



**AICTE Sponsored**  
**One Week National Level Online Short Term**  
**Training Program (STTP)**



**On**  
**RECENT TRENDS AND CHALLENGES IN**  
**POWER MARKET WITH SMART GRID**  
**TECHNOLOGY**

**2<sup>nd</sup> - 7<sup>th</sup> November, 2020 (Phase-I)**

**A REPORT ON STTP (PHASE-I)**

The EEE department of V R Siddhartha Engineering College conducted One Week National Level Online Short Term Training Program (STTP) On **Recent Trends and Challenges in Power Market with Smart Grid Technology (Phase-I) from 2nd - 7th November, 2020**. This STTP aims to discuss the recent trends and challenges in power market, the concept of smart grid and its advantages over conventional grid. This training program provides the knowledge to the participants on smart grid technologies and developments. It also impart the information about overview of deregulated power market structure throughout the world

***Objectives of STTP:***

1. To understand concept of smart grid and its advantages over conventional grid
2. To know smart grid technologies and development
3. To understand the problems associated with integration renewable sources & its solution through smart grid.
4. To know smart metering techniques

The participants also got insights of research opportunities in smart grid technology and challenges in Power Market with integration of renewable energy sources. This STTP was coordinated by Dr. B.Srinivasa Rao, Professor, EEE Department of VRSEC, Vijayawada.

The topics covered during this STTP are:

- ✓ Smart grid technology to overcome the recent trends and challenges in power market
- ✓ Financial and physical power trading mechanism in open market
- ✓ Time Synchronization for Smart Grid Application and digital Substations
- ✓ Renewable energy integration and grid operation under high penetration of renewables
- ✓ Smart Grid and integration of various renewable energy sources
- ✓ Demand response management in a smart grid using machine learning algorithms
- ✓ Generation/transmission investment practices in open market
- ✓ Smart Grid functional Blocks & its operation to handle power markets
- ✓ Existing Power Market Structure in India study
- ✓ Technical Challenges in the operation of Indian Smart Distribution Grid
- ✓ Transmission investment and expansion planning for enabling Power Market Operations

In order to impart the knowledge on these topics we have identified 11 experts from both academia and industry. There are 7 eminent professors from academic institutions and 4 industrial experts have delivered talks during this STTP.

**The resource persons are:**

**Academicians:**

**Dr. Zakir Hussain Rather**, Professor, IIT Bombay, Mumbai

**Dr. Jai Govind Singh**, Associate Professor, AIT, Thailand

**Dr. P. Sanjeevi Kumar**, Assistant Professor, Aalborg University, Denmark

**Dr. R. Gnanadass**, Professor, Pondicherry Engineering College, Pondicherry

**Dr. I. Jacob Raglend**, Professor, VIT, Vellore

**Dr. T. Aruldoss Albert Victoire**, Associate Professor, Anna University, Coimbatore

**Dr. Ch. V. V. S. Bhaskara Reddy**, Professor, A U College of Engineering, Visakhapatnam

**Industry experts**

**Dr. R. Nagaraja**, Managing Director, PRDC, Bangalore

**Dr. P. BalaKrishna**, Sr Lead R&D Application Engineer, GE, Hyderabad

**Er. P. Gopala Krishna**, ADE, TSTRANSCO, Hyderabad

**Er. A. L. K. Jagannath Sarma**, Assistant Divisional Engineer, APTRANSCO, Vijayawada

The inaugural function of STTP scheduled @ 9.30AM on 2-11-2020 (Monday) through virtual Mode: ZOOM Platform. The following esteemed personalities were present during the inauguration session of the programme:

- Dr. R.Nagaraja, Managing Director, PRDC Pvt. Ltd., Bengaluru
- Dr. A. V. Ratna Prasad, Principal, VRSEC
- Dr. PVRL Narasimham, HoD, EEE, VRSEC
- Dr. B. Srinivasa Rao, Coordinator of STTP & Professor in EEE, VRSEC



Inaugural Function of STTP scheduled @ 9.30AM on 2-11-2020 (Monday)

**Day 1 (2-07-2020)-Session 1:**

The first Session Talk on “Smart Grid Technology To Overcome The Recent Trends And Challenges In Power Market” delivered by the chief guest. In this session the participants briefed about the trends and challenges in power market across the globe. “How to overcome these challenges with the use of smart grid technologies” has been explained to the participants. And several research topics are discussed at the end of the session.

**Key note Address**  
**Smart Grid Technologies to Overcome the Recent Trends and Challenges in Power Market**  
 2nd Nov. 2020

**R. Nagaraja**  
 Managing Director  
 Power Research & Development Consultants Private Limited  
 www.prdcinfotech.com

**Agenda**

- Power Market Trends – International and National Scenario
- Challenges in Power Market
- Smart Grid Technologies as solutions
- Future roadmap
- Research avenues

**Structure of Indian Power Sector**

- Policy Making:** Central Government, CEA, State Government
- Regulators:** Central Electricity Regulatory Commission, State Electricity Regulatory Commission
- System Operators:** National Load Despatch Centre, Regional Load Despatch Centres, State Load Despatch Centres
- Generation:** Central Generating Stations, State Generating Stations, Private Sector Players
- Transmission:** Central Transmission Utility, State Transmission Utilities, Private Sector Players
- Distribution:** State Sector Distribution Licensee, Private Sector Distribution Licensee
- Markets:** Trading Licensee, Power Exchanges, Bilateral Markets

**Role of smart grid in power market**

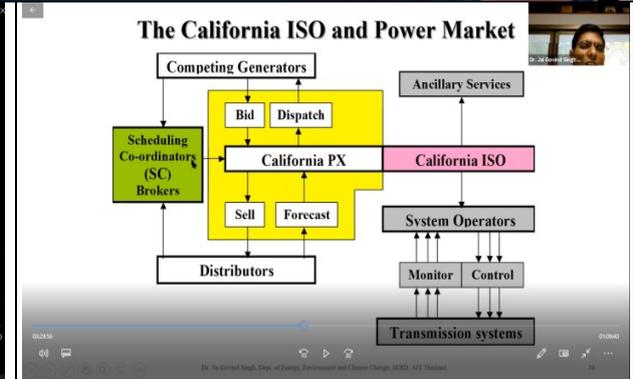
- Microgrid users can interact among each other and trade electric generation over a marketplace.
- On one hand, users make extra profit by selling their excess power or buying cheap electricity from their neighbors.
- On the other hand, the elimination of starting fast ramp generators reduces the operation cost of the power system.
- Hence, energy trading creates a win-win situation for both parties.

**Fig. 3: Energy Trading Among Microgrids**

Ref: Safak Bayram, ... A Survey on Energy Trading in Smart Grid

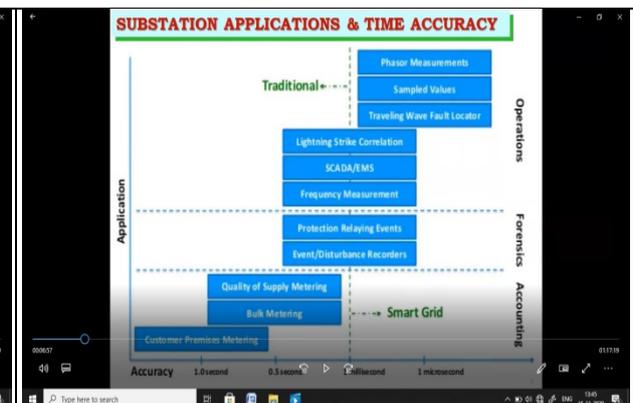
**Day 1 (2-11-2020)-Session 2:**

Dr. Jai Govind Singh, Associate Professor & Academic Chair, SERD, AIT, Thailand has delivered a talk on **“Financial and physical power trading mechanism in open market”**. In this session the participants learned about basics of restructuring in power systems and various power system trading models used in different countries.



**Day 2 (03-11-2020)-Session 3:**

Er. P.Gopala Krishna, Assistant Divisional Engineer, TSTRANSCO, Hyderabad delivered a talk on **“Time Synchronization for Smart Grid Application and digital Substations”**. In this session the participants learned about need of time synchronization in power systems. The speaker highlighted about different types of timing systems used in SCADA systems. The IEEE standards used in digital substations are also described during the session.



## Day 2 (03-11-2020)-Session 4:

Dr. Zakir Hussain Rather, Professor, Department of Energy Science & Engineering, IIT Bombay has delivered a talk on “Grid Operation under high penetration of renewable energy”. In this session participants learned the concepts of integration of renewable sources like wind and solar power to the smart grid. The speaker presented the challenges in penetration of these renewable sources in large scale with suitable case studies.

**Grid operation under high penetration of renewable energy**  
Velagapudi Ramakrishna  
Siddhartha Engineering College,  
Vijayawada  
3 Nov. 2020

Zakir Hussain Rather,  
GMT20201103-090846\_RECENT-TRE1920x1042  
zakir.rather@iitb.ac.in

**Contents**

- Introduction to RE integration-status and technology used
- Grid code regulation for renewables
- Challenges with RE penetration
- Impact on system inertia and remedial measures
- Impact on frequency stability and countermeasures
- Impact on voltage stability and countermeasures
- Case studies
- Emerging issues with RE integration
- Conclusion

**Challenges of variable RE (vRE) energy integration**

- ✓ **Technical**
  - Lack of transmission infrastructure, grid stability, variability of RE sources, weak grid, estimation of effective turbine capacity etc.
- ✓ **Regulatory**
  - Grid code regulation, complexity of subsidy structure and involvement of too many agencies
- ✓ **Industrial barriers**
  - Lack of investment, skilled manpower
- ✓ **Wind resource data collection**
  - Wind potential calculation requires proper data of wind speed at site.
- ✓ **Social and environmental issues**
  - Deforestation for carrying wind turbine and blades

## Day 3 (04-11-2020)-Session 5:

Dr. I. Jacob Raglend, Professor, School of Electrical Engineering, VIT, Vellore has delivered a talk on “Smart Grid and integration of various renewable energy sources”. In this session participants learned about the need of renewable sources in present grid system and challenges in smart grid.

VIT  
Vellore Institute of Technology

VELLORE INSTITUTE OF TECHNOLOGY VELLORE

**SMART GRID & INTEGRATION OF RENEWABLE ENERGY SOURCES**

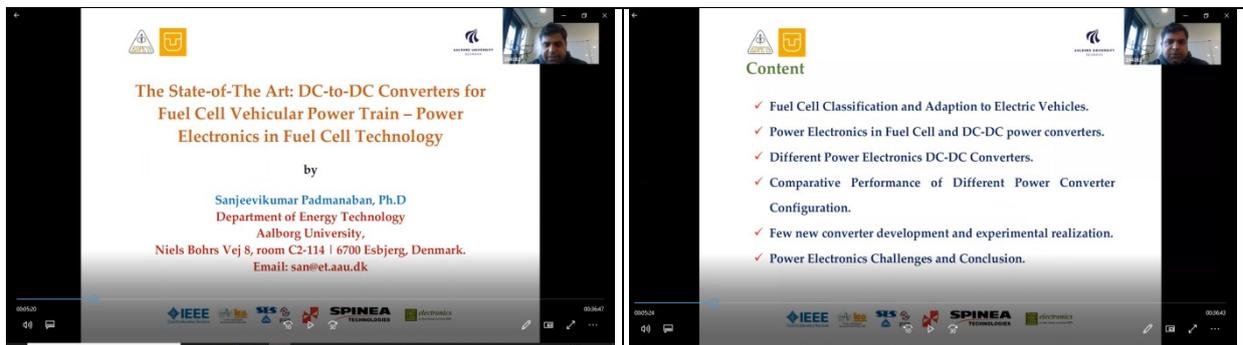
Dr. I. JACOB RAGLEND  
PROFESSOR/EEE  
VELLORE INSTITUTE OF TECHNOLOGY VELLORE  
VELLORE – 632 014

VIT - A PLACE TO LEARN; A CHANCE TO GROW



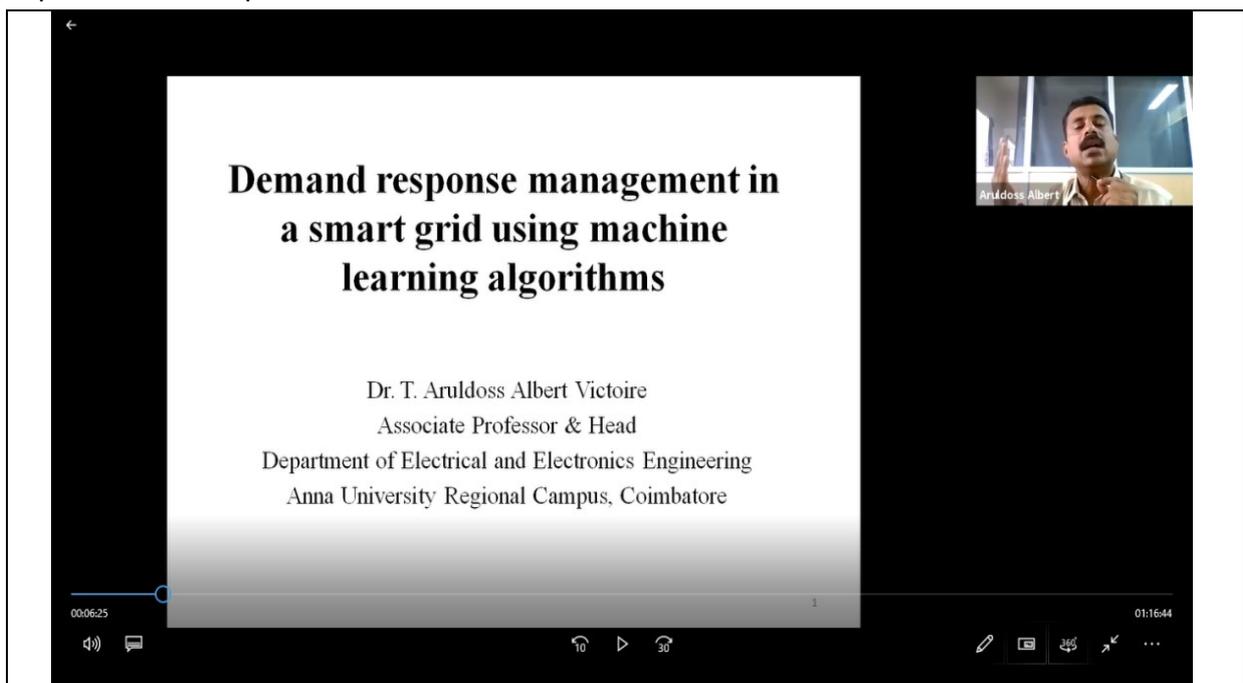
### Day 3 (04-11-2020)-Session 6:

**Dr. P.Sanjeevikumar**, Assistant Professor, Aalborg University,, Dept. of Energy Technology, Denmark has delivered a talk on “**Power Electronics Converters in EVs and Renewables**”. The speaker covered various types of fuel cells used in electric vehicles and different types of converter configurations used in power system applications.



### Day 4 (05-11-2020)-Session 7:

**Dr. T Aruldoss Albert Victoire**, Associate Professor, Anna University, Coimbatore has delivered a talk on “**Demand response management in a smart grid using machine learning algorithms**”.In this session the participants got an exposure on demand response management in smart grid using various machine learning algorithms like ANN and AntLion optimizer techniques with few case studies.



### Outline of presentation

- Smart grid
- Demand response management
- Artificial neural networks
- Meta heuristic methods
- Implementation and discussions

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### Analogy of biological neuron and artificial neuron

Biological Neuron	Artificial Neuron
Dendrites	Input
Cell Nucleus	Node
Axon	Output
Synapse	Interconnections

**Day 4 (05-11-2020)-Session 8:**

**Dr. Jai Govind Singh**, Associate Professor & Academic Chair, Dept. of Energy Environment & Climate Change, SERD, AIT, Thailand has delivered a talk on “Generation/transmission investment practices in open market”. In this session the participants learned different types of investment practices used in generation and transmission expansion with reference to customer point of view and investor point of view.

# AIT

## Generation and Transmission Investment Practices in Open Market

**Recent Trends and Challenges in Power Market with Smart Grid Technology**  
 Department of Electrical & Electronics Engineering, Kanuru Vijayawada-520007, Andhra Pradesh, 2–7 November 2020

**Dr. Jai Govind Singh**, Associate Professor  
 Department of Energy, Environment and Climate Change, SERD, Asian Institute of Technology, THAILAND, Email: [jgsingh@ait.ac.th](mailto:jgsingh@ait.ac.th)  
 Weblink: <https://eecc.ait.ac.th/member/dr-jai-govind-singh/>

**VELAGAPUDI RAMAKRISHNA SIDDHARTHA ENGINEERING COLLEGE**  
 (Sponsored by Siddhartha Academy of General & Technical Education)

An Autonomous Institute  
 Approved by AICTE, New Delhi  
 Affiliated to JNTUK, Kakinada  
 ISO 9001:2015 Certified

### Outlines

- 1 Investor's Perspective for Investment in Generation Capacity
- 2 Customer's Perspective for Investment in Generation Capacity
- 3 Cost-based Transmission Expansion Planning
- 4 Value-based Transmission Expansion Planning
- 5 Conclusion

Disclaimer: This presentation is just for teaching and learning purposes. The major parts of this presentation is taken from the different references. However, some references may not be cited with each individual Figures and Tables though. Some additional info are taken from different other sources, including reports and their citations may not be available here. Therefore, we are not responsible for any unauthorized application.

### Generation Investments in Electricity Markets

- Main variables affecting IRR in this example,
  - Energy sales price
  - Plant factor (utilization factor)
- MATLAB Codes to plot IRR vs. sale price for different plant factors.

**Figure:** Internal Rate of Return for the coal unit of Example as a function of the expected price of coal for various values of the utilization

```

Cap=50; %Capacity; %MW
inv_cost=100*Cap; %Investment cost; %M
%I
for p=0.5:0.1:0.9
    annual_revenue=Cap*1000*P; %Annual revenue; %M
    production=annual_revenue*fact_util; %M
    %I
    for year=1:10
        cost_util=1+year*(annual_revenue-production); %M
        IRR(year)=IRR(cost_util); %I
    end
    plot(year, IRR(year)); %I
end
plot(year, IRR(0.5)); %I
hold on
%I
end
xlabel('year');
ylabel('IRR');
title('IRR vs. price of electricity');
          
```

**Day 5 (06-11-2020)-Session 9:**

**Dr. P. BalaKrishna**, Sr Lead R&D Application Engineer, GE, Hyderabad has delivered a talk on “Smart Grid functional Blocks & its operation to handle power markets”. During this session participants imparts the knowledge on smart grid technology and its framework. The role of smart grid system operator related generation, transmission, distribution and utilities presented. The speaker described the power market functionalities and requirements in the contest of smart grid technology.

# Smart Grid – Technology, Operation Domains enabling Power Markets

By,  
 Dr. Balakrishna Pamulaparthi  
 Sr Lead R&D Engineer  
 GE Renewable Energy  
 Hyderabad Technology Center

### Power Transactions

- Types of transactions:
  - Bilateral transactions
  - Multilateral transactions
  - Non-firm transactions
  - Firm transactions
- To determine the optimal feasible transactions among all possible transactions based on security and economic factors.
- To perform a comparative analysis among different types of transactions based on economic benefits.

➤ If transaction satisfy all system operating constraints then the transaction is called as feasible transaction; otherwise it is said to be infeasible transaction.

➤ In flowchart,  $f$  is the transaction index and  $r$  is the number of transactions.

➤ LIF is the line flow impact factor.

## Agenda

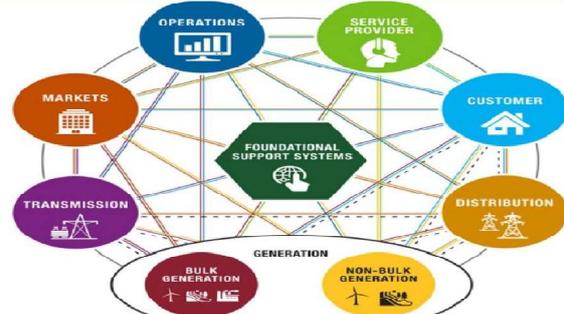
- Smart Grid
- Smart Grid Framework
- Power Market Functionalities
- Power Market Requirements
- Conclusion

11/6/2020

Smart Grid Course - Balakrishna, P

3

## G&O of Asset Management (AM)



11/6/2020

Smart Grid Course - Balakrishna, P

Courtesy: IEEE

48

## Day 5 (06-11-2020)-Session 10:

**Dr. Ch.V.Bhaskara Reddy**, Professor, EEE Department, AU College of Engineering, Visakhapatnam has delivered a talk on “Electricity Markets and Developments: Indian Perspective”. In this session the speaker covered various electricity acts relevant to India. The participants also got awareness on how real time power transactions are happening in Indian grid system and relevant information.

### Electricity Markets and Developments : Indian Perspective

Dr. Ch V V S Bhaskara Reddy

Professor,  
 Department of Electrical Engineering  
 A U College of Engineering (A)  
 Visakhapatnam.

November 06, 2020

### Indian Electricity Act 2003

- Generation has been de-licensed and captive generation freely permitted.
- No licenses in required for generation and distribution in rural India.
- No person shall transmit/distribute/undertake trading in electricity unless he is authorised.
- Region-wise demarkation of the country.
- Open access in transmission with provision for surcharge.
- Unbundle the state electricity boards.
- Setting up of SERC.
- Metering of electricity supplied made mandatory.
- Thefts of electricity made for stringent.



**Day 6 (07-11-2020)-Session 11:**

**Dr. R.Gnanadass, BOYSCAST Fellow, Professor, EEE Department, Pondicherry Engineering College, Pondicherry** has delivered a talk on “Smart Meter Data Analytics Pondicherry – Case Study Distribution Grid”. In this talk, the participants learned the smart distribution grid implementation steps followed by Pondicherry college of Engineering with a case study. Then the speaker highlighted the significance machine learning algorithms and data analytics for power system engineers in monitoring the distribution system through SCADA.

**SMART METER DATA ANALYTICS – PONDICHERRY CASE STUDY**

Dr. R. GNANADASS, BOYSCAST Fellow  
Professor, EEE Department  
Pondicherry Engineering College, Puducherry – 605 014  
(An Autonomous Institution of Government of Pondicherry)  
E-Mail: [g.nar.dass@pec.edu](mailto:g.nar.dass@pec.edu)  
Mobile: 9443084441

**Overview**

- Concepts of Smart Distribution Grid
- Smart Meter operation and data analytics
- Cluster based Distribution Pricing for Pondicherry Case Studies (Feeder and PEC)
- Basics of ML Techniques for the prediction of events with distribution components data
- Sources of dataset

**Take Away Research Problems**

- Protective Schemes for Storage Technologies in Smart grid
- Challenges in protection in the Integration of Distributed Generation in Smart Grid (Solar, Wind, Battery)
- Challenges in protection during the implementation of AC-DC Grid
- Applications of Machine and Deep Learning techniques to monitor distribution components.

**ISGF India Smart Grid Knowledge Portal**

Online Training Program on ARTIFICIAL INTELLIGENCE AND ROBOTICS FOR UTILITIES AND SMART CITIES  
From 14 September - 04 November 2020

**Day 6(07-11-2020)-Session 12:**

**Er. A.L.K.Jagannath Sarma, ADE, APTRANSCO, Vidyutsoudha, Vijayawada** has delivered a talk on “Transmission investment and expansion planning for enabling Power Market Operations”. In this session the speaker covered the evolution of power market with Indian perspective.

**Transmission Investment and expansion planning for enabling Power Market Operations**

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SPP-VRSEC-Vijayawada 2<sup>nd</sup>, 28<sup>th</sup> November-2020

**Evolution of Power Markets**

- Adequate and reliable transmission is a key enabler for the power market.
- Instantaneous delivery of Power not possible. There is always time lag to the extent of one hour.
- We have to bid at 10:45 P:M to get power at 0-15 A:M
- In June 2017, “One Nation, One Grid ”
- In July 2017, “One Nation-One Grid-One Price”
- Increased interstate transmission capacity in the recent past.
- Transmission congestion leads to Market Splitting.
- Multiple Discovery of Prices
- About 6 to 8% of Electricity is being traded through Market presently

Finally, in last day afternoon a formal valedictory function conducted. In this session the convenor and HoD of EEE, Dr. P V R L Narasimham gave the observations made during this STTP Phase-1 program. He also invited the participants to join for other two phases of this STTP Phase -2 & 3 scheduled in last week of Dec 2020 and 2nd week of Feb 2021.

Then the coordinator of STTP gave the overall remarks on the program. There are total 100 registrations received from the faculty, research scholars and working Engineers. Finally, 72 participants enrolled for the program in which only 63 participants have been attended this one week STTP program (phase-1).

During the valedictory session few participants give their feedback on the program. One of the participants suggested include few talks relevant to research contributions made by the eminent faculty in this Power market and Smart grid technology.

The coordinator conveyed his thanks to all the participants for their active participation in the STTP. The coordinator expressed his gratitude towards AICTE for sanctioning this event to EEE department of VRSEC. Followed by valedictory function, an online test conducted for the assessment of participants learning skills.

(Dr. B.Srinivasa Rao)  
Signature of STTP Coordinator

HOD-EEE