DST-UKIERI Work Shop

“SKY”-Surya-Shakti Kishan Yojna

for Solarization of Ag Consumers

Presented By:
Jatin Upadhyay, DE (R&D), GPRD Cell, GUVNL. dernd2@gprd.in
Out Line Of Presentation

- Introduction of the SKY Scheme for its various key concerns.
- Introduction of Feeder level connection scheme for SKY
- Introduction to KEY components for SKY: Metering Console and Watch Dog Transformer/Device.
- Introduction to Monitoring software: Solar Energy Data Management (SEDM)
- Discussion on one Case Study for various aspects after SKY implementation
Introduction Of SKY Scheme

- Background and Objective of Scheme
- Implementation Profile of the Scheme
- Benefits to Farmers and Society
- Financial Source, Income, Repayment
- Future Indications
KEY OBJECTIVE OF SCHEME

- Ensuring day time power to farmers
- Providing secondary source of income for farmers – supporting GoI objective of doubling farmers income by 2022
- Reducing electricity subsidy burden of state government
- Reducing cross-subsidy burden of other consumers
- Improving financial health of DISCOM
- Supporting GoI target of 175 GW renewable energy by 2022
Agriculture Consumption V/S Revenue

Gujarat Power Research and Development Cell, GUVNL, IIT-Gandhinagar

Agriculture: Connections and Demand

- Total Agriculture Connections as on 2016-17: 13.86 Lakh
- Average Contract Demand: 11.48 HP

Agriculture: Electricity Bill Recovery

- Farmers: Rs. 1,103 Cr.
- Government subsidy: Rs. 5,088 Cr.
- Cross subsidy: Rs. 4,358 Cr.
- TOTAL: Rs. 10,891 Cr.
Implementation Profile

- Scheme applicable for Grid connected Farmers i.e. the existing Agriculture consumers.
- At least 70% of the existing consumers of the individual distribution feeder should participate in the scheme.
- The capacity of grid Connected Solar PV would be 1.25 times of Contract Load in HP. Farmer can also install additional Solar PV Capacity with limited scheme benefit
  - e.g. 10 HP AG Connection → 12.5 KW Solar PV System
- The selected feeder shall be provided 3-Phase Power Supply from for 12 Hours during Day time from sunrise to sunset
- Capital cost sharing
  - 30%, CFA
  - 30%, GoG Loan
  - 35%, GoG Loan on behalf of farmer, Loan period is for 7 years.
  - 5%, Farmer Upfront Payment
- Farmer Revenue on net generation (i.e. generation minus consumption)
  - Rs. 3.50 /kWh, Feed-in Tariff by DisCom on net generation
  - Rs. 3.50 /kWh, Evacuation-based Incentive (EBI) as Govt. of Gujarat Subsidy, for 7 years, up to 1,000 kWh/KW/year
Note: EBI is a generation-based subsidy by Govt. of Gujarat to match MNRE's 30% capital subsidy.
Benefits To Farmers

- The ownership of Solar System is of Farmer after Loan period completion
- Permanent Income to Farmer for injecting surplus energy into grid.
- 12 Hours of power supply during day time with Grid support
- It is possible to grow crop under the solar panel as well.
- Social Empowerment of farmer
- Consolidation of Rural Economy by Local employment generation opportunity
Benefits To Society And Environment

- One third reduction of generation of electricity through Non-Renewable sources and preservation of Environment.
- Due to distributed solar generation, land requirement for solar parks, expensive infrastructural modifications could be avoided.
- Maximum utilization of installed distribution network.
- Reduction in Transmission and Distribution Losses.
- Reduction in burden of agriculture subsidy.
- Reduction in cross subsidy to other consumers
- Conservation of Energy and Water
Farmer’s Cash Flow (Case: 10 hp, 12 kW)

<table>
<thead>
<tr>
<th>Farmer’s Expenses</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Total System Cost (SPV Cost)</td>
<td>Rs. 6,03,540</td>
<td></td>
</tr>
<tr>
<td>Upfront Investment (@5% of SPV System Cost)</td>
<td>Rs. 30,157</td>
<td></td>
</tr>
<tr>
<td>Loan Amount (@65% of SPV System Cost)</td>
<td>Rs. 3,92,301</td>
<td></td>
</tr>
<tr>
<td>Loan Terms</td>
<td>6% p.a., 7 years</td>
<td></td>
</tr>
<tr>
<td>Annual Loan Repayment</td>
<td>Rs. 68,771 /yr</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Farmer’s Income</th>
<th>During Loan Term (Up to 7 years)</th>
<th>After Loan Term (Beyond 7 years)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sale to DisCom (@ Rs. 3.50/ kWh)</td>
<td>Rs. 46,200 /yr</td>
<td>Rs. 46,200 /yr</td>
</tr>
<tr>
<td>Evacuation-based incentive (1000Kwh/KW/year) (@ Rs. 3.50/ kWh)</td>
<td>Rs. 42,000 /yr</td>
<td>-</td>
</tr>
<tr>
<td>Savings in electricity bill</td>
<td>Rs. 4,800/yr</td>
<td>Rs. 4,800/yr</td>
</tr>
<tr>
<td>Gross Income</td>
<td>Rs. 93,000/yr</td>
<td>Rs. 51,000/yr</td>
</tr>
<tr>
<td>Annual Loan Repayment (Less:)</td>
<td>Rs. 68,771 /yr</td>
<td>-</td>
</tr>
<tr>
<td>Farmer’s Net Annual Income</td>
<td>Rs. 24,229/yr</td>
<td>Rs. 51,000/yr</td>
</tr>
</tbody>
</table>
# Data Base for Pilot Project for 137 AGDOM feeders

<table>
<thead>
<tr>
<th>Sr.</th>
<th>DisCom</th>
<th>No. of Feeders</th>
<th>Avg. Consumers/Feeder</th>
<th>Avg. ‘HP’/Consumer</th>
<th>Avg. ‘kW’/Consumer</th>
<th>Total Pilot Cost (Rs. Crore)</th>
<th>Metering Console Qty</th>
<th>WDD Qty</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>DGVCL</td>
<td>21</td>
<td>118</td>
<td>6.31 hp</td>
<td>7.89 kW</td>
<td>Rs. 106.94</td>
<td>1663</td>
<td>683</td>
</tr>
<tr>
<td>2.</td>
<td>MGVCL</td>
<td>33</td>
<td>85</td>
<td>11.01 hp</td>
<td>13.76 kW</td>
<td>Rs. 193.40</td>
<td>2466</td>
<td>843</td>
</tr>
<tr>
<td>3.</td>
<td>UGVCL</td>
<td>23</td>
<td>49</td>
<td>22.11 hp</td>
<td>27.64 kW</td>
<td>Rs. 144.07</td>
<td>921</td>
<td>345</td>
</tr>
<tr>
<td>4.</td>
<td>PGVCL</td>
<td>60</td>
<td>99</td>
<td>11.86 hp</td>
<td>14.86 kW</td>
<td>Rs. 423.95</td>
<td>5160</td>
<td>1807</td>
</tr>
<tr>
<td></td>
<td>TOTAL</td>
<td>137</td>
<td>91</td>
<td>11.49 hp</td>
<td>14.36 kW</td>
<td>Rs. 868.37</td>
<td>10210</td>
<td>3678</td>
</tr>
</tbody>
</table>
Technical Connection Scheme

Gujarat Power Research and Development Cell, GUVNL, IIT-Gandhinagar

Before

11 kV / 433 V

433 Vac, 3-ph, 50 Hz

11 kV

After

11 kV / 433 V

11 kV / 433 V

433 Vac, 3-ph, 50 Hz

Consumption Meter

PV Inverter

Solar Meter

Net-Meter

Agriculture Field

Pump
Feeder-level Scheme Details

Gujarat Power Research and Development Cell, GUVNL, IIT-Gandhinagar

GETCO 66/11 kV S/S

11 kV

66 kV

Farmer 1

Consumption Meter

Pump (7.5 hp)

Generation Meter

Inverter

PV Array (9.38 kW)

433 V

11/0.433 KV “Audit-Watchdog” Distribution Transformer

Farmer 2

Consumption Meter

Pump (10 hp)

Generation Meter

Inverter

PV Array (12.5 kW)

433 V

“Watchdog Device (WDD) (For load control and monitoring)

Farmer 3

Net Meter

Pump (50 hp)

Generation Meter

Inverter

PV Array (62.5 kW)

433 V

Farmer 4

Consumption Meter

Pump (5 hp)

Generation Meter

Inverter

PV Array (6.25 kW)

433 V

Farmer 5

Consumption Meter

Pump (5 hp)

Generation Meter

Inverter

PV Array (12.5 kW)

433 V

Farmer 6

Net Meter

Pump (10 hp)

Generation Meter

Inverter

PV Array (62.5 kW)

433 V

To Other Locations
Farmer-level Metering Scheme

- Monitoring
- Billing
- Analytics

LEGEND
- Power Cable
- Meter Telemetry
- RS-485 Data

433 Vac 3-ph, 50 Hz
FROM/TO GRID

NET METER

IoT Based DCU

CONSUMPTION METER

GENERATION METER

To Pump

From PV

INVERTER-1

INVERTER-2

Power Cable
## Salient features

1. **3-Phase Bidirectional** Energy Meters with RS485-3 Nos (Whole current/CT meters)

2.  
   i. **Solar Generation Meter** (Solar Generation Recording)
   ii. **Consumption Meter** (Pump Consumption Recording)
   iii. **Net Meter** (Consumer Tariff Meter for Import-Export Energy Recording)

3. **Single Phase Unidirectional** Energy Meter with RS485-1 No (If Sky consumer is with farm house connection)

4.  
   - Communication Device- IoT based DCU with RS485
   - Communication media: GPRS/GSM/Wi fi/Ethernet

5. Enclosure with double shutters make it pilfer proof

6. Weather proof, can be installed out door

7. Readymade meter wiring with incoming and outgoing terminal connectors

8. IoT device with local storage SD card

9. Single communication device will communicate all 4 meters, inverter

10. facility can be developed in future if required for Connect/Disconnect
Metering Console

Whole Current Meter Type

CT- Meter Type
## Need For Watchdog device

1. There are 2 Types of Power supply Schedules for Agriculture feeders of Gujarat DISCOMs (1) 3 Phase (2) 1 Phase
   - During 3 Phase schedule Agriculture consumers avail 3 phase power supply for only 8 hours per day for remaining Hours avail 1 Phase supply
   - Schedule of 3 Phase power of each agriculture feeder supply changes every week.

2. SPV system to be installed under SKY scheme needs grid support during day hours i.e. 7am to 7pm

3. As per scheme provision, feeder will be covered under SKY with minimum 70% farmers participation

4. SKY feeders Shall be provided 3 phase power supply for day time 12 hours and for rest of the hours, single phase through SDT/PLMT as per prevailing practice

5. 3phase power supply for 8 Hours to non-SKY consumers shall be catered through Watchdog Transformer/ Watchdog Device. For rest of the hours single phase power supply through WDT and SDT/PLMT.

6. Power supply schedule and various Parameters Can be remotely Configured as and when required.

7. If SKY feeders is made ON for 24 Hours, the non-SKY consumers can be scheduled in rotation mode during day/night hours also.
Key Components of WDD/WDT
- Energy Meter
- IoT Based DCU
- Contactors
- SMPS
- Power Terminal Block
- Door Sensor
Watchdog Device

- Electrical Parameters
- Load and Consumption Pattern of Transformer
- Single/Three Phase Status
- Three Phase Output Status
- Pump Status

- Power Quality Analysis
- Energy Auditing
- Pump Running Hours
- SAIFI, SAIDI at Transformer

- Overload & Voltage Protections
- Demand Side Management

- Schedule Operations without manual intervention
- Remote Load Disconnect /connect in case of irregularities

- Measurement & Monitoring
- Audit & Analysis
- Protections & Operations
- Smart Control Commercial Loss Reduction
WDD/WDT-Operation Modes

- **Non Solarization Mode**
  - Similar to existing system, Feeder inputs = Feeder Output
  - Input : 3 Phase Voltage ➔ Output : 3 Phase
  - Input : 1 Phase Voltage ➔ Output : 1 Phase

- **Solarization Without Compensation Mode**
  - Duration and “Start/Stop Time” Based Mode
  - Current Time – Day Start Time <= Three Phase Running Hours Limits

- **Solarization With Compensation Mode**
  - Three Phase Output running hours based mode
  - In case feeder is off for half an hour during three phase Start and Stop time, farmer will get additional half an hour extension because feeder will remain in Three phase for 12 Hours a day due to solar plant
  - “Three Phase Output Running Hours” <= Three Phase Running Hours Limits

- **Remote Control Mode**
  - Remote operations :
  - 1. All Three Phase On
  - 2. All Three Phase Off
  - 3. Single Phase On
Dash Board – Feeder Status
- Consumer Summary
- Communication Summary
- Input Status Summary
- Power Summary
- Voltage Summary
- Output Status Summary
## SEDM-Solar Energy Data Management System

- **Map View and Grid View**
  - Geo Location of Consumer
  - Separate Indication based on Current Status
  - Consumer Details
  - Consumer Type & Ratings
  - Communication Status
  - Power Status
  - Output Status
  - Voltage Status
  - Hyperlink for Detail Analysis of Individual Consumer

<table>
<thead>
<tr>
<th>No.</th>
<th>Consumer Details</th>
<th>Load Details</th>
<th>Type &amp; ratings</th>
<th>Communication Status</th>
<th>Communication</th>
<th>Voltage</th>
<th>Feeder Power (Fdr to Cons : +, Cons to Fdr : -)</th>
<th>Status</th>
</tr>
</thead>
</table>
| 1   | 26232005520, PATEL, PRAKASHBHAI AMBALAL | Contract Load (HP) : 36  
Pump (HP) : 36  
MD Limit (KW) : 26.84  
AC Plant Capacity (KW) : 50 | Category : Skype-Solar  
Rating : 100/5 | RSSI Good (25)  
PORT : | | R : 263.67  
Y : 256.05  
B : 254.04 | {-10.6 KW  
-25.68 KW  
-36.32 KW  
-0.00 KW  
-0.00 KW} | [14/02/2019 13:38:01]  
[14/02/2019 13:38:01]  
[14/02/2019 13:38:01]
Map View
- Longitude, latitude of actual installed location has been mapped
- Identification of System based on Current Status
  - Not Live
  - Live, Generation Off, Pump Off
  - Live, Generation Off, Pump On
  - Live, Generation On, Pump Off
  - Live Generation On, Pump On
Consumer wise all four Meter Instantaneous Data & Trend Analysis
Consumer and meter wise Power Trend and Export energy Chart

SEDM-Solar Energy Data Management System
## SEDM-Solar Energy Data Management System

### WDD/WDT Consumer Monitoring

<table>
<thead>
<tr>
<th>Status &amp; Run Hours</th>
<th>3 Phase Input (Day)</th>
<th>3 Phase Output (Day)</th>
<th>Pump (Day)</th>
<th>3 Phase Input (Total)</th>
<th>3 Phase Output (Total)</th>
<th>Pump (Total)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>252 Min</td>
<td>251 Min</td>
<td>247 Min</td>
<td>35713 Min</td>
<td>24541 Min</td>
<td>11992 Min</td>
</tr>
<tr>
<td></td>
<td>ON</td>
<td>ON</td>
<td>ON</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Meter Details

- **Avg. Active Energy**: 902.4 KWH
- **Voltage**: R = 249.4, Y = 250.66, B = 250.76
- **Current**: R = 9.17, Y = 9.65, B = 9.15
- **Act Power**: R = 1.35, Y = 1.5, B = 1.46
- **PF**: R = 0.57, Y = 0.61, B = 0.63
- **Time**: 2019/02/14 22:08:00
Gujarat Power Research and Development Cell, GUVNL, Gandhinagar

SEDM-Solar Energy Data Management System

Feeder Analytics
- Energy Analytics
- Feeder Energy Analytics
- Loss Calculations and Distribution
- Energy Summary Reports
- Performance Analytics
- System Analytics
Pump Consumption Monitoring

- **Total Pump Consumption Indicator**
  - Sum Of Consumption of All Consumers in chosen duration
  - Consumption = Last Reading – Initial Reading

- **Total Pump Consumption : Feeder Trend**
  - Day Wise Total Pump Consumption in chosen Duration is plotted in bar chart

- **Consumer wise Consumption :**
  - Consumer Wise Total Pump Consumption in chosen Duration is represented in table/grid

- **Consumer Consumption Trend:**
  - Day Wise Pump Consumption of selected Consumer for chosen duration is plotted in bar chart
Solar Generation Monitoring

- Solar Generation Indicator
  - Sum Of Generation of All Consumers in chosen duration
  - Generation = Last Reading – Initial Reading
- Solar Generation : Feeder Trend
  - Day Wise Solar Generation in chosen Duration is plotted in bar chart
- Consumers wise Solar Generation :
  - Consumer Wise Solar Generation in chosen Duration is represented in table/grid
- Consumer Solar Generation Trend
  - Day Wise Solar Generation of selected Consumer for chosen duration is plotted in bar chart.
**SED-M Solar Energy Data Management System**

- **Feeder to Consumer (Drawl) (CI) – Indicator**
  - Sum Of Net Meter Import Energy of All Consumers in chosen duration

- **Consumer to Feeder (Injection) (CE) - Indicator**
  - Sum Of Net Meter Export Energy of All Consumers in chosen duration

- **Net Energy – Indicator**
  - Net Energy represents if the chosen feeder is Exporting (Indicated with Green up Arrow) or Importing Energy (Indicated with Red Down Arrow) Net Energy = CI – CE

- **Energy Check – Indicator**
  - Energy Check represents balance of all the energy of the chosen feeder.
  - % Energy Balance = (((Solar Generation + CI) - (Pump Consumption + CE)) / (Solar Generation + CI))
- Substation to Feeder (FI) – Indicator
  - Feeder Meter Import Energy in chosen duration
- Feeder to Substation (FE) – Indicator
  - Feeder Meter Export Energy in chosen duration
Feeder – Loss Calculations

- Feeder is a Star Point receiving from multiple sources and providing it to multiple loads
  - All Input to Feeder = CE + FI (Consumer Export + Feeder Import)
  - All Output From Feeder = CI + FE (Consumer Import + Feeder Export)
  - Loss = All Input to Feeder – All Output from Feeder
  - Loss (KWh) = (CE + FI) – (CI + FE)

- Fixed Loss = (Feeder Input Energy * 5%)
  - Feeder Input Energy (FIE) = Feeder Import Energy + Consumer Export Energy

- Accountable Loss (AL) = Total Feeder Loss – Feeder Fixed Loss
  - Loss is less than Fixed loss then Accountable loss is Zero (0)

- Loss to be distributed only on SKY Consumers (Not on NSKY, Non AG). If Accountable loss is zero (0) then no loss should be applied to Consumers.
  - Consumer to Feeder After Loss = CE - ((AL/FIE) * CE)
  - Feeder to Consumer After Loss = CI + ((AL/FIE) * CI)
  - Net Energy After Loss = CI After Loss - CE After Loss
Performance Analytics

- Avg. Consumption Per Day Per HP
  - Average of Sum Of Consumption of All Consumers per HP in chosen duration
  - Total Pump Consumption / No of Consumers / HP

- Avg. Generation Per Day Per kW
  - Average of Sum Of Generation of All Consumers / kW in chosen duration
  - Generation / No of Consumers / kW

  - Avg. Generation Feeder Trend
  - Day Wise Average of Generation / kW in chosen Duration is plotted in bar chart

  - Avg. Solar Generation Consumer Trend
    - Day Wise Generation of selected Consumer / kW for chosen duration is plotted in bar chart.
Performance Analytics

- Avg. Consumption Per Day Per HP
  - Average of Sum Of Consumption of All Consumers per HP in chosen duration
  - Total Pump Consumption / No of Consumers / HP

- Avg. Generation Per Day Per kW
  - Average of Sum Of Generation of All Consumers / kW in chosen duration
  - Generation / No of Consumers / kW
  - Generation : Feeder Trend
  - Day Wise Average of Generation / kW in chosen Duration is plotted in bar chart
  - Consumer Trend
  - Day Wise Generation of selected Consumer / kW for chosen duration is plotted in bar chart

- Avg. System Three Phase Availability
  - Average of Three Phase Supply Hours available of all Sky Consumers in chosen duration.
  - If Three Phase supply is available to Consumer then IoT System calculates three phase available minutes
### Sky Scheme Case Study

#### SKY-Nityanand feeder of UGVCL

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Solar generation (Kwh)</td>
<td>15593.01</td>
<td>17379.5</td>
<td>15749.3</td>
<td>20986.2</td>
<td>19920.71</td>
<td>12076.2</td>
<td>13329.8</td>
<td>15360.19</td>
<td>14277</td>
<td>7871.51</td>
<td>15503.7</td>
</tr>
<tr>
<td>Pump consumption (Kwh)</td>
<td>6214.9</td>
<td>12969.4</td>
<td>13409.59</td>
<td>15017.6</td>
<td>5322.49</td>
<td>2481.29</td>
<td>149.8</td>
<td>1728.11</td>
<td>2263.41</td>
<td>3382.81</td>
<td>5674.1</td>
</tr>
<tr>
<td>Net Energy (KWh)</td>
<td>-9356.2</td>
<td>-4400</td>
<td>-2326.68</td>
<td>-5948.6</td>
<td>-9586.3</td>
<td>-14565.1</td>
<td>-13620</td>
<td>-12003.4</td>
<td>-4477.7</td>
<td>-9821.71</td>
<td>-6084</td>
</tr>
</tbody>
</table>

-20000 -15000 -10000 -5000 0 5000 10000 15000 20000 25000

---

**Legend**:
- **Solar generation (Kwh)**
- **Pump consumption (Kwh)**
- **Net Energy (KWh)**
Site Photographs for installation & Commissioning
Site Photographs for installation & Commissioning
Installation of Harmonic Analyzer on SKY Feeder

Harmonic Study in Power Distribution Systems
Page 7: Voltage & Current - THD Harmonics %

Gujarat Power Research and Development Cell, GUVNL, Gandhinagar
Thank You