

Energy Efficient Pump Systems for Indian Agriculture

Feasibility study in cooperation with TERI

EEMODS 2017, Rome Italy, 7 September 2017
Session: Pumps 1

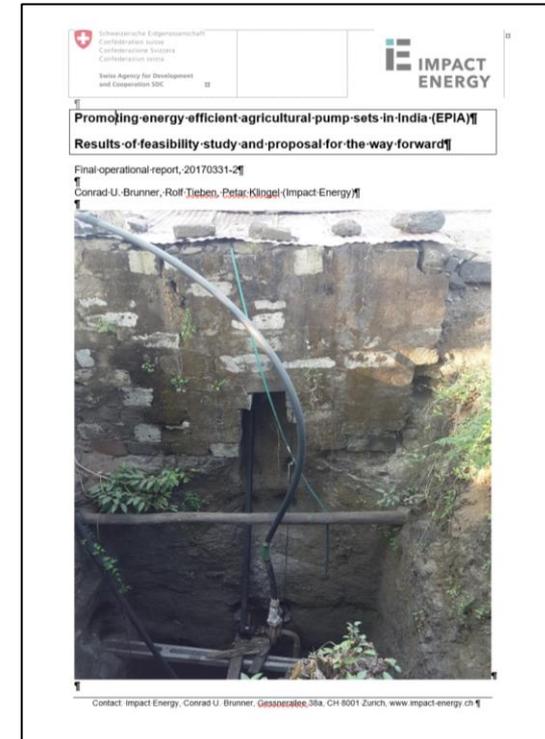
Conrad U. Brunner, Rita Werle, Rolf Tieben, Petar Klingel
Impact Energy, Zurich, Switzerland

Girish Sethi, Prosanto Pal, Nilesh Nagesh Shedge
TERI, Delhi, India



Promoting Energy Efficient Agricultural Pump Sets in India

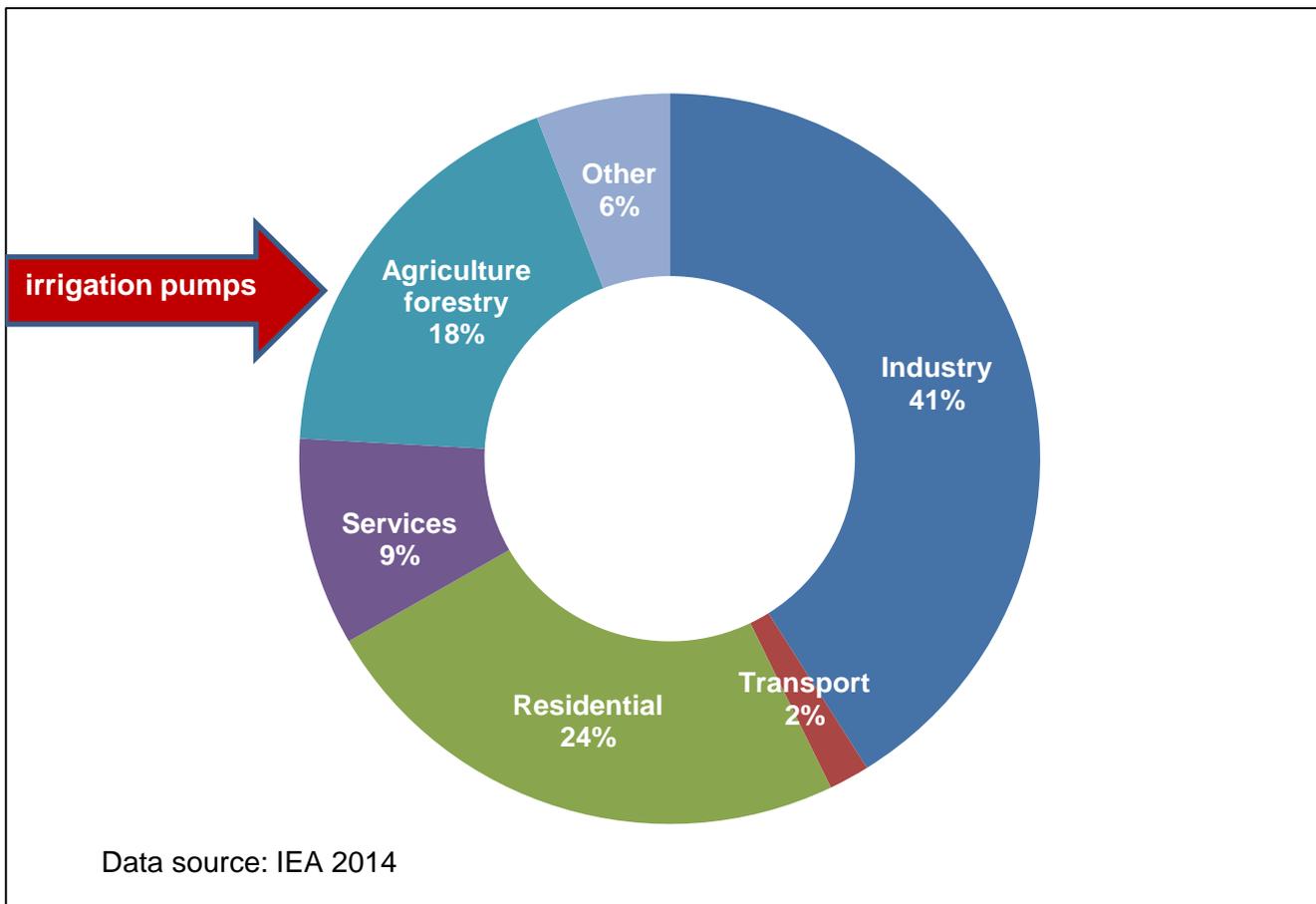
- **Goal:**
Support the Indian pump industry to develop energy efficient submersible pumps in agriculture for sustainable irrigation
- **Tasks:**
Understand role and importance of stakeholders, quantify efficiency gap and potential electricity savings
- **Way forward:**
Define a larger project "electricity & water" to stimulate market transformation toward sustainable irrigation and to reduce CO₂ emissions.



Indian agriculture: starting point

1. High relevance of agriculture:
 - ▶ land use, GDP, electricity consumption
2. Farmers:
 - ▶ pay low/no price for electricity (and water)
3. Electricity supply irregular:
 - ▶ under-voltage, damage to motors, limitation for new technologies
4. Irrigation when electricity available:
 - ▶ not when most needed (at night)
5. Irrigation by traditional (inefficient) means:
 - ▶ traditional flooding
6. 3 000 pump manufacturers in two major clusters:
 - ▶ 35% market share for agriculture
7. Farming traditions make any change difficult:
 - ▶ social/political taboos

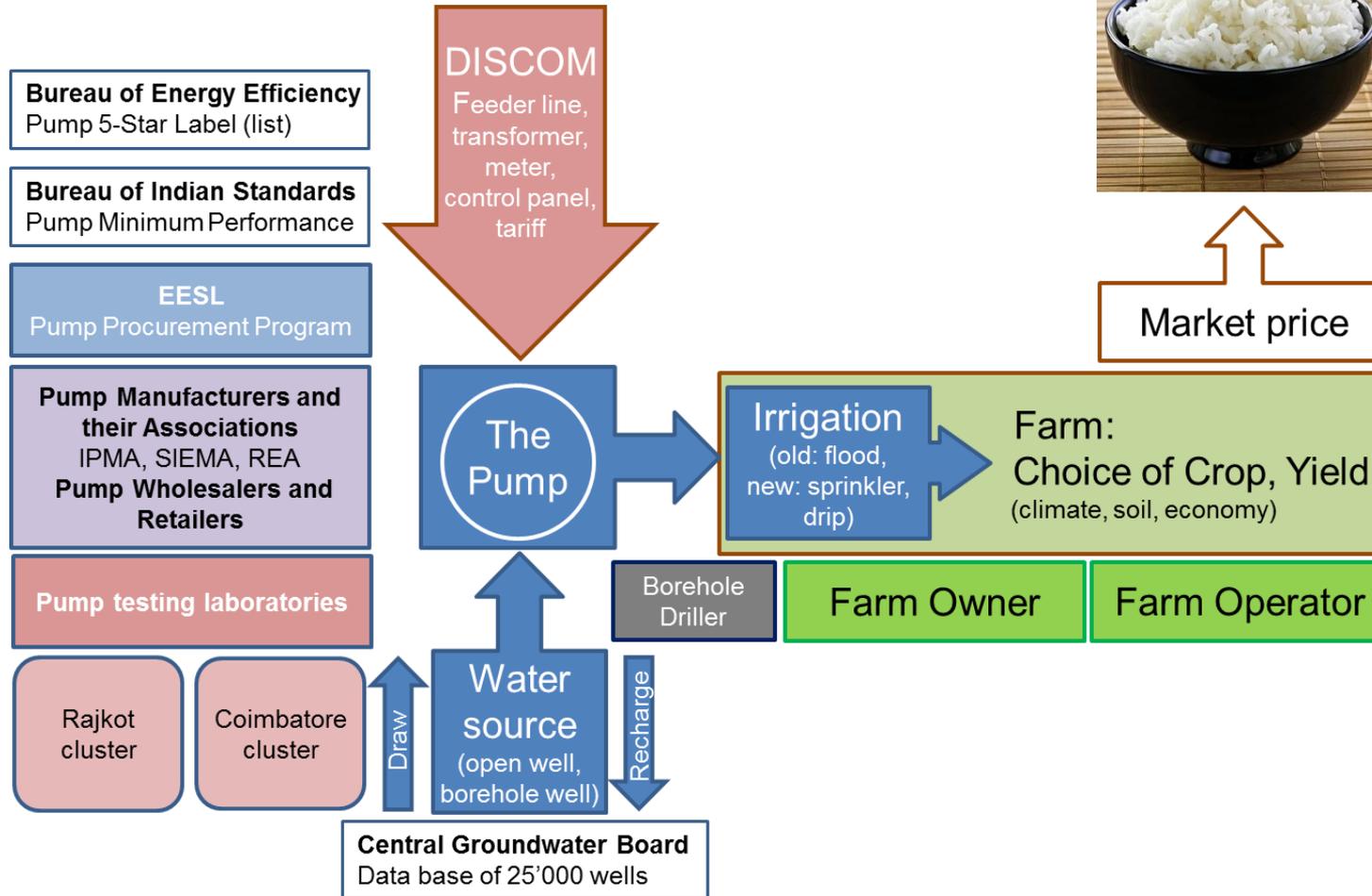
India: electricity consumption 2014



Complex system of stakeholders



Market price



Groundwater

Water resupply:

- Rain
- Monsson season

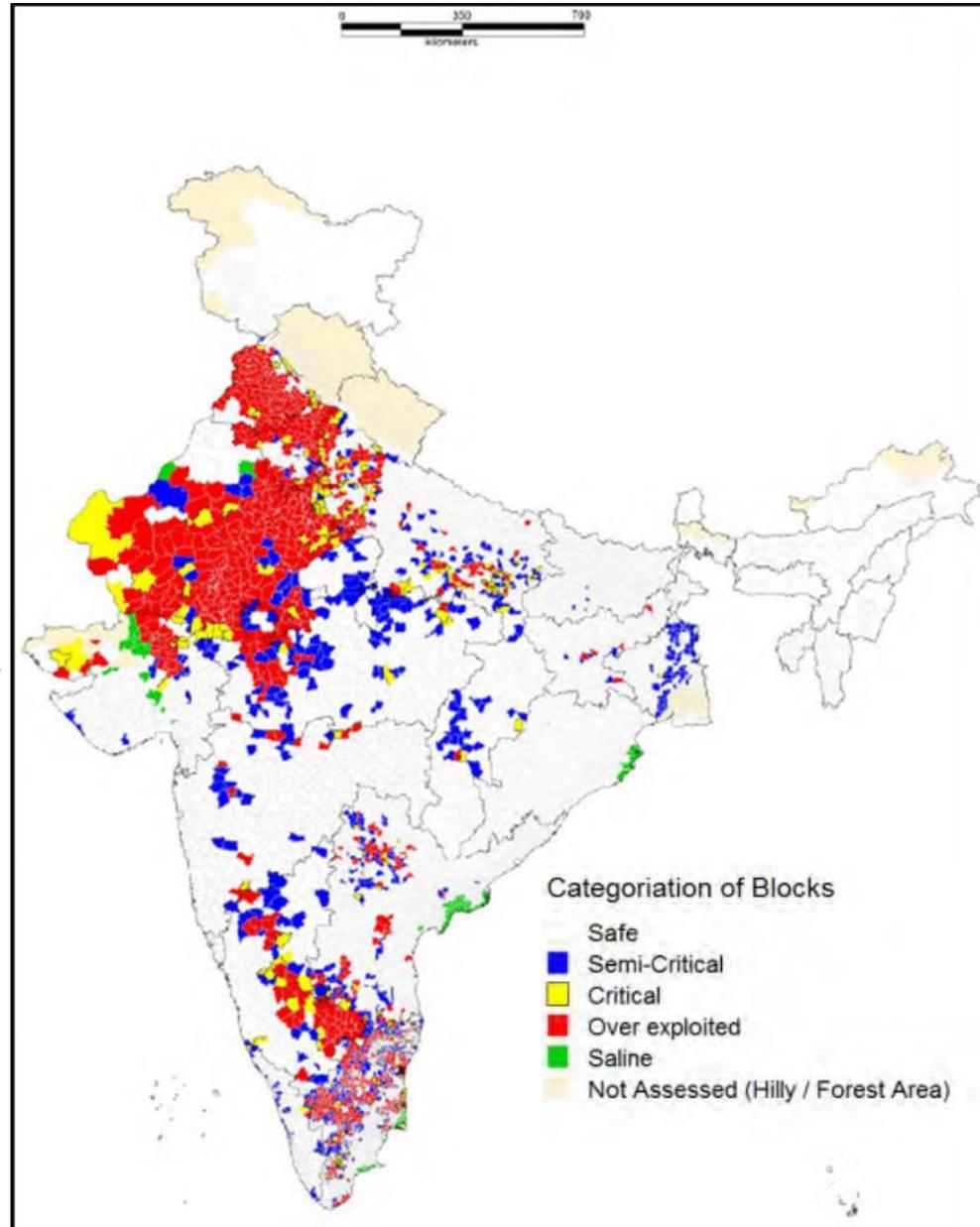
Water-table sinks

- 39% - 56% of wells fall
- 10 cm - 100 cm per year

Categories of risk

- 29% are semi-critical, critical or overexploited

Source: Groundwater Board 2016, Yearbook 2014-15



Irrigation technologies

Flooding



inefficient

Sprinkler



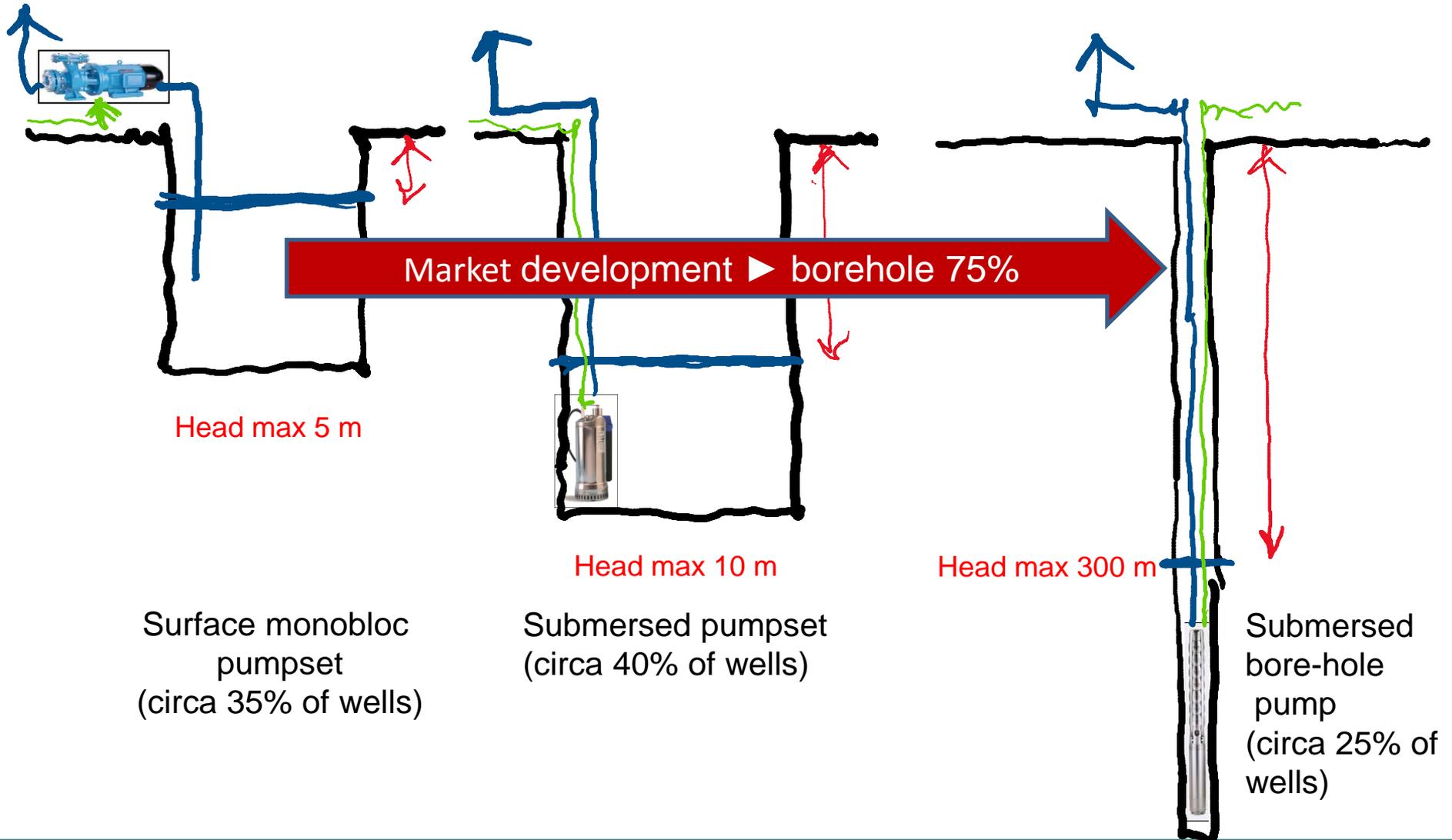
more efficient

Drip



most efficient

Well and pump typology



Horizontal drilling



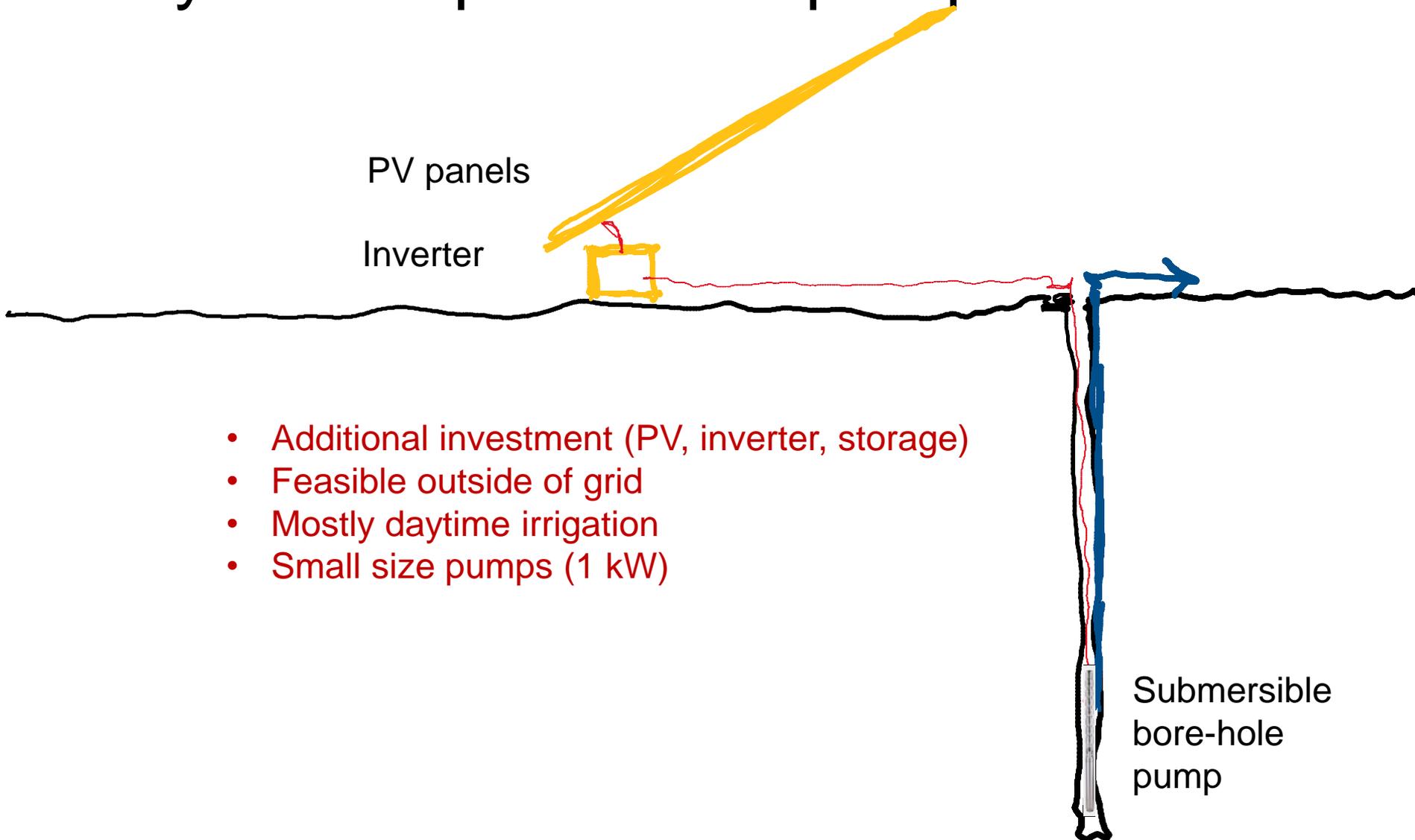
Source: Tamil Nadu

Better use of water resources

- Better irrigation: drip or sprinkler
- Harvest seasonal water supplies:
 - recharge open wells
 - use check dams
- Reduce deep drilling
- ▶ Avoid lowering of water table

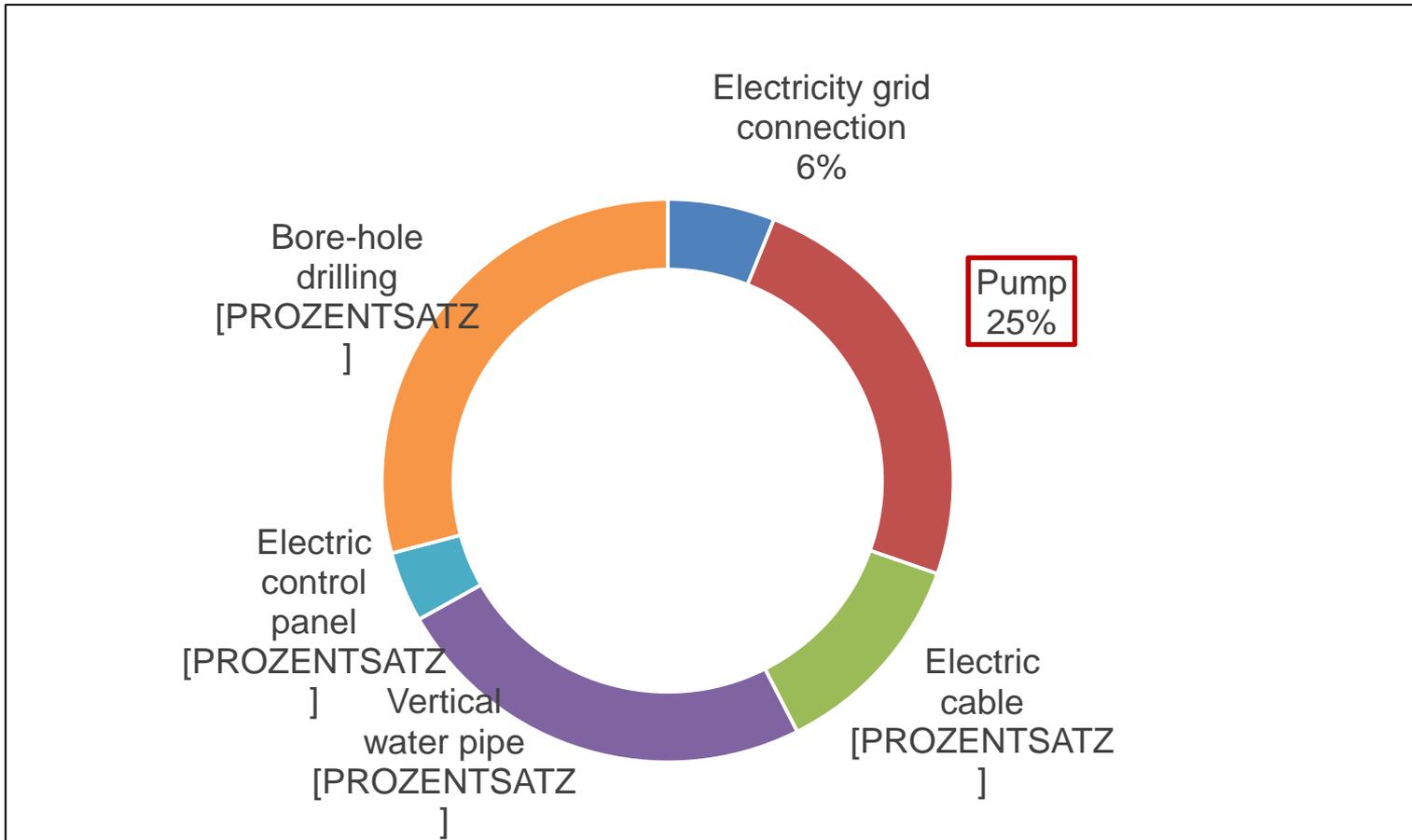
50% less water = 50% less pump energy

Why all this pain: solar pump?



- Additional investment (PV, inverter, storage)
- Feasible outside of grid
- Mostly daytime irrigation
- Small size pumps (1 kW)

Investment cost (new installation): pump is only one quarter



Cost analysis: TERI in Rajkot, 135 m drilling

Survey submersible pump efficiency

- General rules for comparison
 - nominal head and flow (no partial load)
 - 2-pole, 3-phase, 50 Hz motors
 - nominal voltage and frequency (no under-voltage)
 - regular multi-stage borehole pumps: market products (no preference for top superior or cheaper products)
 - comparison motor-efficiency, pump-efficiency, combined efficiency

- India
 - select most popular submersible pumps
 - manufacturer data (material, manufacturing, cost)
 - BEE-label registration performance data (usually based on third party tests)
 - 11 manufacturers
 - total 61 pumps
 - pumps meet IS 8034, amendment 2012, efficiency requirements for pump and motor

- International
 - use head and flow from most popular Indian borehole pumps (10 types)
 - manufacturer data (catalogue, not tested)
 - 3 international manufacturers
 - total 30 pumps
 - all pumps meet EC no 547/2012 Minimum Efficiency Index (MEI) < 0.4

Efficiency borehole pump set (15 cm)

Motor

- Submersible induction motor
- Small diameter
- Water cooled internal/external
- Water filled gap
- Can to protect stator

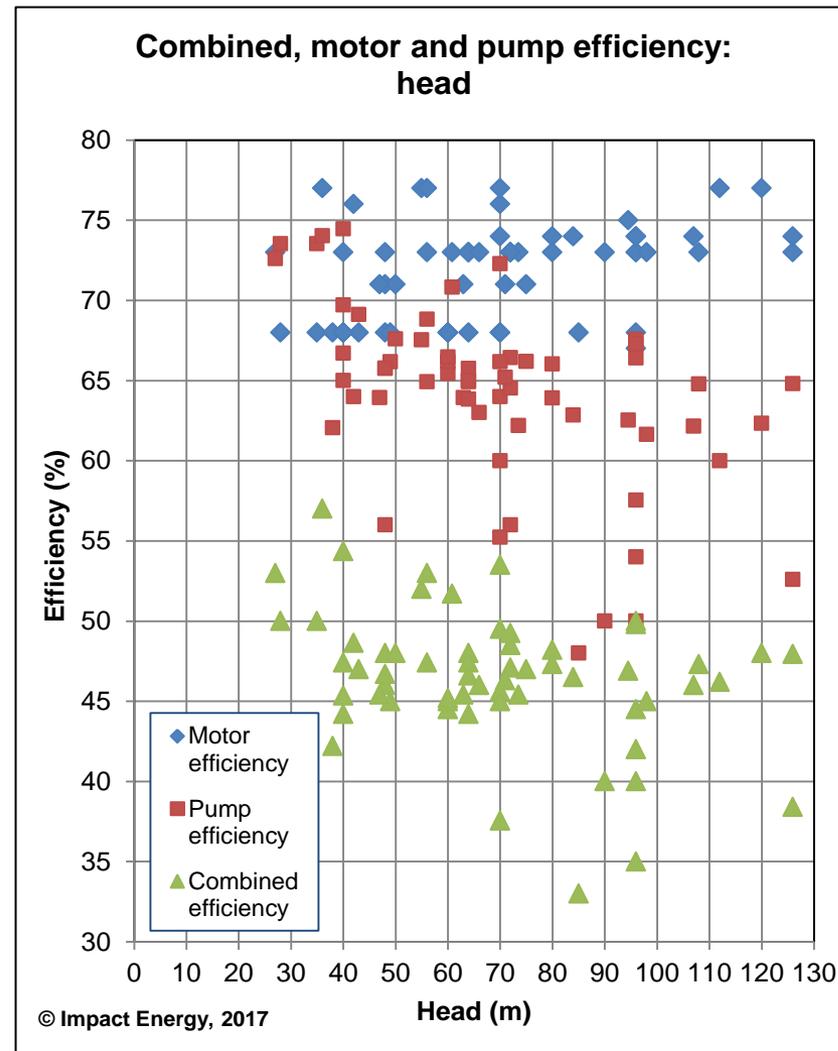
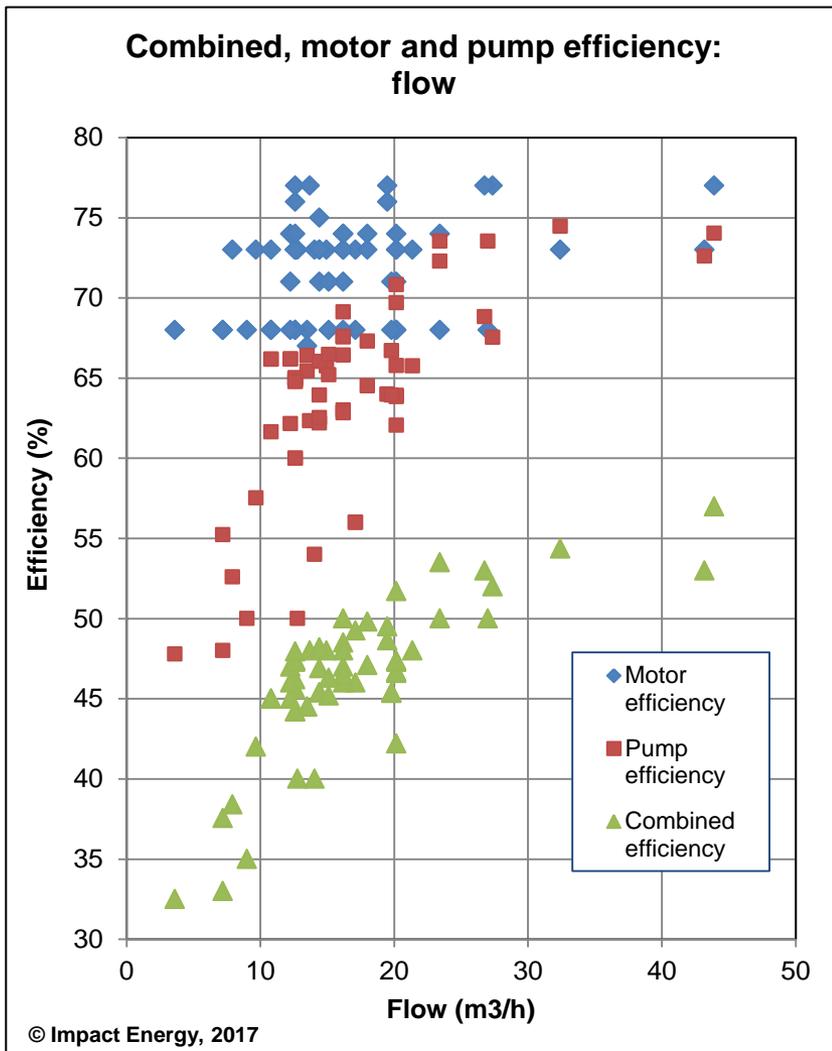
Pump

- Multistage submersible pump
- Sand
- Small diameter
- Backflow
- Impeller
 - shape (efficiency)
 - material (durability)
 - manufacturing technology
 - weight (inertia)

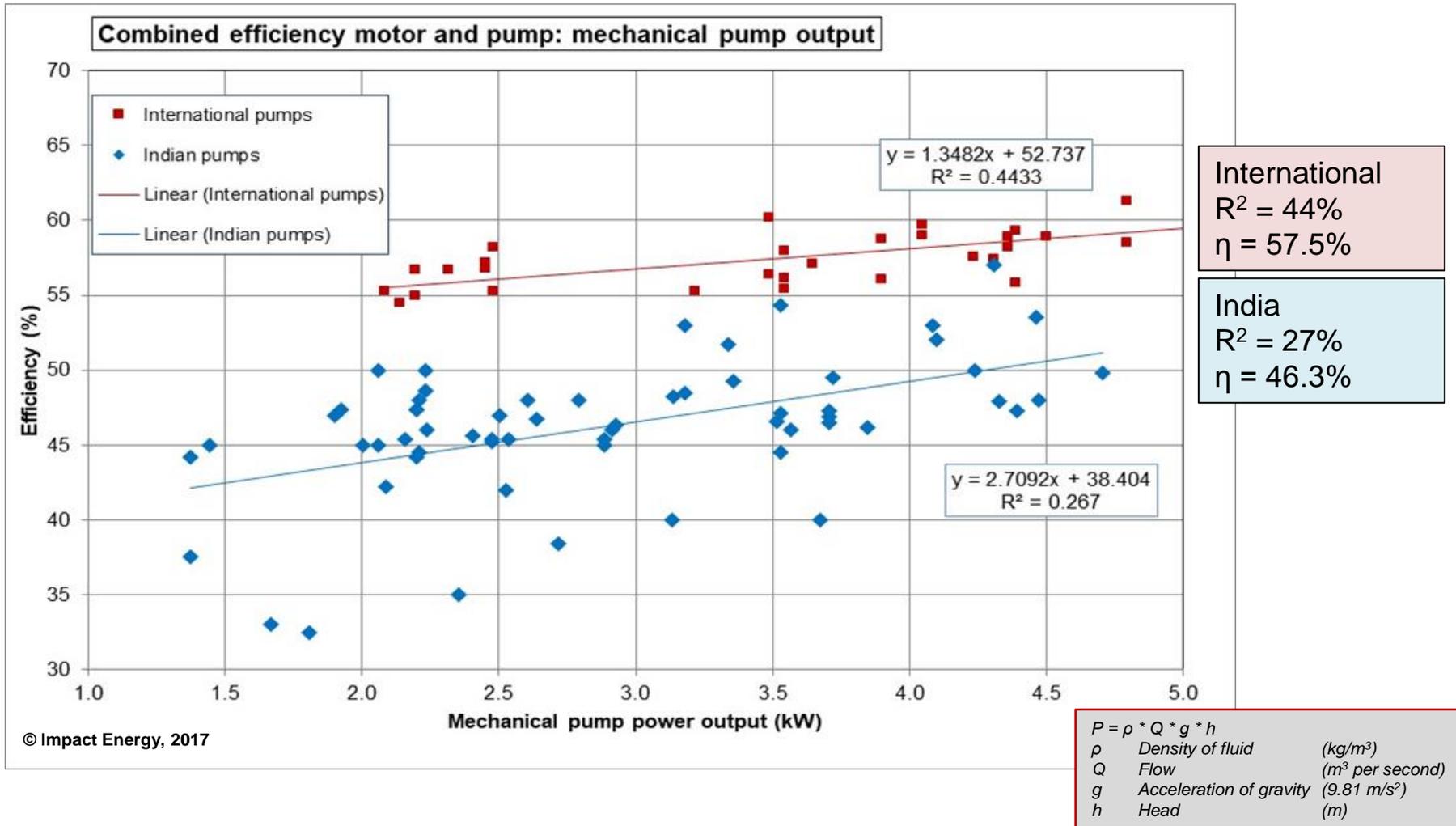
Indian pump factory: cast impellers



Efficiency: Indian submersible pumps



Submersible pumps: efficiency results



Electric energy: savings potential

Pump survey submersible borehole pumps	Manu- facturers	Pump models	Power (average)		Head (avg)	Flow (avg)	Efficiency (average)		
			electric	mechanical			pump	motor	combined
			kW _{el}	kW _{mech}			m	m ³ /h	%
India	11	61	5.0	2.9	71.3	16.7	63.9%	71.9%	46.3%
International	3	30	5.9	3.5	67.6	21.9	72.6%	79.2%	57.5%
Sum	14	91							
Energy savings							12.0%	9.3%	19.5%

relative

Electricity savings	Submersible pumps	Electric power	Operating hours	Electricity consumption		CO ₂ emission	Efficiency improvement	Savings		Power plants
	million	kW	h/a	kWh/a	TWh/a	Mt CO ₂ /a	%	TWh/a	Mt CO ₂ /a	number
Sales	2	5	1'500	7'500	15	12.3	19.5%	2.9	2.4	2.2
Stock	20	5	1'500	7'500	150	123	19.5%	29.3	24.0	21.6

258 MWe

absolute

Stationary replacement calculation: theoretical 100% compliance

Key Findings for India

1. Pump (pump and motor) efficiency can be improved
2. Water use for irrigation can be lowered
3. Electricity supply and tariffs can be part of economic considerations
4. Energy savings potential:
 - in 10 years the entire stock of pumps is renewed
 - only highly efficient pumps are used
 - the electricity savings can then reach 2.6% per year of the total electricity consumption of India

The way forward: technology & policy

Develop «sustainable irrigation»

- **Goal: low electricity use and water table remains stable**

Pumps

- standards & labels are increased/mandatory
- pump manufacturing is moving forward: capacity building for advanced technology
- financing for investment

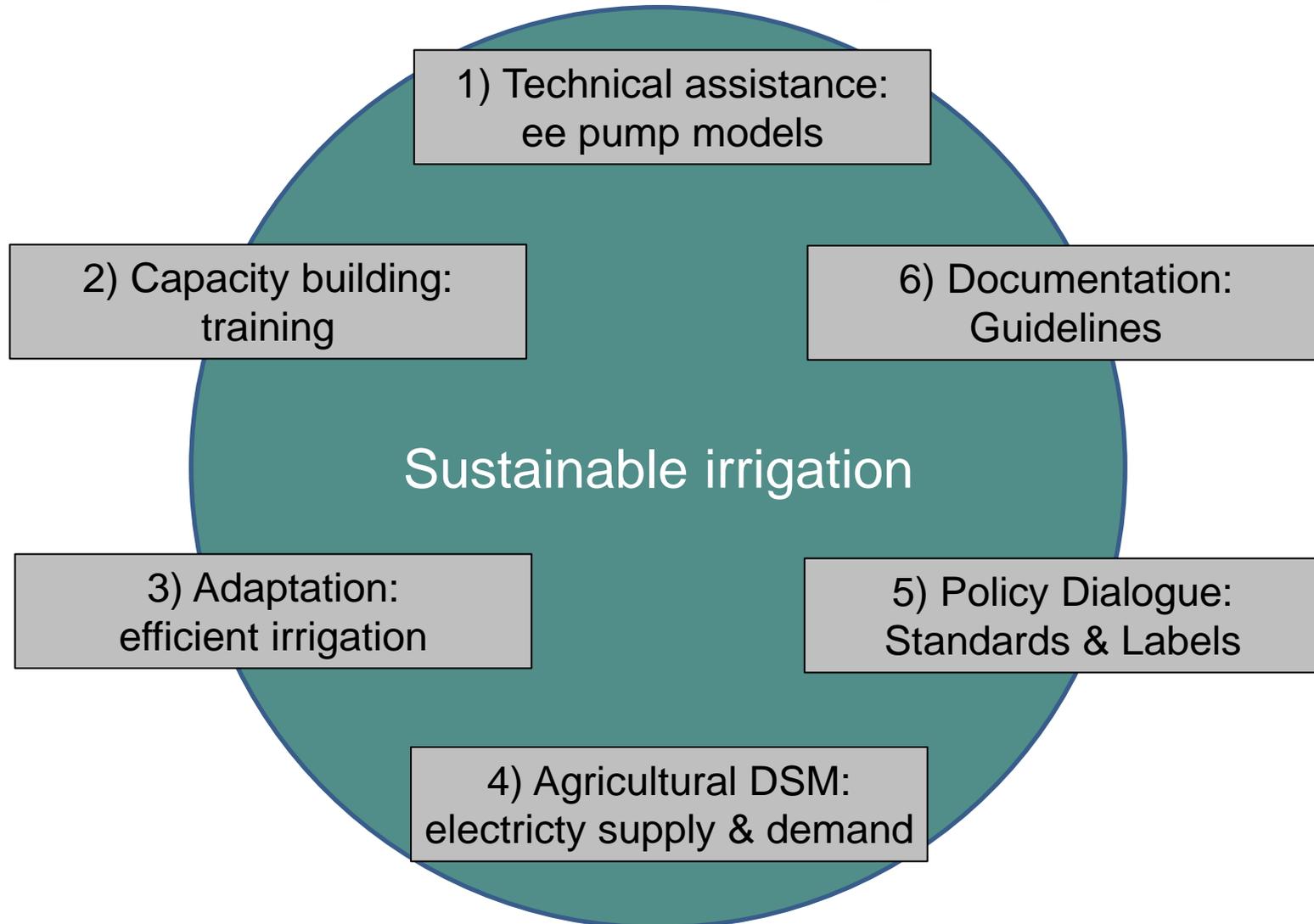
Surface water is carefully harvested after monsoon

- open wells are favored over borehole wells
- wells are recharged with horizontal drilling
- a policy for deep boreholes is needed
- advanced irrigation methods: drip and sprinkler

Introduce economic incentives for all stakeholders

- price of water (limitation to access of deep drilling)
- price of electricity (slowly approach full cost)
- discount on premium pumps

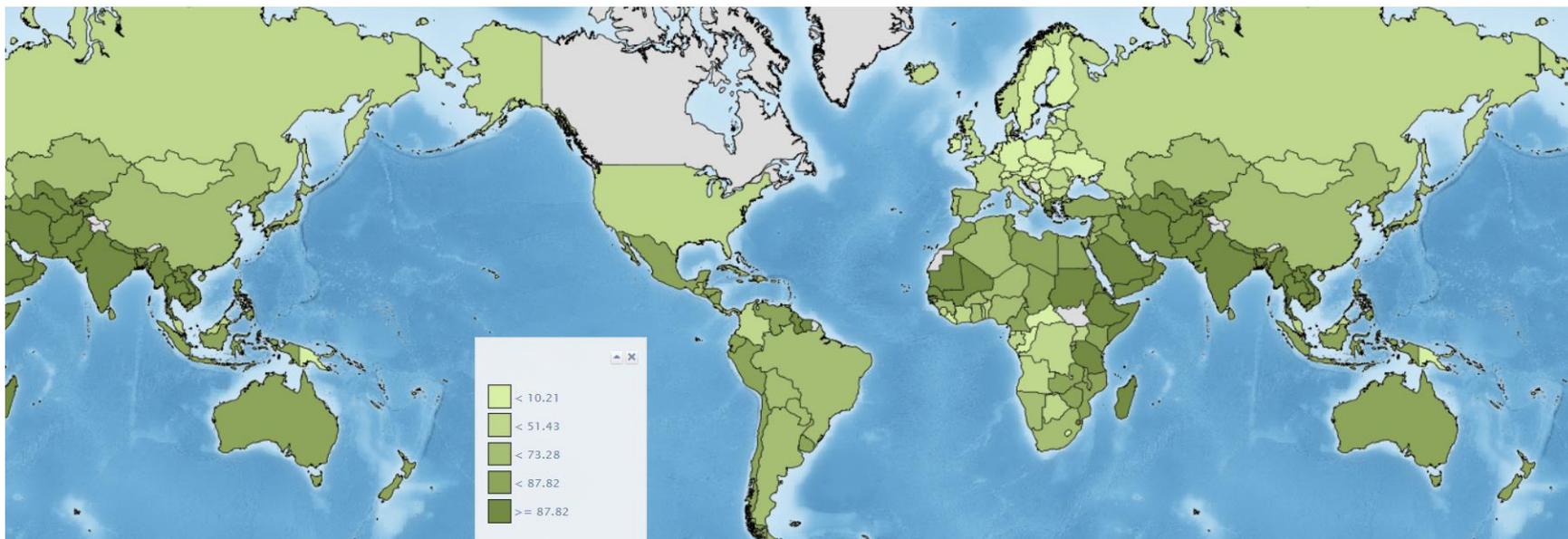
Proposed pilot projects: contribution of agriculture towards CO₂ emission reduction



Global outreach

- Agriculture in arid zones
- Developing countries

Proportion of total water withdrawal withdrawn for agriculture (%)



Source: FAO Aquastat http://www.fao.org/nr/water/aquastat/maps/World-Map.WithA.Twith_eng.htm

Contact

- Conrad U. Brunner, cub@impact-energy.ch
- Rita Werle, rita.werle@impact-energy.ch

- Impact Energy
Gessnerallee 38a, 8001 Zurich Switzerland
- www.impact-energy.ch

- www.topmotors.ch
- www.motorsystems.org
- www.motorsummit.ch

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