

Innovation to Overcome Complex Problems

Ashok Jhunjhunwala

IIT Madras

ahsok@tenet.res.in

Leveraging ICT towards quality in Education

Indian Education over the years

- Have had great gains in terms of
 - Quantity
 - 95% of children go to school today
 - 22 million youngsters in colleges: GER still not good
 - 1.5 million children enter engineering colleges each year
 - Equity
 - Even the poorest are able to access schools and colleges
 - Almost 25% of college students from below poverty line and rural areas
- But still very poor in terms of Quality
 - Need to fix this in coming years
 - ICT may help
 - Different MHRD committee gearing to drive ICT
 - To colleges to begin with

Infrastructure I : Connectivity

- Fibre connectivity to each institute at the earliest
- While this is happening
 - Strong mirror server with available broadband connection
 - along with wifi connectivity within college campus
 - A DTH channel which pushes content to mirror serve
 - live or stored files
 - Cost at each institute: a few lakhs
- Identify public places (say next to play grounds or parks)
 - Provide broadband connectivity (preferably with fibre) and wifi and make it available to students on Aakash tablet

Infrastructure II: Access Devices

- Wide screen displays in a few classrooms
 - Panning Cameras for two way-communications
- Aakash IV as Access devices for students
 - 7" robust tablets from multiple vendors
 - Bulk price at around Rs 2500 + ED + ST
 - Distribution to each student through Colleges
- Exclusive Aakash market place for downloading applications on Aakash
 - Set up security mechanism whereby applications can be only accessed by registered Aakash tablets

Pedagogy I

- Live delivery of High Quality Lectures in class using video on high-speed internet
 - Placing the Best teachers in front of students
 - Controlled interactivity between students and Lecturer
 - part of main curriculum (about ten lectures)
 - where rest of course/ tutorials/ Interactions handled locally
- Interactive e-books
 - Besides text, includes video, ppt, animation, images, quiz modules, dictionary, reference links for each section
 - Worksheets with peer correction, translations using crowd-sourcing, discussions forum for each chapter
- Group Interactive Learning using ICT tool
 - Small group (10-15 students) study together with or without a tutor
 - using audio/ synchronous video view /text chat/ file sharing / white-board like tools

Pedagogy II

- Virtual Labs
 - A significant portion of curriculum experiments can now be carried out virtually
- e-quiz and e-evaluation
 - Means to enhance the level of understanding of the student
 - Objective/ exact answer: Computer-based automated evaluation
 - Subjective/long answers: evaluation by a tutor / introduce peer-evaluation
- Some MOOCs
 - NPTEL along with IT industry plans for all Engineering students, three on-line CS courses (basic requirement for IT employment)
 - videos of single concept modules, online material, quizzes, machine-graded and peer-assessed assignments, Q&A with mentors
 - Programming Languages
 - Design and Analysis of Algorithms
 - Data Structures
 - Certification by IT industry / NASSCOM

Portals & Depositories and e-Governance

- Enable public-private agencies to build portals for
 - Storage and authenticated transcripts and records of students (across all levels including entrance exam performance)
 - Authentic, reliable information on accreditation status of all educational institutions
 - including prospectus of courses offered by institutes at different times
 - Information on certification and quality of school/colleges accredited by authorized agencies
 - Repository of all student research thesis and project reports
- Computerization of College Accounts, administration, record-keeping

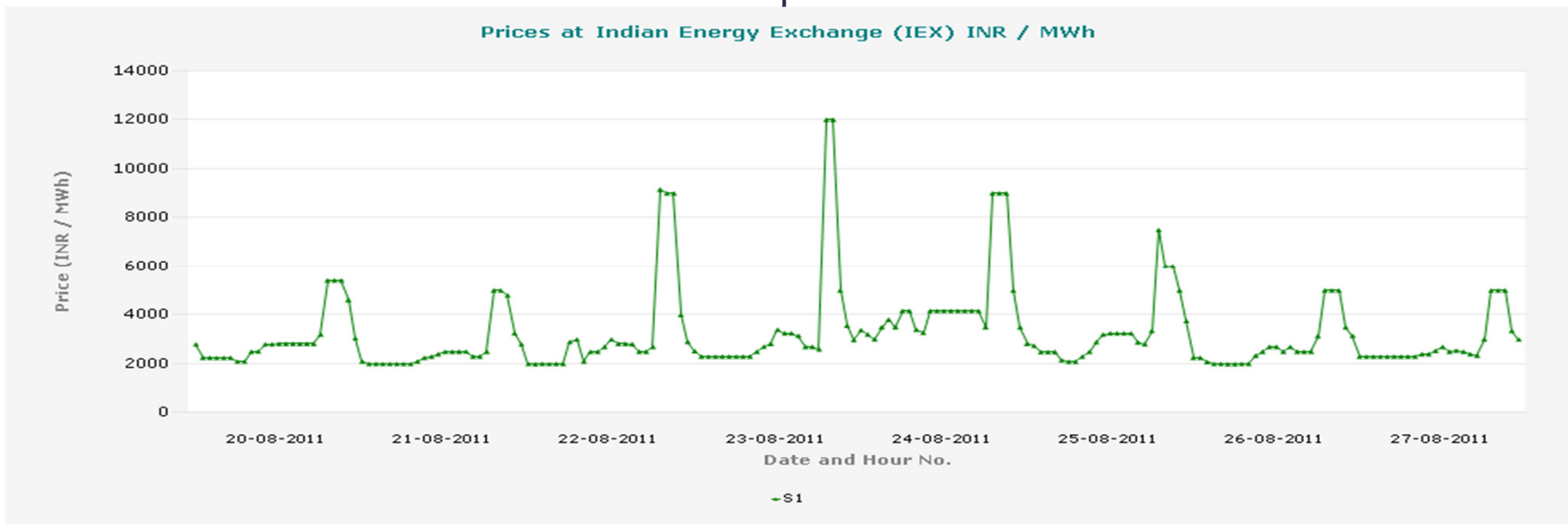
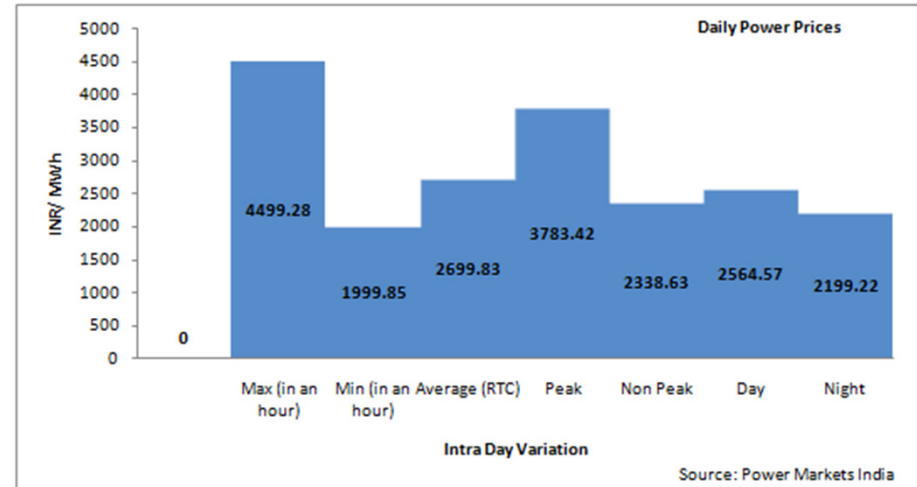
Also focus on

- Teacher training and driving motivation
 - Use mixture of ICT based training and in-person training
- Training of administrators in education
- Regulations for graded autonomy

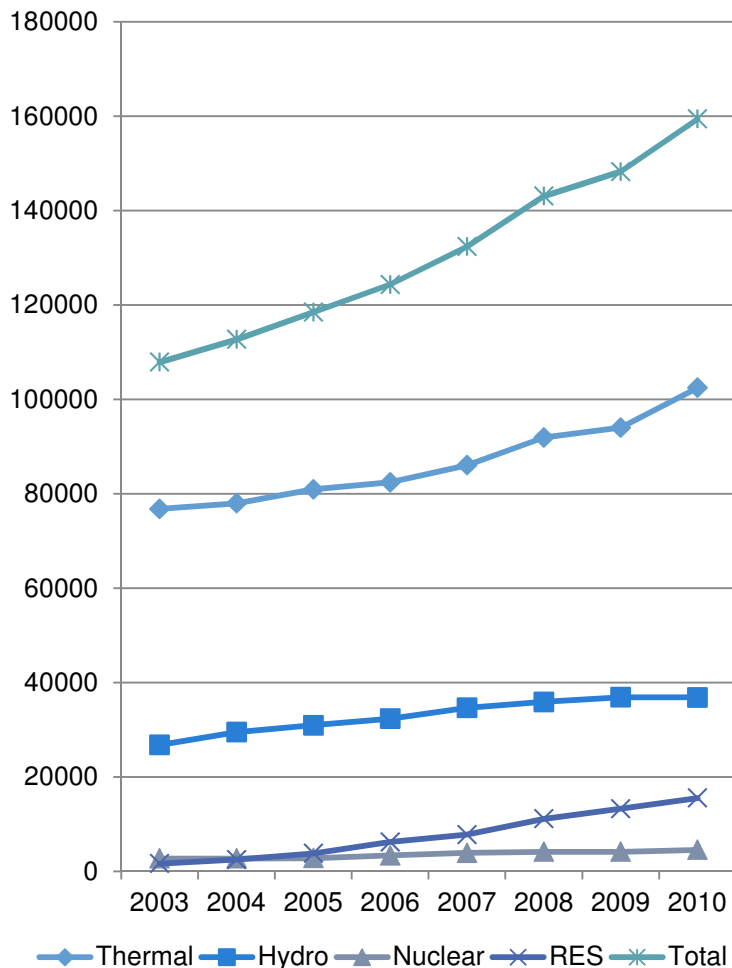
Can we get 50% power from Solar
PV by 2030!

India's Real Power Deficit

- Huge power shortage during peak hours
 - As evident from the fluctuating prices at Power Markets at source
 - Day variation of Rs 2 to 4.5 per unit
 - Prices vary from Rs 2 to 12 per unit in one week
 - About 50 to 70% needs to be added to the price to account for T&D and operation costs



India's Fuel-wise Generation-Capacity (MW)



- Coal: good for base-load
 - significant domestic reserves
 - proven reserves of 105 billion tonnes
 - could last 200 years at current production level
 - Not good for environment
- Natural gas share up from 4.4% to 10% in last 15 years
 - emit half as much CO₂ per kWh as compared to coal-based plants
- Hydroelectric potential of 600 billion kWh per annum
 - Capacity of 148.7 GW
 - only 23% realised so far
 - High initial costs and developmental risks
- Nuclear: small

Commercial Power Options

- Grid: Rs 5 to 9 per kWh: **ram-bharose (as per god's will)**
- Diesel generator: Rs 23 per unit when at 80% load: **instantaneous**
 - at 40% generator load, costs goes up to Rs 35 per unit
- Electrical battery back-up: storage costs over Rs 12- 15 per kWh
- Solar PV: under Rs 5 per kWh when dc is used: **day time only**
 - Conversion to AC may add Rs 1 per unit; land may add ???

Solar PV power price at DC level

Lead acid battery

Battery cost (per kWh)	Rs. 6,000.00
discharge	40%
Number of cycles	1500
interest rate	14%
cycles used per day	1
Losses	10%

Battery cost (to deliver 1kWh)	Rs. 15,000.00
depreciation (years)	4.11
Storage cost per unit	-Rs. 15.35



But can DC be used?

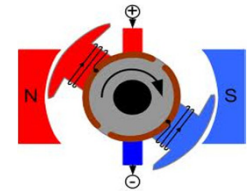
- Lighting

- CFL is four times more energy efficient than tungsten bulb and neutral to AC or DC
- LEDs, 4 to 10 times more efficient than CFL, use only DC power



- Motor: small BLDC motor 2 time energy efficient as compared to AC motor

- Historically brush replacement needed – but not anymore
- A fan is primarily a motor – a dc fan also allows better speed control
- A refrigerator is essentially a motor
- An air-conditioner has a motor (even-though it involves cooling)
- A washing-machine / grinder is a motor



- Electronics: all electronics (mobiles/TV/Computers) use low voltage DC

- Need an ac/dc power adaptor to charge



- World switched to AC primarily for transmission of power

- Any ac / dc conversion or vice-versa implies 7 to 15% losses

Has time come to switch back – at least at customer's premises?
solar can then be used directly in buildings

Vision: Can India get 50% of power from Solar PV by 2030?

- Need to work on different sectors:
 - Residential
 - Commercial (Offices)
 - Rural: mostly irrigation load
 - Industry (to figure out)

Step 1: Decentralized usage
to shave off day-time peak

- Make Utilities financially viable
 - Contain subsidy
- Provide uninterrupted Power to homes
- Create a pull for Solar
- Create a pull for energy-efficient DC appliances

Residential

Innovative Scheme for no Power cuts (patent pending)

In additional to the current line, EB will provide an additional line

- This line will carry a small amount of power (100 Watts) at 48V DC
 - But will be **uninterrupted 24 x 7 – will have no power-cuts**
 - Will need separate wiring and use DC appliances
 - Can be used to provide lights / fans/ electronics and even LED / LCD TV
 - May not support refrigerator, air-conditioners, air-cooler, mixie, grinder, hair-drier

• **But is 100 Watts enough? Can power today (can be installed incrementally)**

- 2-3 LED lights : 2W to 15W (equivalent to 4W to 30W tube-lights)
- 2 DC fans (BLDC) : 30W each (equivalent to 70W AC fan)
- Mobile/laptop/tablet charging: Require new chargers - Far more energy efficient (few watts to 50 W)
- LCD / LED TV with DC input: 22inches TV consumption about 40W

enable three lights + 2 fans + cell-phone charging or with a small TV (24" LED) & one fan

• Tomorrow

- DC powered energy-efficient refrigerators and DC air-conditioners?



But 100W could pose limitation tomorrow

- One can enhance DC power
 - With incremental modular investments of as little as Rs 5000
 - Add solar panels and batteries to the augment existing uninterrupted DC power Supply
 - At Rs 15000 investment, one may enhance DC line to 225W most of the time
 - Add more fans / lights / plug-points / refrigerators
- Of course AC power can continue to be used with existing devices
 - But with power-cuts



Offices

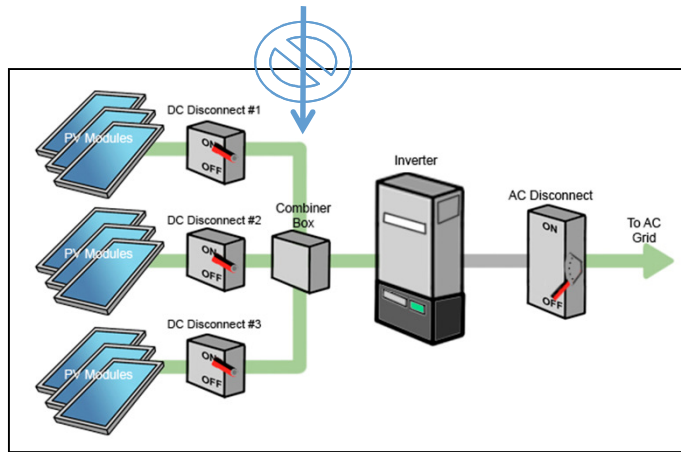
Commercial Buildings: Decentralized Solar PV



- Would be ideal in day time: complement grid
 - Direct usage in offices / shopping malls can reduce the **day time peak load**
 - Makes economic sense today, provided there is space for solar PV installation
 - **Natural Load – demand match for cooling**
 - no additional land cost; T&D losses controlled
 - **Gradual shift to DC usage** will add cost and energy-efficiency
- What about **evening peak loads**? Solar can not help
 - Reducing consumption by **introduction of time of day metering**
 - Can one start and close office early!!
 - Using some storage

Solar Deployment today: subsidy driven

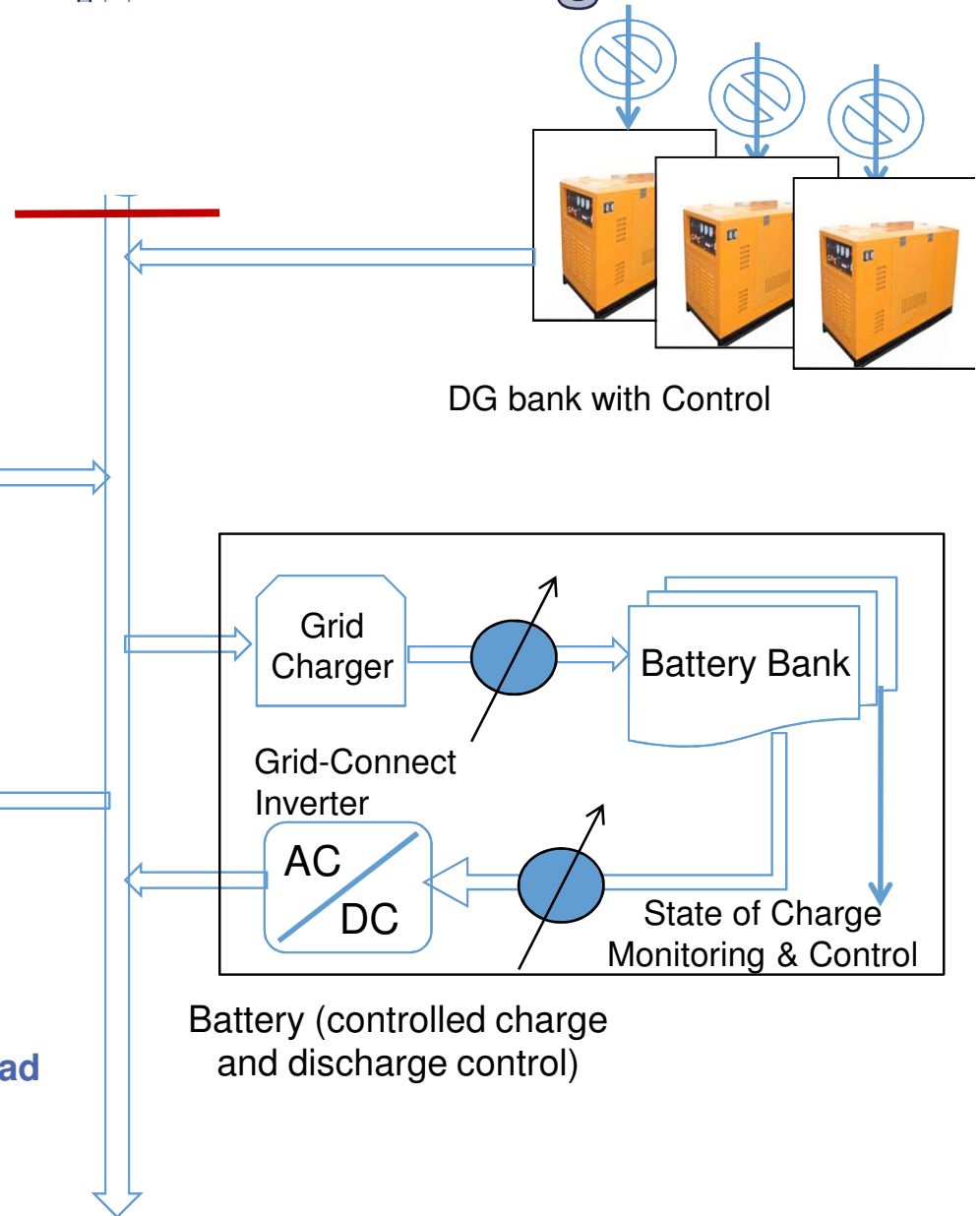
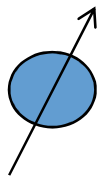
Grid Connected Solar Inverter with MPPT
DC and AC Disconnect Provisions



Electrical Load with Load Control



Smart controller for peak shaving – DG turn ON/OFF, battery charge / discharge current, **Load control**



Available Power Air-conditioners and Air-coolers

- Use **Natural Supply Demand Match**
 - Use solar DC power directly to drive
 - Air-conditioner with BLDC motors based compressor
 - Reduce cooling when available power low
 - Air-coolers with BLDC Motors based compressors
 - Use smart Controller for Load and supply match

Agriculture

Solar powering of Agricultural Pumps

- 18 million agricultural water pumps in India
 - 10 million active today
 - Significant savings possible of subsidized electricity
- Current pump-sizing determined by 1-2 hour power availability
 - Solar Agricultural pumps could be run for 10 hours
 - Need much smaller sizing pumps : will pump required water
 - Would reduce solar array size
 - Minimize costs as well as minimal shaded agricultural land
 - But needs VFD pumps which will pump water for 10 hours
- Solar water pumps along with drip-irrigation desirable

Solar Powering of Industry

Industry

- Still in the works
 - Solar generation on roof can certainly play a role
 - Use of DC lighting will help
 - Some of the motors can become more efficient...

Social Innovation

- Complex and intractable problems of the nation
 - Can be dented with a series of innovations
 - Technological Innovations
 - Business Innovations
 - Organizational Innovations
 - Require dedication and spirit that
 - *there is an answer*
 - Just dig deep