

# 23<sup>rd</sup> Domestic Use of Energy Conference

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Rwanda



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# **Sustainable Energy Generation From Pumped Hydropower**

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# Presentation Layout

- Introduction
- Need for Small Hydro-Power Plant (SHP)
- Pumped storage HP design
- Automated PSH plant Control
- Conclusions



# Introduction

- Power, backbone of every economy.
- Consistent, reliable, adequate supply
- RES, zero or little threat to human lives
- South Africa
  - 90 % of energy from coal
  - 12<sup>th</sup> biggest CO<sub>2</sub> emitter in the world



# Need for SHP

## 1. Material:

- Depletion of coal stocks and quality
- high maintenance levels
- plant failure and inadequate reserves

**2. Pollution:** green house carbon emission

**3. Environmental:** Climate change

**4. Cost:** High cost of other power plants  
e.g. coal

- It is available, renewable and sustainable
- Low or zero maintenance cost



# Need for SHP

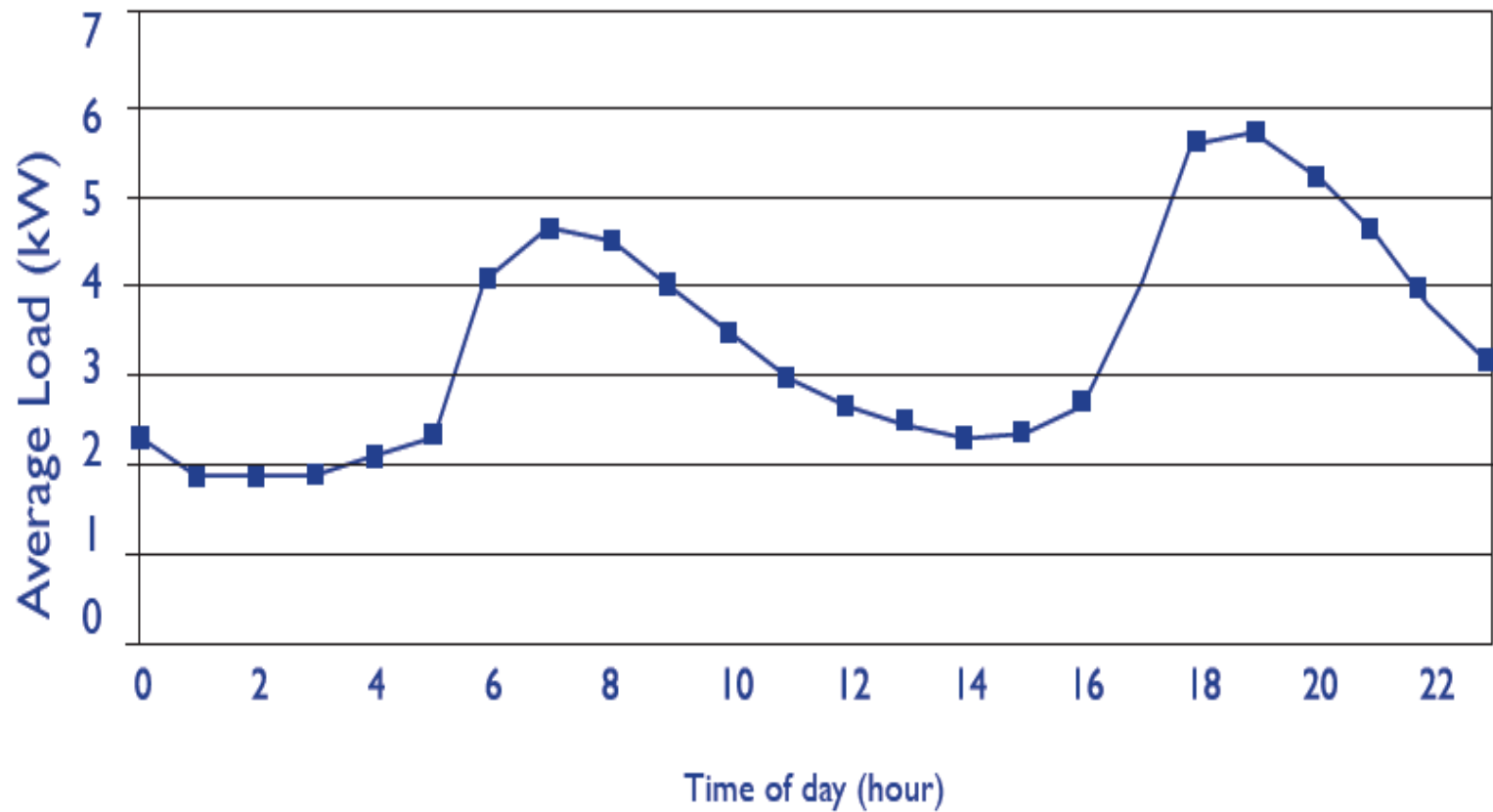
- Stand-alone System or Grid-Connected
- Simple technology, no need for technician
- Global energy demand increases
- SHP is considered
  - the most cost effective
  - environmentally friendly energy generation
- No Huge storage facility
  - -> Energy should be generated when needed



# Prospects of SHP in South Africa

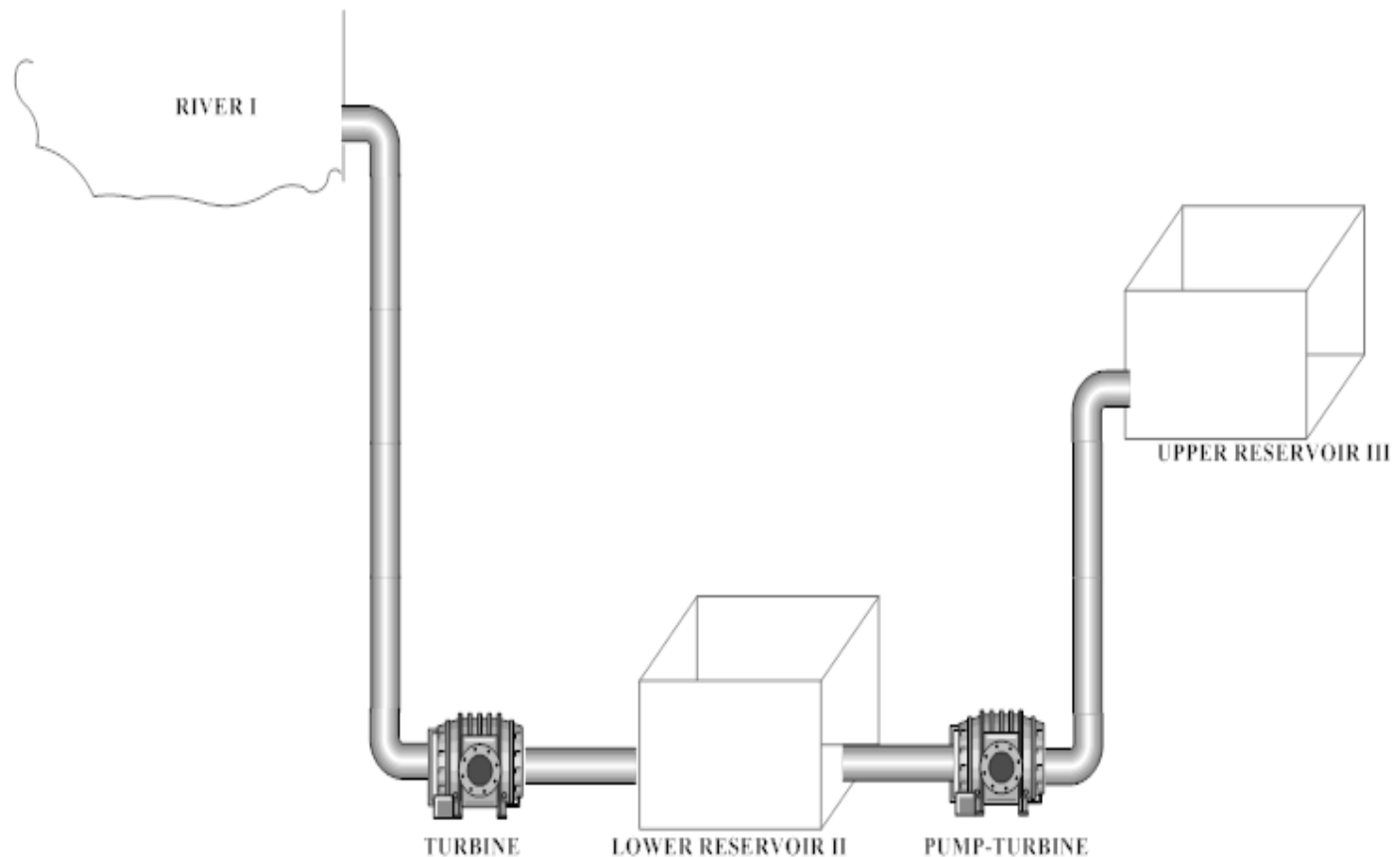
- 8 000 suitable potentials in KZN and EC provinces,
  - capable of generating 100 MW
- SHP highly-distributed in South Africa
- Timely utilization of this potential
  - saves the overburdened power generation sector

# Average South African household daily electricity consumption pattern





# Proposed SHP Hybrid plant. The idea is to meet peak electricity demand.



# Pumped storage HP design contd

- Allocate pumping power

$$P_{pump} = \frac{\rho_w \cdot g \cdot Q_p \cdot H_p}{\eta_p} \text{-----(1)}$$

- Compute flow at each power requirement and estimate average pumping  $Q_p$

$$-Q_{pump} = P_p \cdot \eta_p / \rho_w \cdot g \cdot H_p \text{-----(2)}$$

# Pumped storage HP design

Calculate losses in the pumping mode and compute the value of  $h_L$

- Compute, minor head losses,

$$h_{\text{minor}} = \frac{v^2}{2g} * (K_{\text{entrance}} + K_{\text{valve}} + 2K_{\text{bend}} + K_{\text{exit}})$$

- Compute, major head losses

$$h_{\text{major}} = f * \frac{l}{D} * \frac{v^2}{2g} (K_{\text{suction}} + K_{\text{delivery}})$$

Compute PSH generated power using

- $P_g = \rho_w \cdot g \cdot Q_g \cdot H_g \cdot \eta_t$  -----(3)



# Design Parameters

## River-run of Plant

- Power = 3.924kW
- Turbine efficiency = 0.8
- Flow = 0.05m<sup>3</sup>/s
- Head = 10m

## Pumped Storage Plant

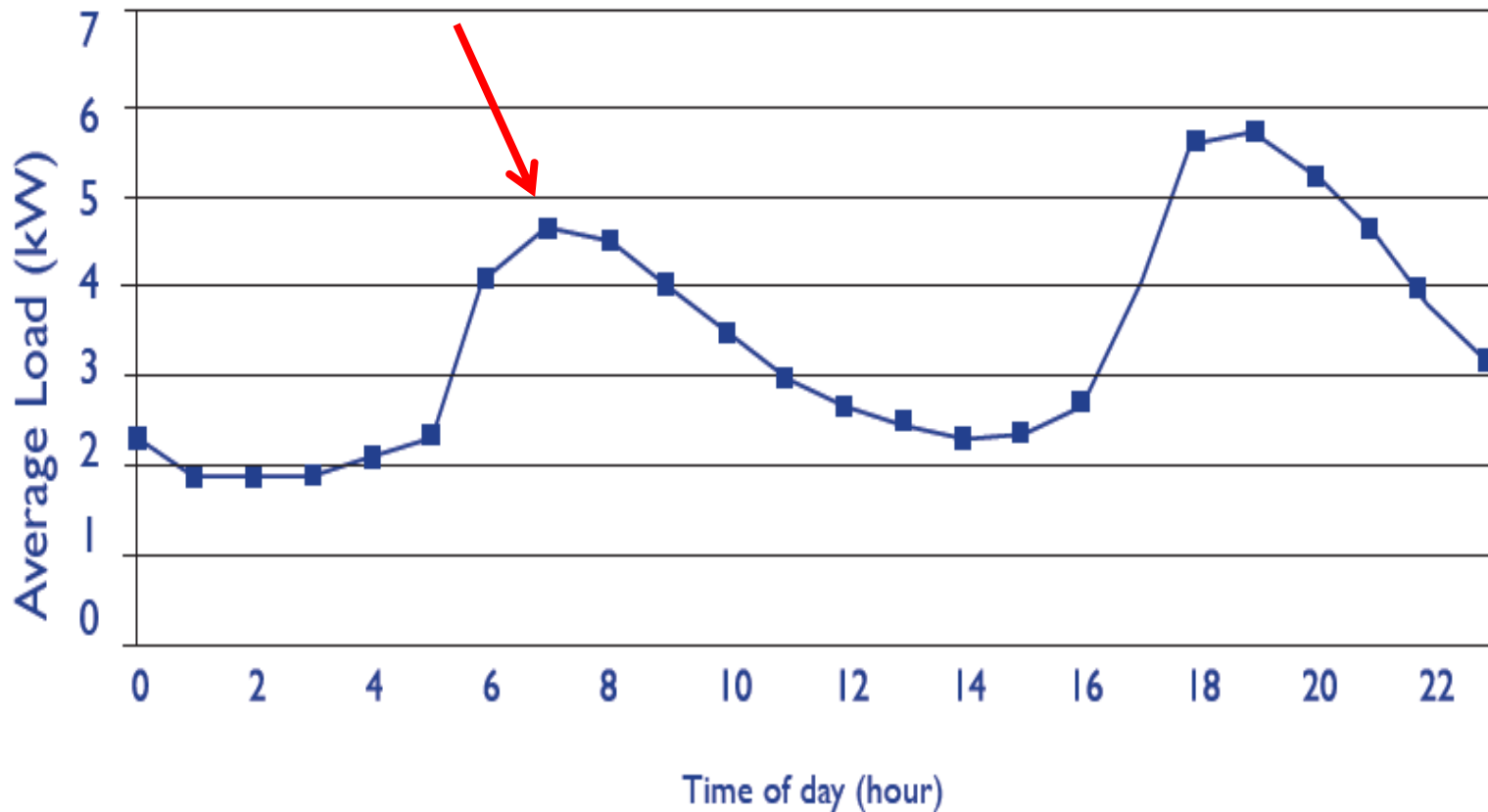
Head = 5m

Flow = 0.04m<sup>3</sup>/s

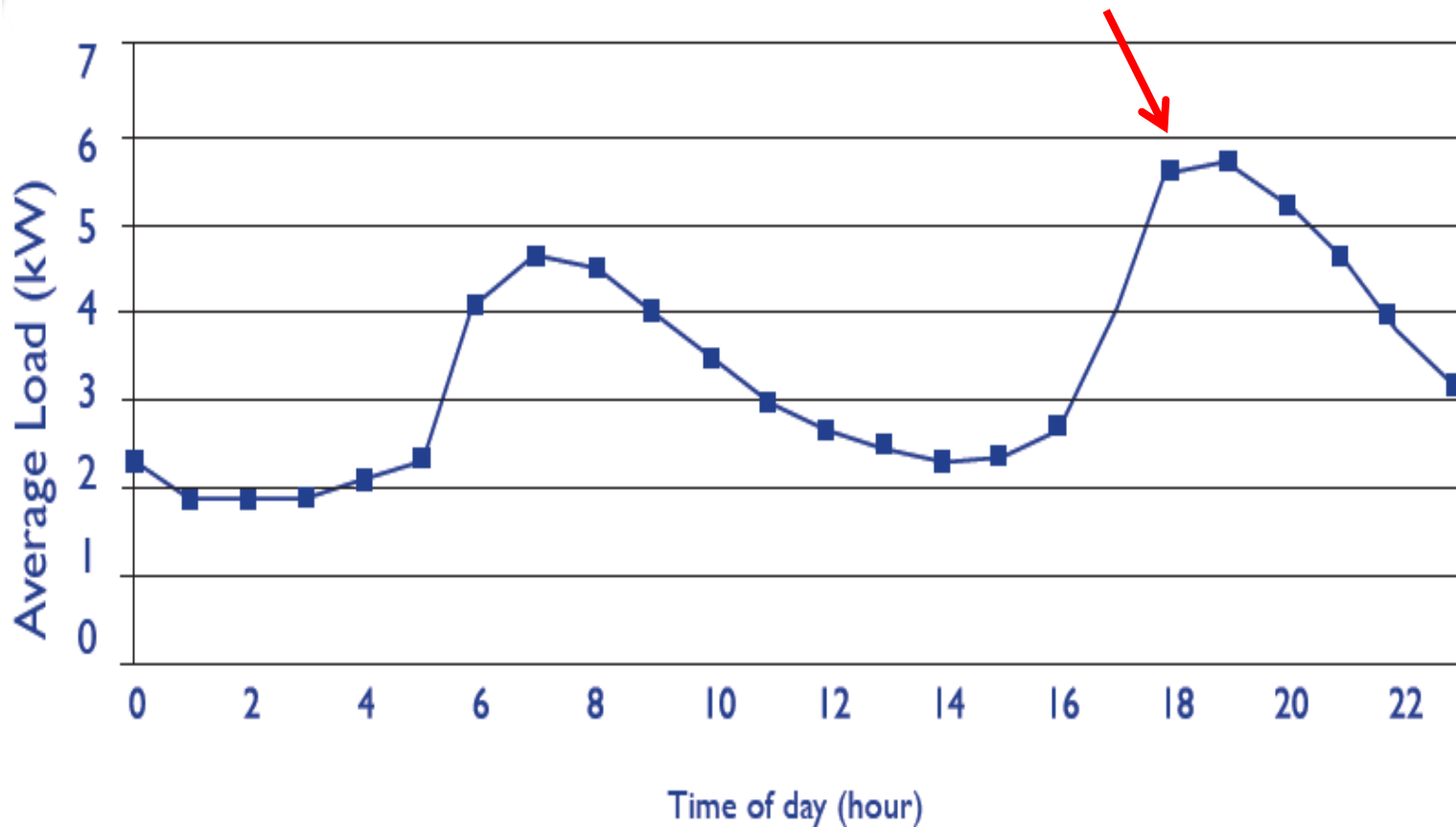
Reversible-turbine efficiency = 0.75

Generated power at full capacity = 2.616kW (this is additional power to meet peak demand)

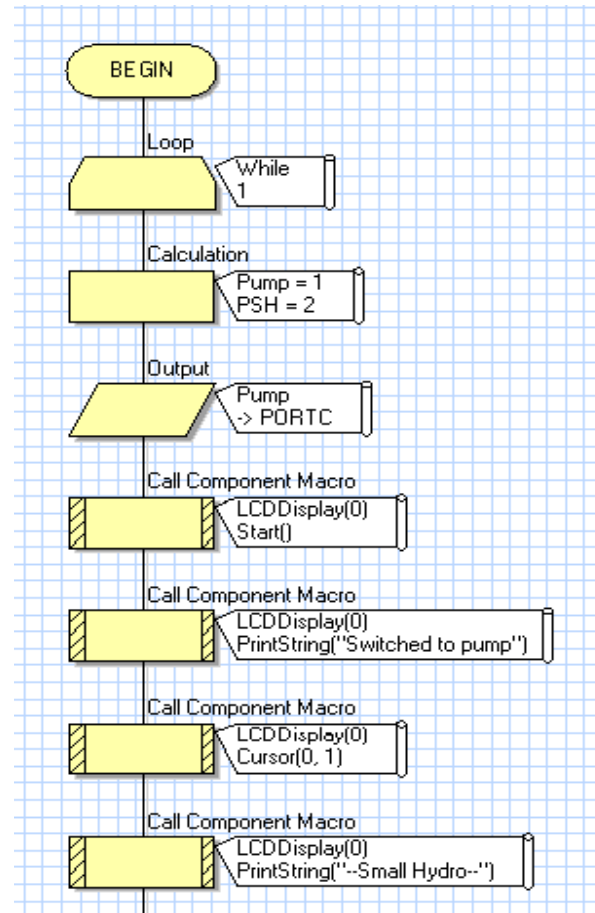
Between the hours of 5am to 10am  
PSH helps to meet power demand



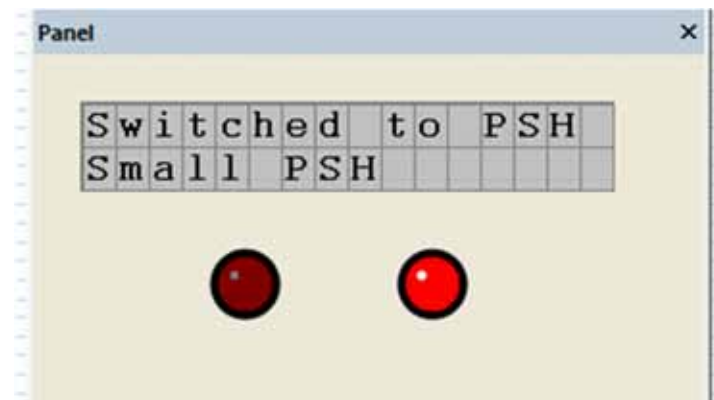
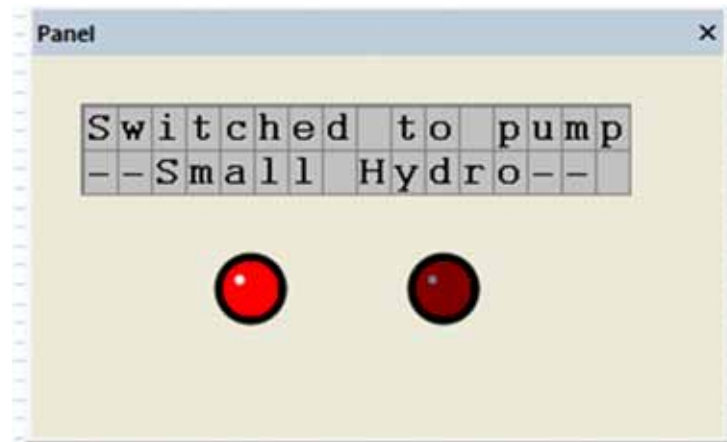
Between the hours of 5pm to 9pm  
PSH helps to meet power demand  
from the extra 2.616kW



# Flowcode control flowchart

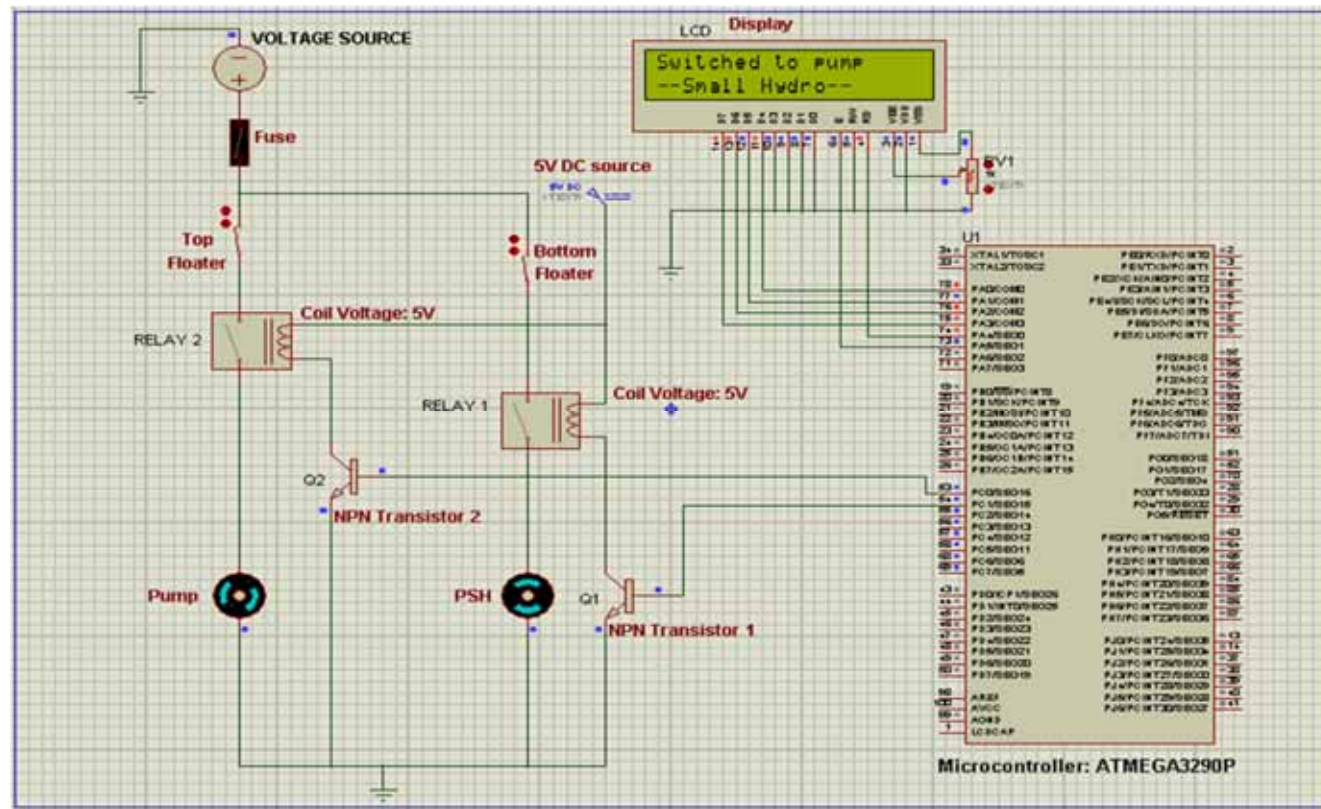


# Flowcode panel display

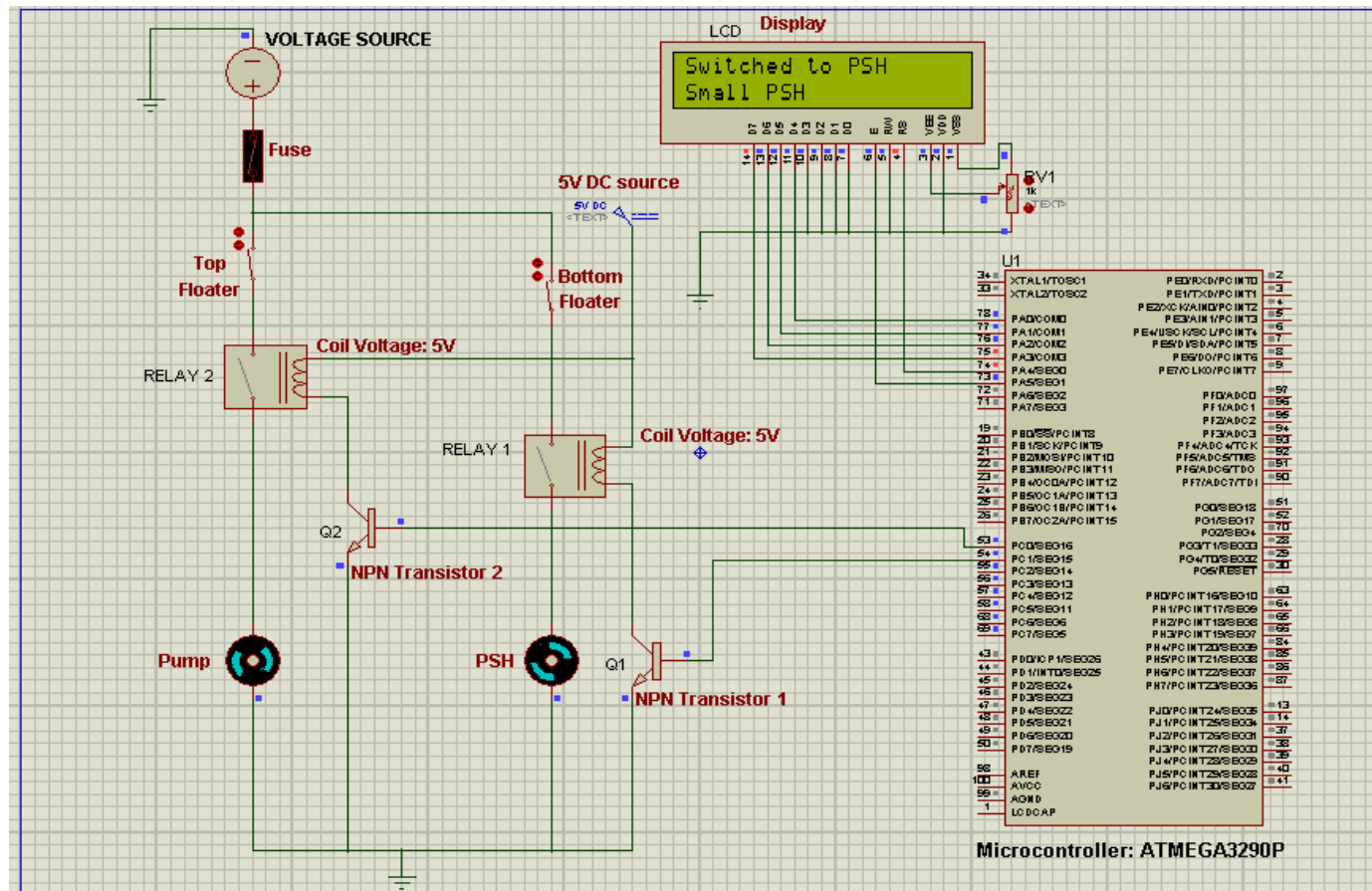




# Proteus microchip control arrangement (pumping mode)



# Proteus microchip control arrangement (PSH generation mode)





# Conclusions

- SHP for small communities in developing countries
- Two hydro generation systems combined
  - to meet peak electricity demand
- Effective control
  - every plant activity shown
  - ensuring maximum use of rejected power



# Conclusions

- The design ensures power is stored and made available only when needed
- Unnecessary plant breakdown is avoided
  - Due to over-pumping or over-generation
- Can work as
  - Stand-Alone for Rural Electrification
  - Feed the main grid



# Acknowledgement

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Thank You

