360 | | 360 |
| Oil/kerosene use | Number | ltr/family/month | ltr/month | ltr/year | kWh/ltr | kWh/year |
| Household kerosene | 0 | 4 | 0 | 0 | 10 | 0 |
| Village grinder | | | | 200 | 10 | 2000 |
| Tractor | 1 | | | 6000 | 10 | 60000 |

Division of electricity consumption into end-uses

| Electricity (kwh/y) | Light | Radio/TV | Refrigerator | Grinder | Water pump | Total | Costs |
|----------------------|-------|----------|--------------|---------|------------|-------|-------|
| Batteries | 18 | 0 | 0 | | | 18 | 21000 |
| Households with grid | 2628 | 3284 | 0 | | | 5912 | |
| Clinic & office | 25 | 0 | 475 | | | 500 | |
| Agriculture | | | | 3600 | | 3600 | |
| Common facilities* | 259 | | 360 | | 360 | 979 | |
| Total | 2930 | 3284 | 835 | 3600 | 360 | 11009 | |

- In this case street lights, cold storage, water pump

| Investments "pico-hydro.." | Pieces | Costs | Loan | Subsidy | Cash |
|------------------------------|--------|--------|--------|---------|--------------|
| Pico-hydro plant | 1 | 200000 | 140000 | 50000 | 20000 I.Rs. |
| Chulhas, 50 families | 50 | 12500 | 0 | 0 | 12500 I.Rs. |
| CFL's 4 per family*50 | 200 | 44000 | 0 | 0 | 44000 I.Rs. |
| CFLs, mayor office, clinique | 5 | 1100 | 0 | 0 | 1100 I.Rs. |
| CFLs, 4 street lamps | 4 | 880 | 0 | 0 | 880 I.Rs. |
| Total for energy solutions | | 258480 | 140000 | 50000 | 78480 I.Rs. |
| Additional costs: | | | | | |
| Minigrid | 1 | 200000 | 150000 | 0 | 50000 I.Rs. |
| Street lamps | 4 | 28000 | 0 | 0 | 28000 I.Rs. |
| Water pump | 1 | 4000 | 0 | 0 | 4000 I.Rs. |
| Small cold storage | 1 | 10000 | 0 | 0 | 10000 I.Rs. |
| Total additional costs | | 242000 | 150000 | 0 | 92000 I.Rs. |
| Investment, total | | 500480 | 290000 | | 170480 I.Rs. |
| Investment per family | | | | | 5683 I.Rs. |

| "pico-hydro+chulha" Energy Balance | Fuel (kWh/year) | | | Electricity Total | | | Efficiency* | | End-use (kWh/yr) |
|---------------------------------------|-----------------|----------------|------|---------------------|--------|----------------|----------------------------------|-------------|---------------------|
| | Wood | Dung/ waste | Gas | Diesel/ kerosene | | All sources | Fuel | Electricity | All energy |
| Stove, improved chulha | 218,700 | | | | | 218,700 | 24% | | 52,488 |
| Stove, type 2 (dung) | | 0 | | | | 0 | 11% | | 0 |
| Light | | | | 0 | 2,930 | 2,930 | 0.3% | 60% | 1758 |
| Radio/TV | | | | | 3,284 | 3,284 | | 50% | 1642 |
| Refrigerator | | | | | 835 | 835 | | 50% | 1642 |
| Village grinder (agriculture) | | | | 2000 | 3,600 | 5,600 | 15% | 60% | 2460 |
| Water pump (other) | | | | | 360 | 360 | | 75% | 270 |
| Tractor (agriculture) | | | 914 | | | 914 | 50% | | 457 |
| | 218,700 | 0 | 914 | 60,000 | 11,009 | 292,624 | | | 12000 |
| Costs, total | 4860 | 0 | 1440 | 155000 | 41200 | 202500 | Rs/year**** | | |
| Cost/household, excl. Agr. | 162 | 0 | 29 | 0 | 0 | 162 | Rs/year per family in average | | |
| Income in village | 4860 | 0 | | 0 | 9200 | 14060 | Rs/yr that stay in village** | | |
| Work | 89 | 0 | | 2 | | 91 | Work in hours/day*** | | |
| | | | | | | | CO2 emissions kg/y | | |

* Electric efficiencies are relative to best available technology.

** It is estimated that 20% of battery costs are going to local shop/seller in the village

*** It is estimated that it takes 1/2 hour to collect 1 kg firewood and 1/2 hour to collect and dry 1 kg cow dung

**** For electricity is estimated that the annual cost of 10,000 Rs. + 31.200 Rs. to pay for investments in pico-hydro facility

| Annual payments "pico-hydro+chulhas" | |
|--|----------------|
| Energy payment incl. Loan for micro-hydro incl. mini grid* | 202500 I.Rs/yr |
| Payment, excl. Agriculture | 34028 I.Rs/yr |
| Payment per family excl. Agriculture, average | 1134 I.Rs/yr |
| Payment per family compared with present situation (- is savings), average | -779 I.Rs/yr |
| Payment per family compared with future "BAU"(- is savings), average** | -3626 I.Rs./yr |

* Loan repayment is assumed to be annually 10% of the total value of the loan (low-cost loan)