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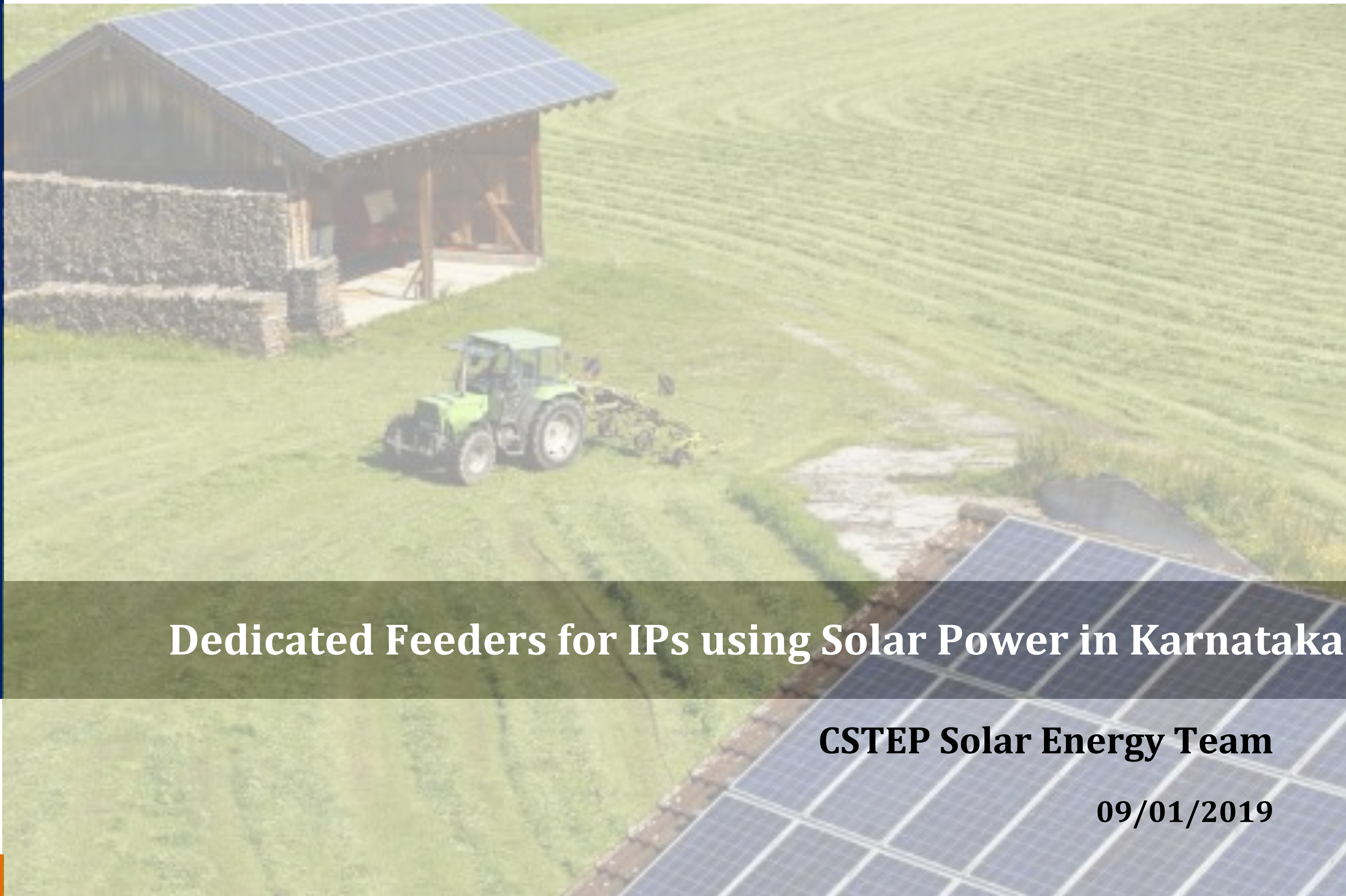

Dedicated Feeders for IPs using Solar Power in Karnataka

CSTEP Solar Energy Team

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Outline

- Background & Rationale
- Objectives
- Methodology
- Results
- Recommendations

Background & Rationale

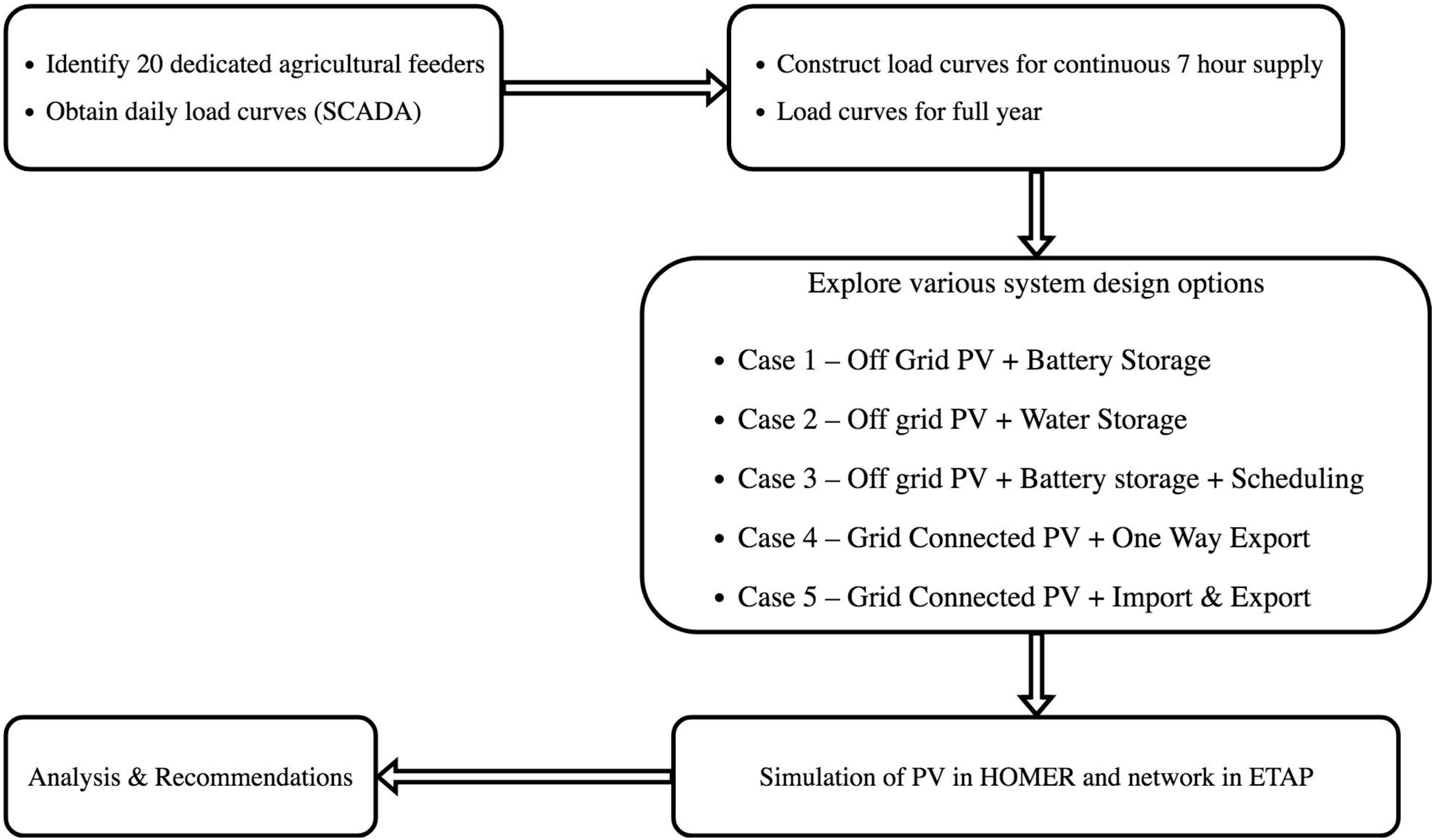
- Annual subsidy for agricultural electricity ~INR 10,000 crores
- 6,078 number of feeders of which 72% segregated as agricultural feeders
- Cost of solar-PV today less than INR 3.5/kWh
- Potential of decentralised solar plants to supply agricultural feeders

Objective

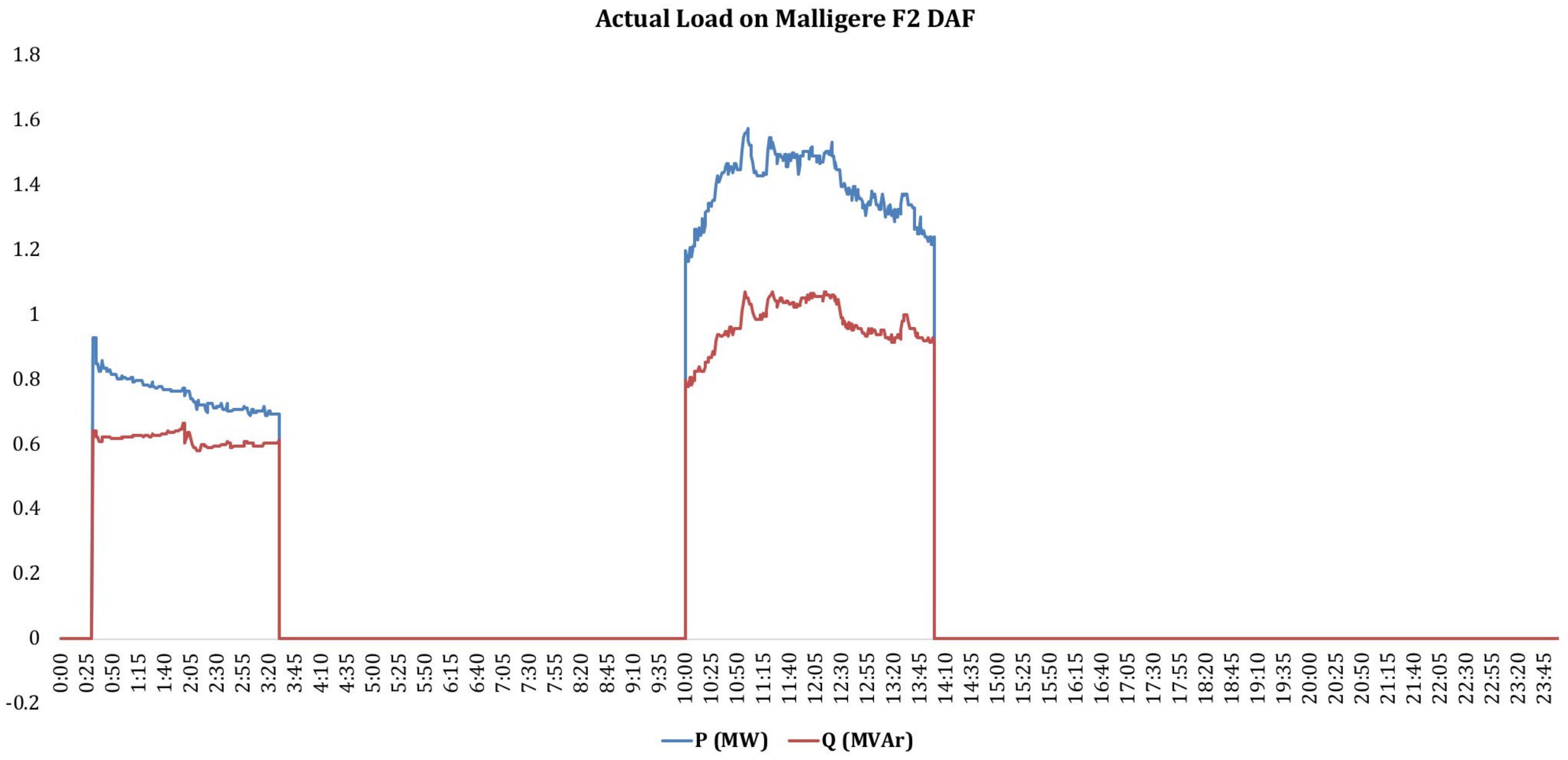
- Examine technical and financial feasibility of supplying dedicated agricultural feeders with solar power in Karnataka

Methodology

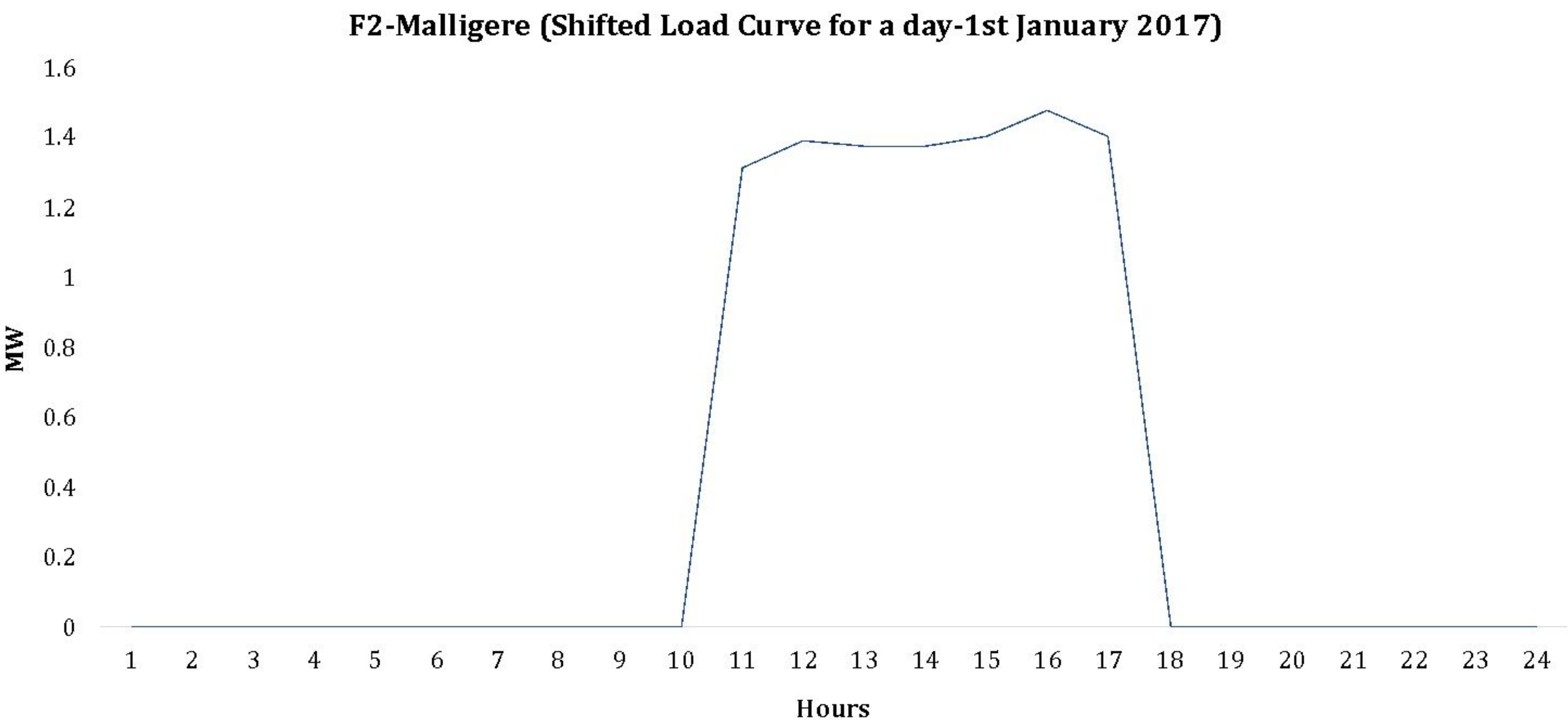
Methodology



Case Study Banangadi Substation

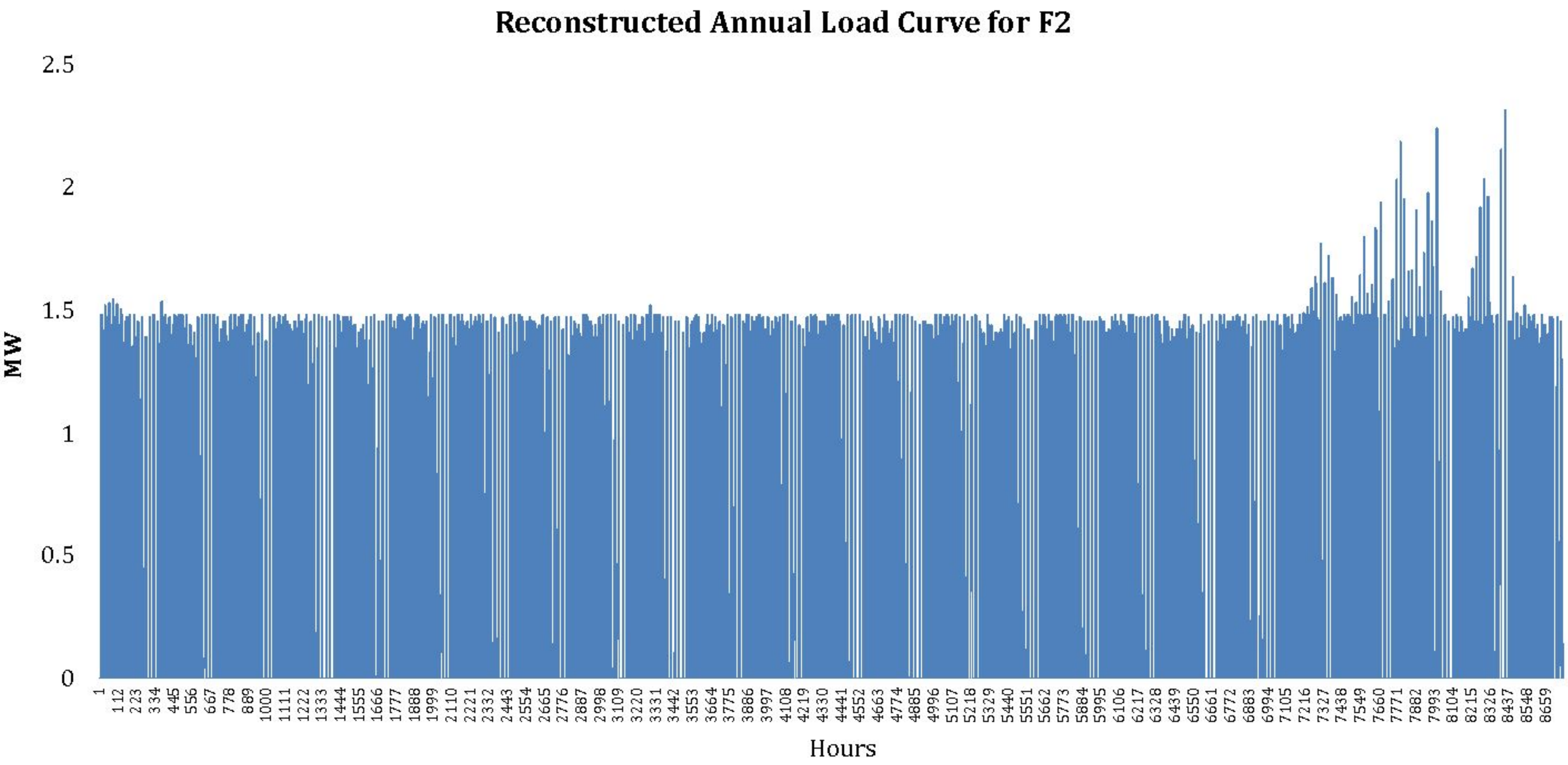


Restructured Load Profile



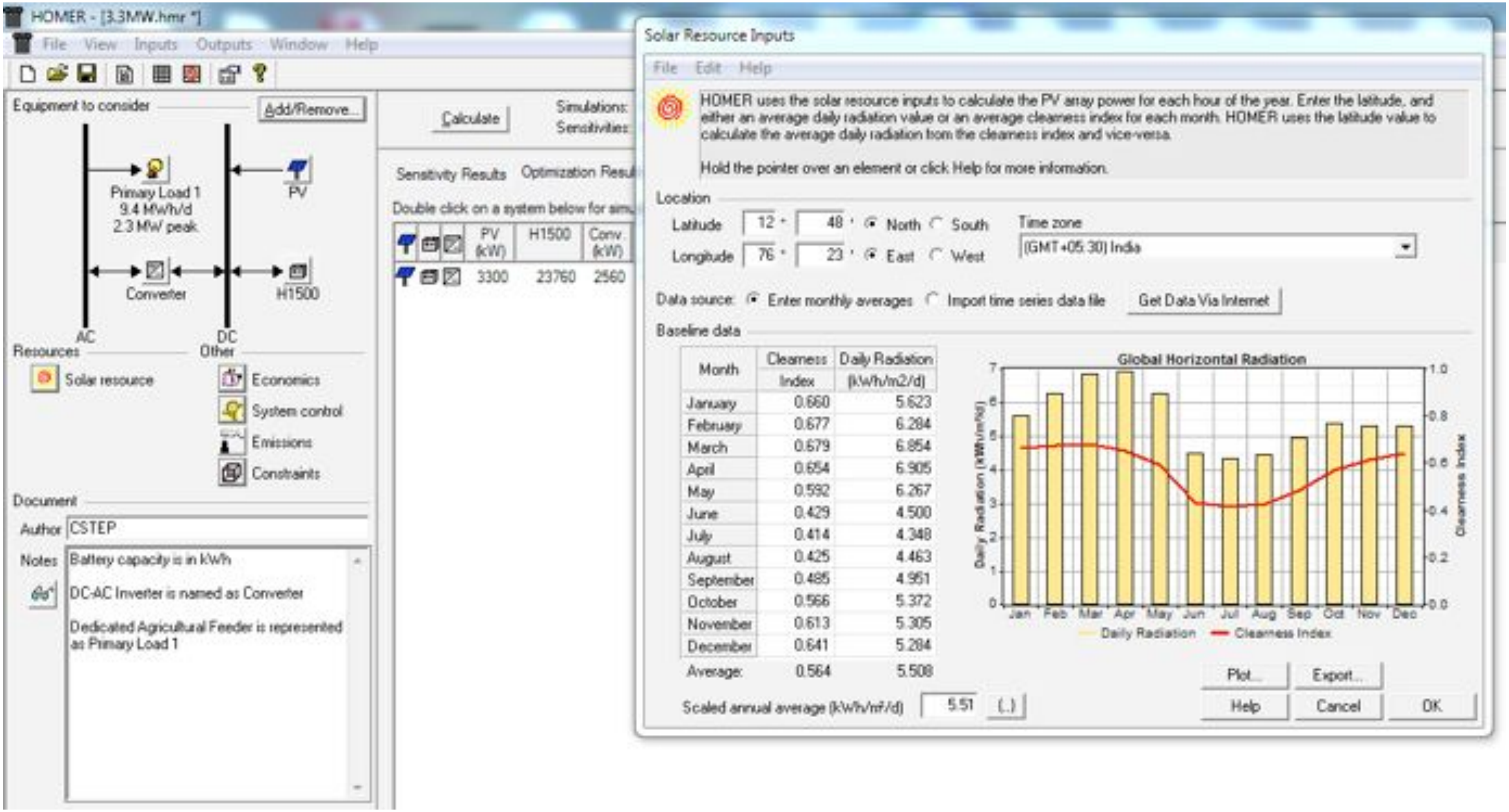
7 hours of uninterrupted power supply to dedicated agricultural feeder using solar

Restructured Annual Load Curve

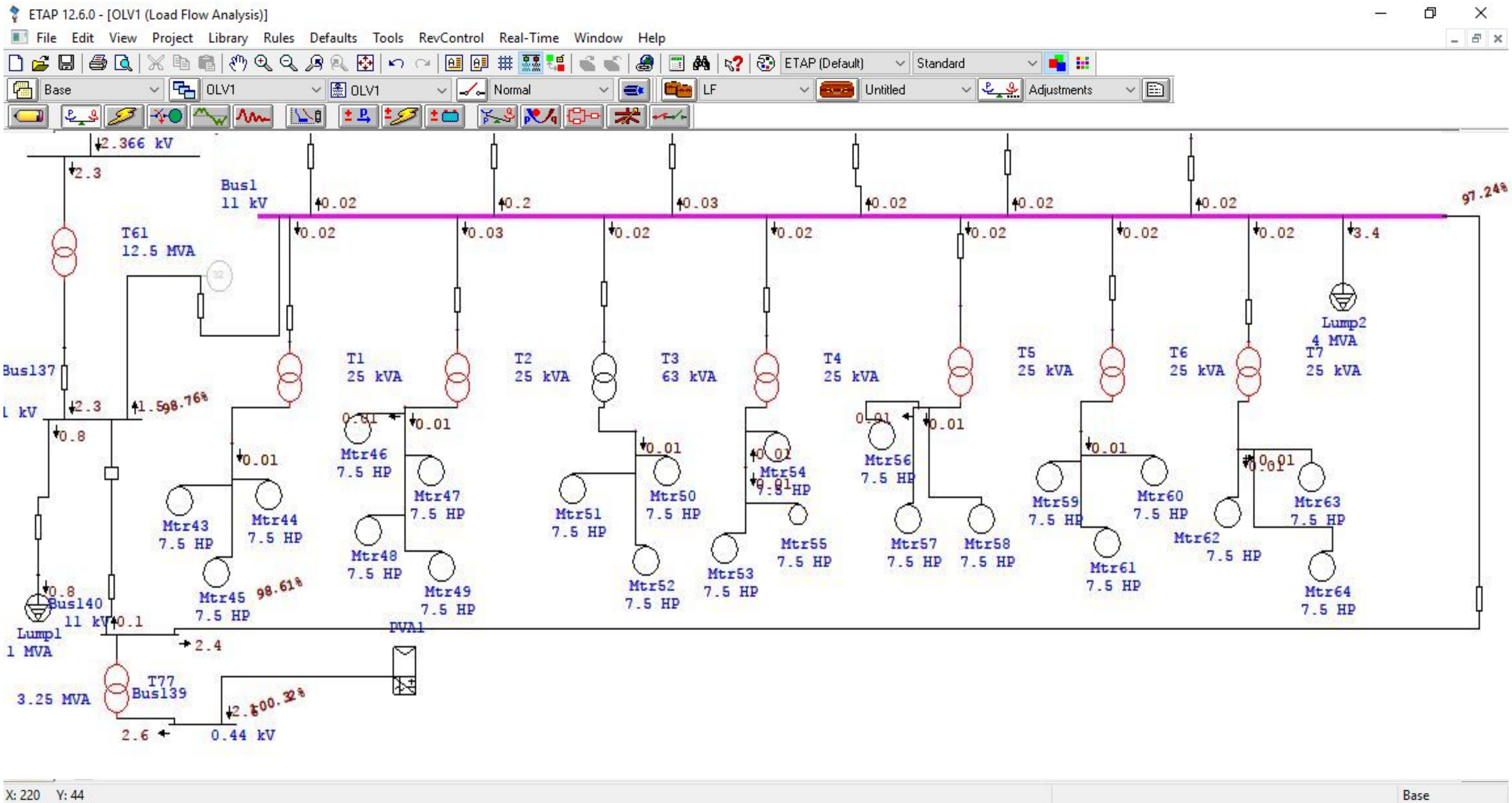


- Peak load – 2.3 MW; Annual demand – 3.4 MU
- Peaks occur during crop planting season

HOMER Simulation of Off-Grid PV Plants



ETAP Simulation for Network with Proposed PV Plants

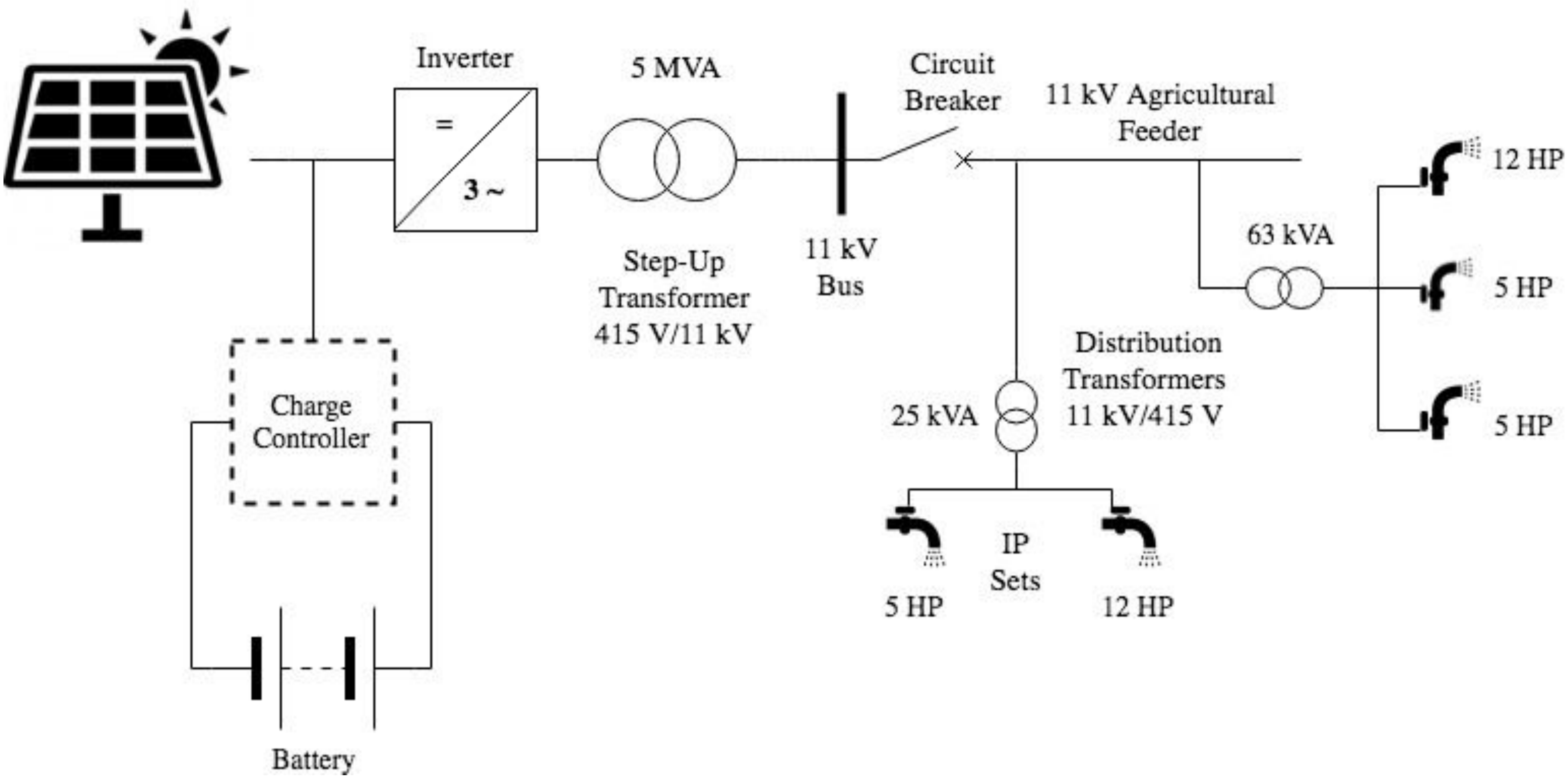


Assumptions

Solar PV	Battery	General
• Capital cost – INR 4.25 cr./MW • C.U.F. – 19% • Lifetime – 25 years • O&M costs – 1% of capex with annual escalation of 5.72% • Inverter replacement after 13 years • Land area required per MW – 5 acres	• Capital cost – INR 1.35 cr./MWh • Depth of discharge of Pb-Acid battery – 40% • Lifetime – 5 years • O&M costs included in PV O&M costs	70% of transformer at substation can be loaded with PV 100% capex provided by GoK (with 75:25 debt equity ratio) Capital cost for constructing surface water tank (25m X 10m X 2m) = INR 8 lakhs Other cost assumptions as per KERC benchmark costs (Discount rate, term loan details, etc.)

Results

Case 1: Off-Grid PV Plant with Battery Storage



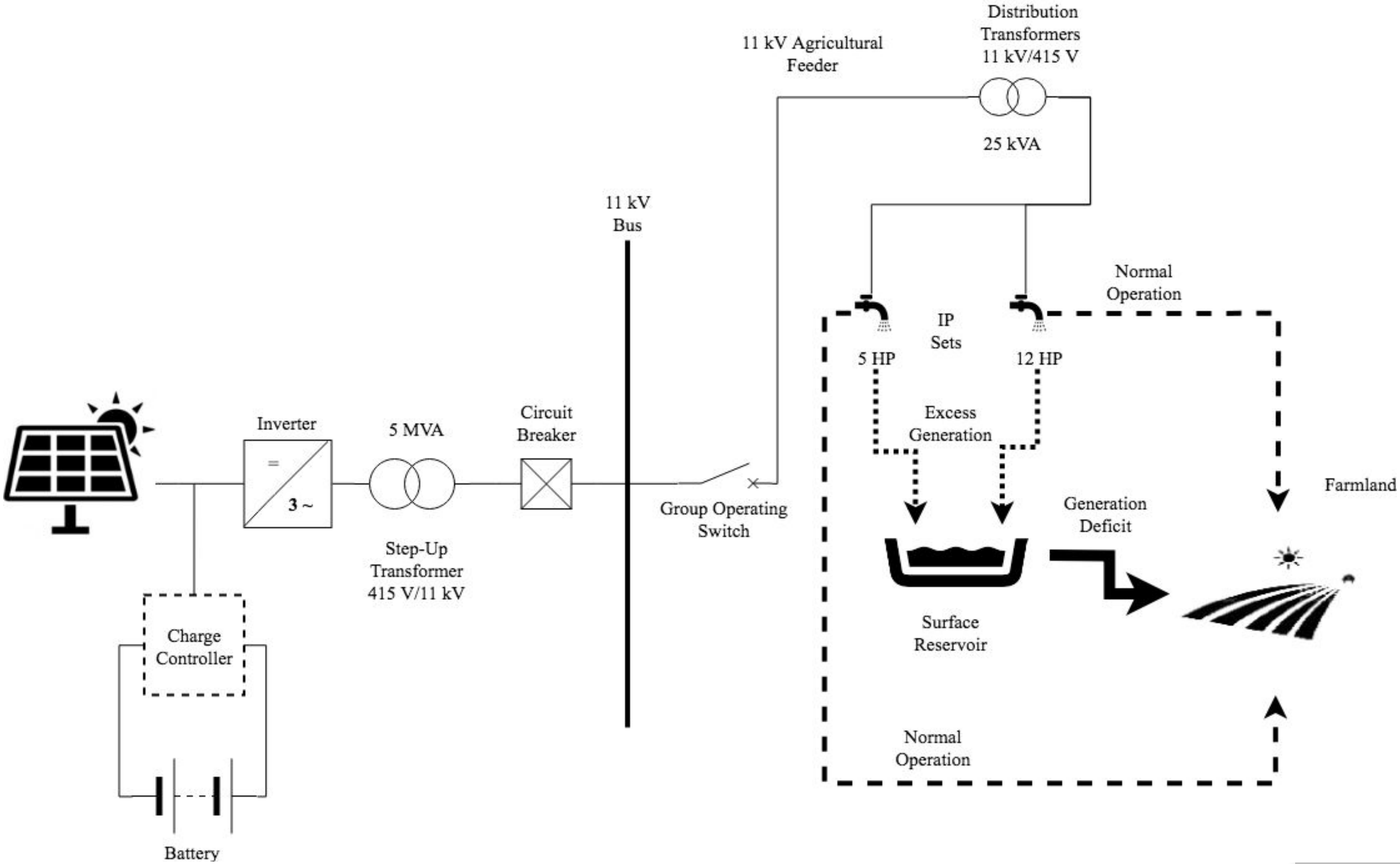
Case 1: Off-Grid PV with Storage - Results

- 2 options to meet the load on F2

	Option 1: Low PV & high storage	Option 2: High PV & low storage
PV capacity required (MW)	3.3	6.5
Pb-Acid battery size required (MWh)	71.3	21.6
Capital cost (INR cr.)	110	57
Land required (acres)	16.5	32.5
PV annual generation (MU)	5.5	10.9
Annual load (MU)	3.4	
LCOE (INR/kWh)	**23.1**	**13.1**

- Peaks in demand lead to oversizing of PV & battery
  - Leads to high excess and wastage and thus high LCOE
- Off-grid PV with battery storage is financially unviable

Case-2: Off-Grid PV Plant with Water Storage



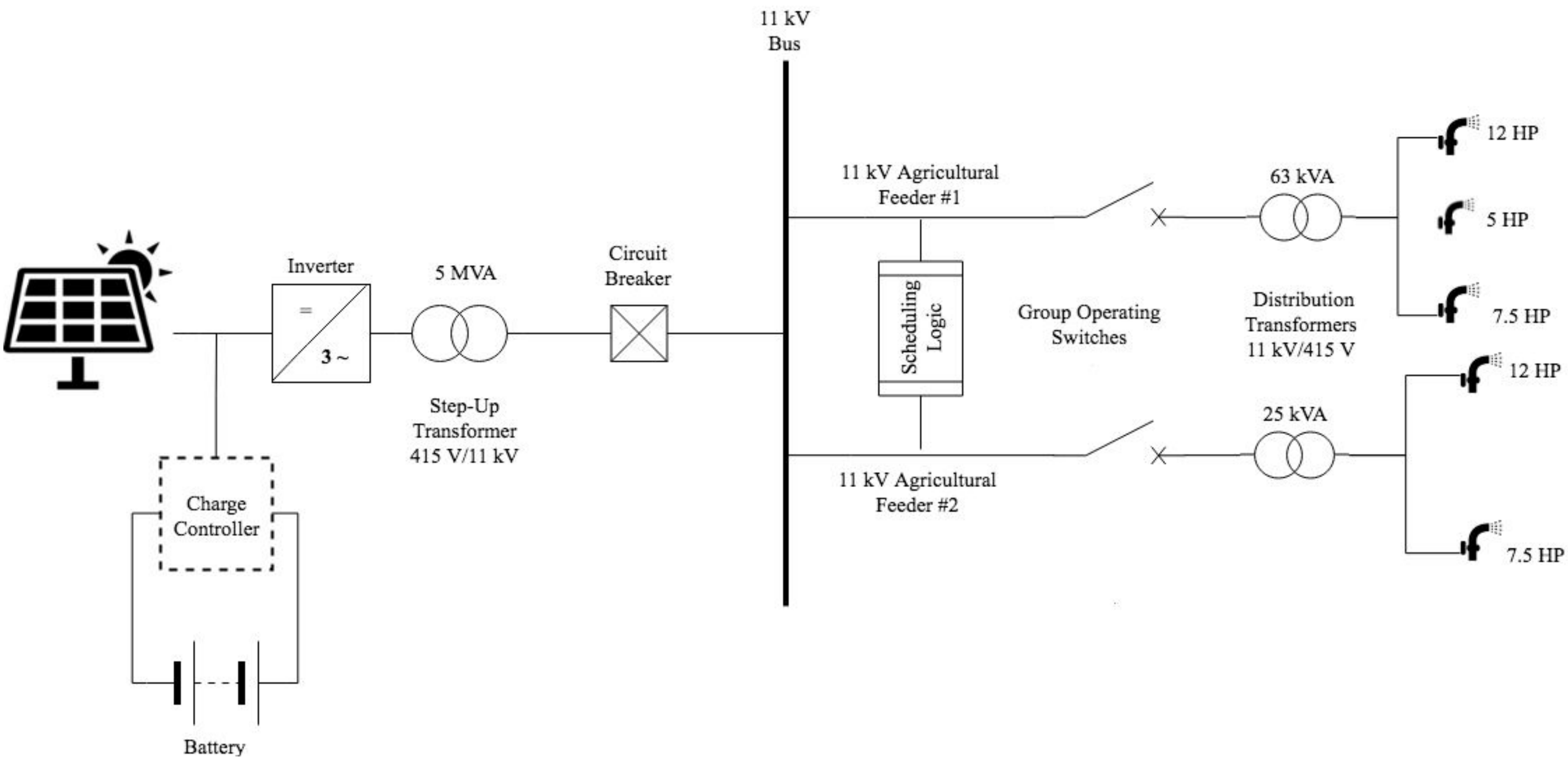
Case 2: Off-Grid PV with Water Storage - Results

- Higher PV requirement to meet F2 load because of low battery size
  - Peak demand leads to higher water storage requirement
  - Excess electricity generation during other times leads to high LCOE

PV capacity required (MW)	13
Water storage required (m^3)	444
Capital cost (INR Cr.)	63
Land required (acres)	67
PV annual generation (MU)	21.6
Annual load (MU)	12.3
LCOE (INR/kWh)	**11.5**

- Off-grid PV with water storage is financially unviable

Case-3: Off-Grid PV Plant with Battery Storage and Scheduling (2 DAFs with Single PV Plant)



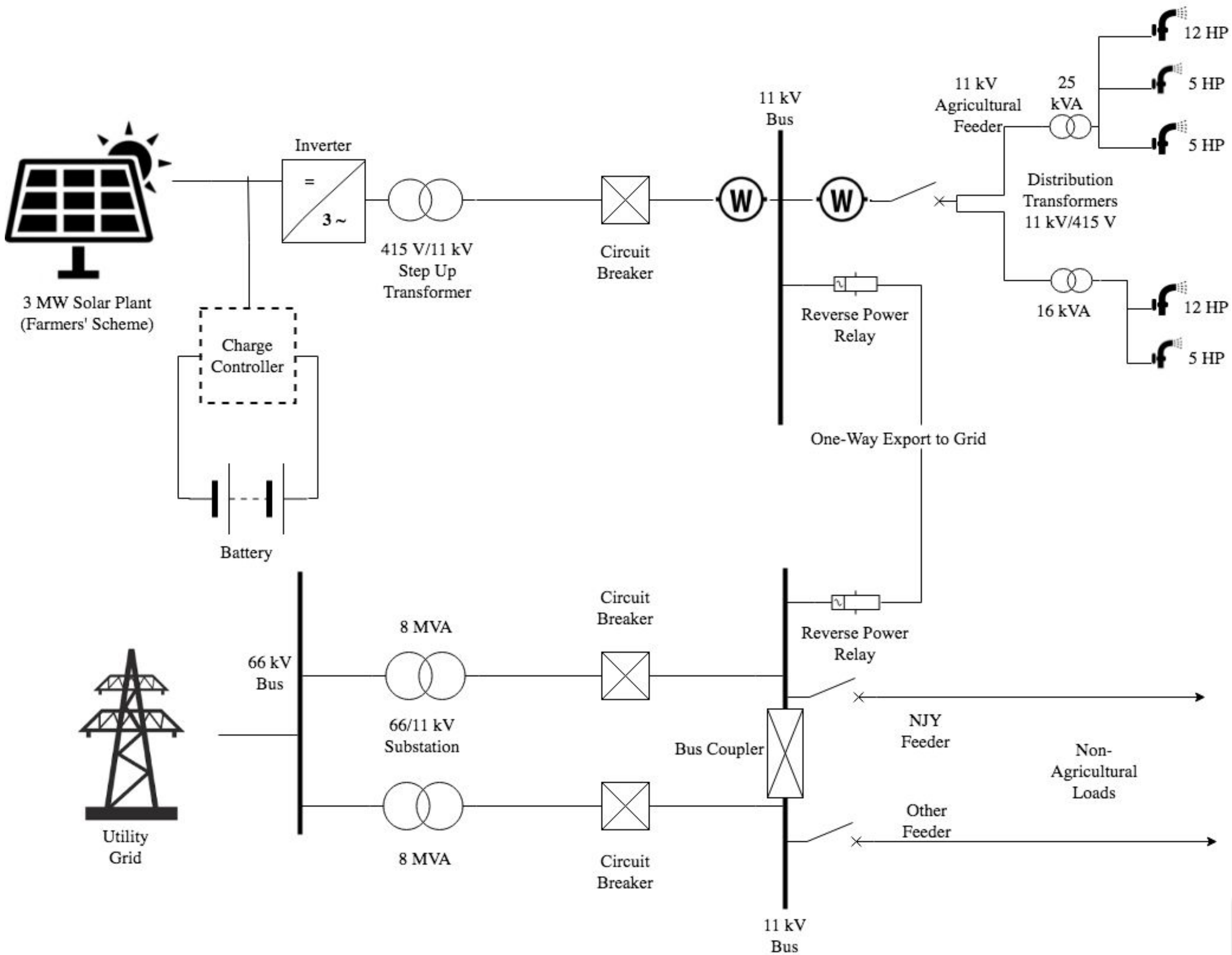
Case 3: Off-Grid PV with Battery & Scheduling – Results

- 2 options to meet F2 & F3 load

	Option 1: Low PV & high storage	Option 2: High PV & low storage
PV capacity required (MW)	3.2	9
Pb-Acid battery size required (MWh)	94.3	21.6
Capital cost (INR cr.)	141	67
Land required (acres)	16	45
PV annual generation (MU)	5.3	14.9
Annual load (MU)	3.4	
LCOE (INR/kWh)	**29.5**	**16.1**

- Peaks in demand lead to oversizing of PV & battery
  - Leads to high excess and wastage and thus high LCOE
- Off-grid PV with battery storage and scheduling is financially unviable

Case-4: Grid-Connected PV Plant with One-Way Export to Grid



Case 4: One Way Export to Grid – Results

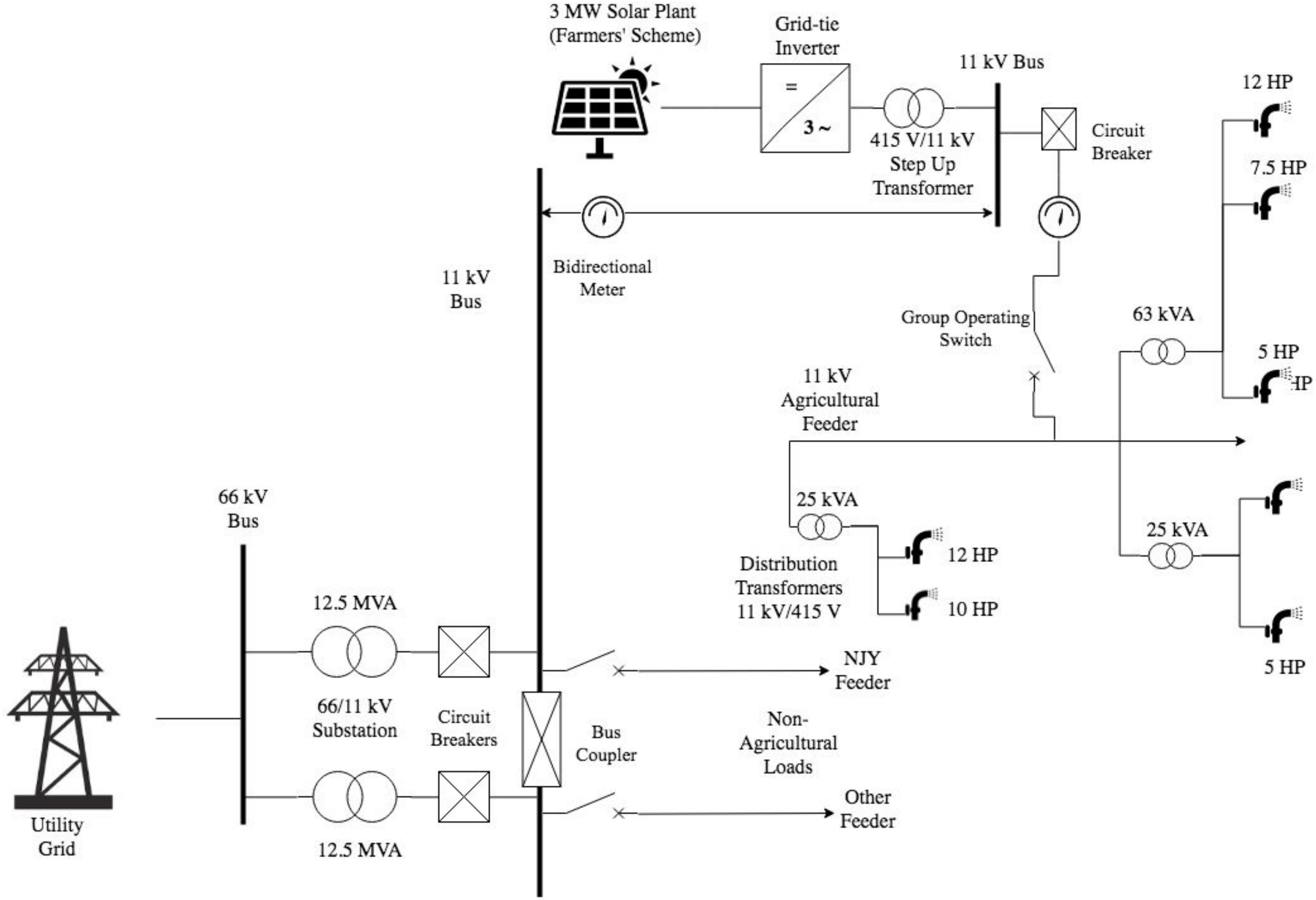
- Scope in all 3 previous off-grid designs to export excess to grid unilaterally

System Design	Battery Storage	Battery Storage & Scheduling	Water Storage
PV capacity required (MW)	6.5	9	13
Pb-Acid battery size required (MWh)/ Water storage required (m^3)	21.6	21.6	444
Capital cost (INR cr.)	56.8	67.4	62.5
Land required (acres)	32.5	45	67
LCOE (INR/kWh)	**7.8**	**6.5**	**5.8**

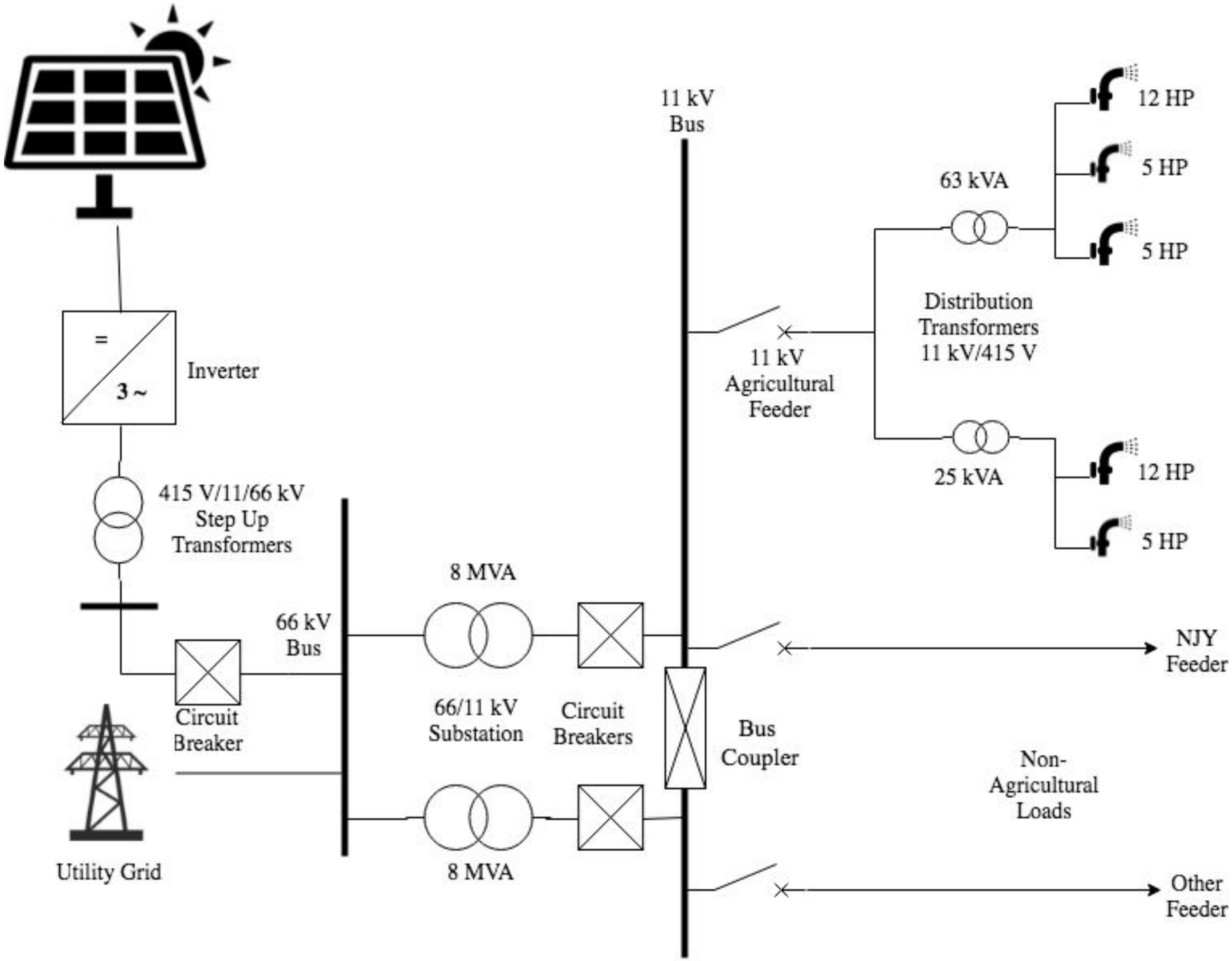
•Reverse power relays are not present in the distribution sector till date

•Water storage possible only in places with surface irrigation

Case 5(a) : Grid-Connected PV Plant with Import/Export Option



Case 5(b) : Grid-Connected PV Plant at HT Side



Case 5: Grid-Connected - Results

	Case 5(a): PV plant connected at LT side	Case 5(b): PV plant connected at HT side
PV capacity required (MW)	3	3
Capital cost (INR cr.)	13	13
Land required (acres)	15	15
PV annual generation (MU)	5.1	5.2
Annual load (MU)	3.4	
Import from grid (MU)	0.7	0.6
Export to grid (MU)	2.2	2.3
LCOE (INR/kWh)	**4.2**	**4.0**

- Choice of plant location depends on distance from substation and resource assessment
- System design is technically and financially viable

Conclusions & Recommendations

- Off-grid solutions are financially unviable
- Community level water storage with PV & one-way export to grid is promising
  - Pilots in specific areas
- Grid-connected PV with import/export should be implemented
  - Close monitoring by DISCOMs and Energy Department with accurate meter readings

Impact & Savings for GoK with Grid-Connected PV System Design

- Total solar PV capacity required to replace DAF loads completely ~ **11 GW**
- Based on existing grid infrastructure, installable PV capacity ~ **3 GW**
  - ➢ 34% of state's agricultural load can be met with ~5 BU of solar-based generation
- Total investment required ~ INR 12,500 crores
  - ➢ Annual savings ~ INR 1,875 crores
  - ➢ Payback period – 7 years
  - ➢ Project IRR – 17%

THANK YOU

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