Irrigation Modernization and Design of Pipe Distribution Networks

TOTAL LIFE COSTS

Cost Effective Design for Pumped Systems must consider Lifetime Cost

- Low construction costs requires small pipes, but this means high pipe flow velocities, pumping pressures, and high energy costs.
- To optimize a design, the “total” costs, i.e., the sum of the construction costs and the discounted energy costs over ~25 years, should be calculated and compared for various design alternatives.
- The most cost-effective design is likely to be achieved for flow velocities in the pipes of 0.7-1.5 m/s.

Power Required & Energy Cost

$$P(kw) = \frac{Q(l/s) \times Ht(m)}{102 \times e1 \times e2}$$

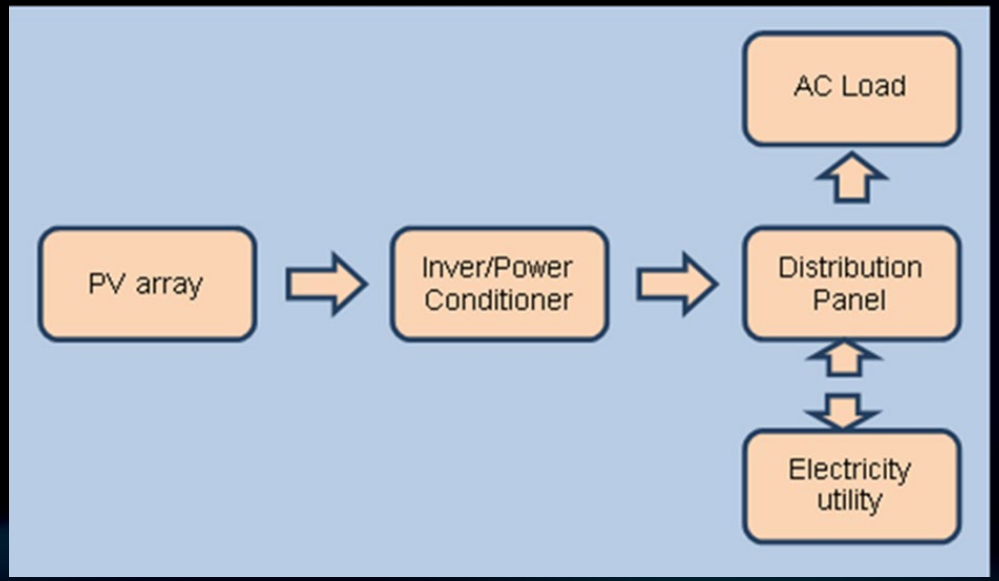
- Q is the pumped discharge (l/s)
- Ht the pumping head, comprising static lift and friction losses (m)
- e1 the pump efficiency (in the order of 0.6–0.8 for new pumps)
- e2 the motor efficiency (0.7–0.9 for electric motors)

ENERGY USED = POWER X DURATION OF PUMPING

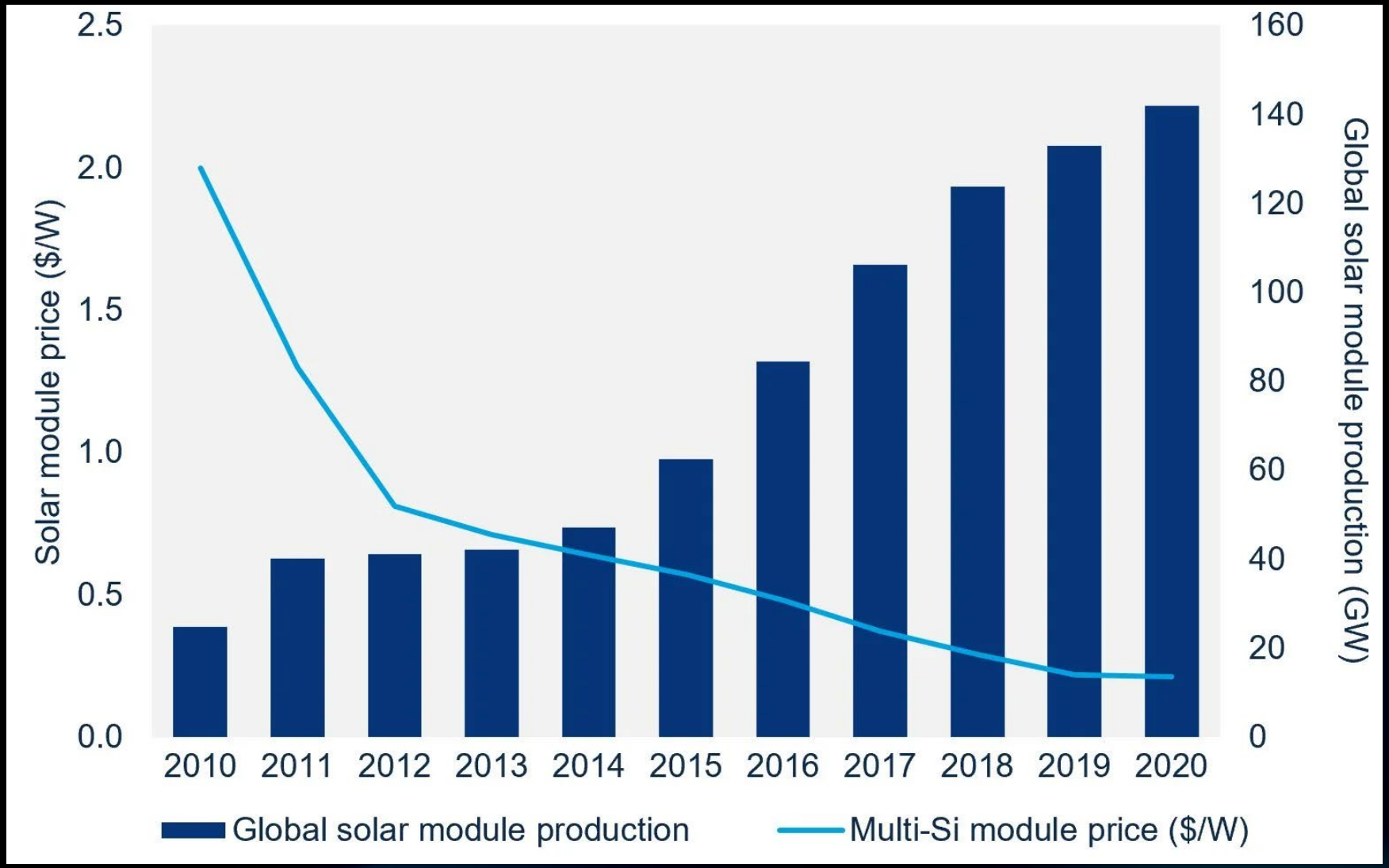
ENERGY COST = ENERGY TARIFF X ENERGY USED

Solar

- Grid connected solar can reduce energy costs
- Solar will usually only meet a proportion of peak power requirement
- Solar panels: 150W/m^2
- Cost: $0.30/ Watt



Cost of solar modules



Exercise: Pumping Cost for Pump Pressure Scheme and Total Life Cost for HLC PDN-1

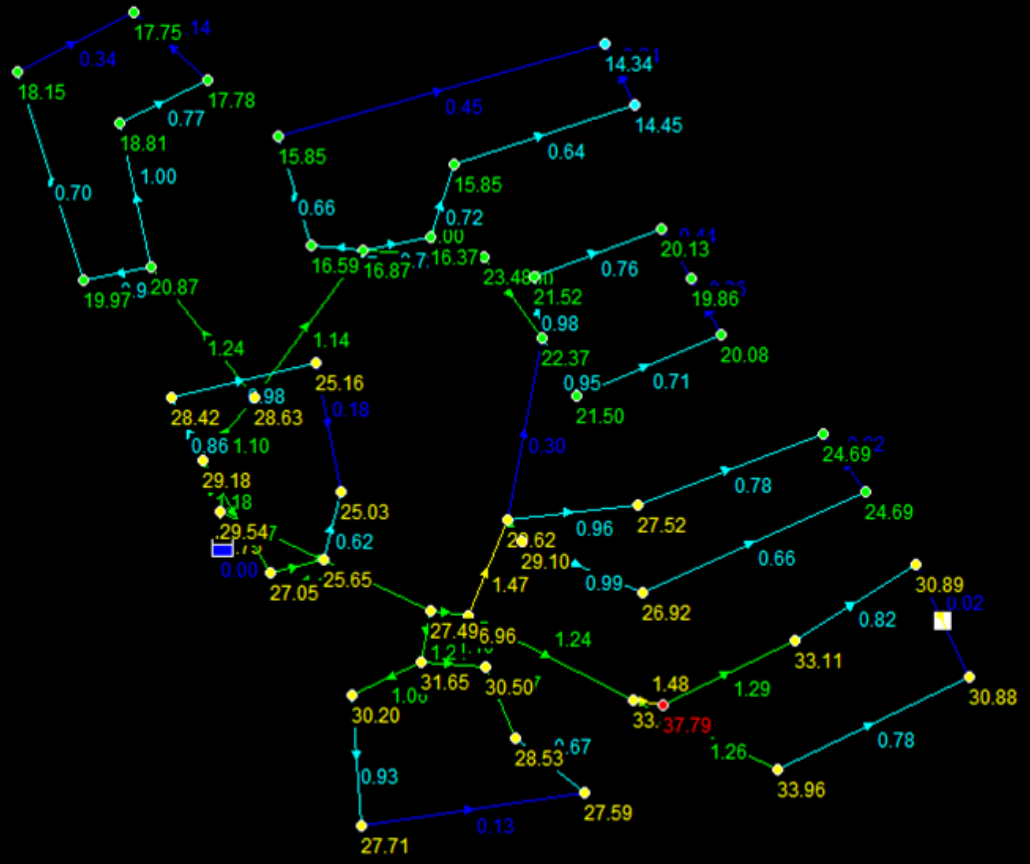
- Step 1: Calculate power requirement (e1=0.8, e2=0.8).
- Step 2: Calculate energy requirement and annual cost of energy for scheme. Adopt: (i) duration of pumping to give 485 mm over command area, and (ii) energy cost of $0.055/kWh

$$P(kw) = \frac{Q(l/s) \times Ht(m)}{102 \times e1 \times e2}$$

Power and Energy Requirements		
Head at pumping location	675.0	m
Ground Elevation	642.0	m
Pressure head	33.0	m
Suction head	2.0	m
Total pumping head	35.0	m
Design flow	344.5	l/s

Energy Required				
Pumping duration	18.0	hours	peak month	
Factor	0.3		All months	
	1,971	hours		
Command area	503.5	ha		
Volume pumped	2,444,434	m3		
	485	mm over command area for the year		
Energy Required	364,052	kWh/ year		
Unit cost of energy	15.2	PKR/kWh	Agric use	
	0.055	$/kWh		278
Energy charge	5,533,595	PKR/ year		
Annual cost of power	5,533,595	PKR		
	19,905	$		
	0.008	$/m3		
	10,990	PKR/ha per year		
	39.5	$/ha per year		

- Step 3: Discount annual cost of energy over 30 years to determine net-present cost, in $ and $/ha. Adopt:
  - Net CA of 503 ha
  - NPV function (excel)
  - Discount rate of 5%



Total Life Cost of Pressure PDN System

Capital Investment Cost

Cost of Pipes: $187,834, $ 373/ha

Cost of Scheme: $ 469,584, $ 933/ha (60% of total life cost)

Energy Cost

Annual cost of energy: $ 19,978

Net present cost at 5% discount rate: $305,989, $ 608/ha (40% of total life cost)

Total life Cost: $ 775,573, $ 1,540/ha

Discounted energy costs			
Area	504		
USD/ha	40		
		Discount rate:	5.0%
Year	Cost	NP Value, USD:	305,989
1	19,905	USD/ha	608
2	19,905		
3	19,905		
4	19,905		
5	19,905		
6	19,905		
7	19,905		
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