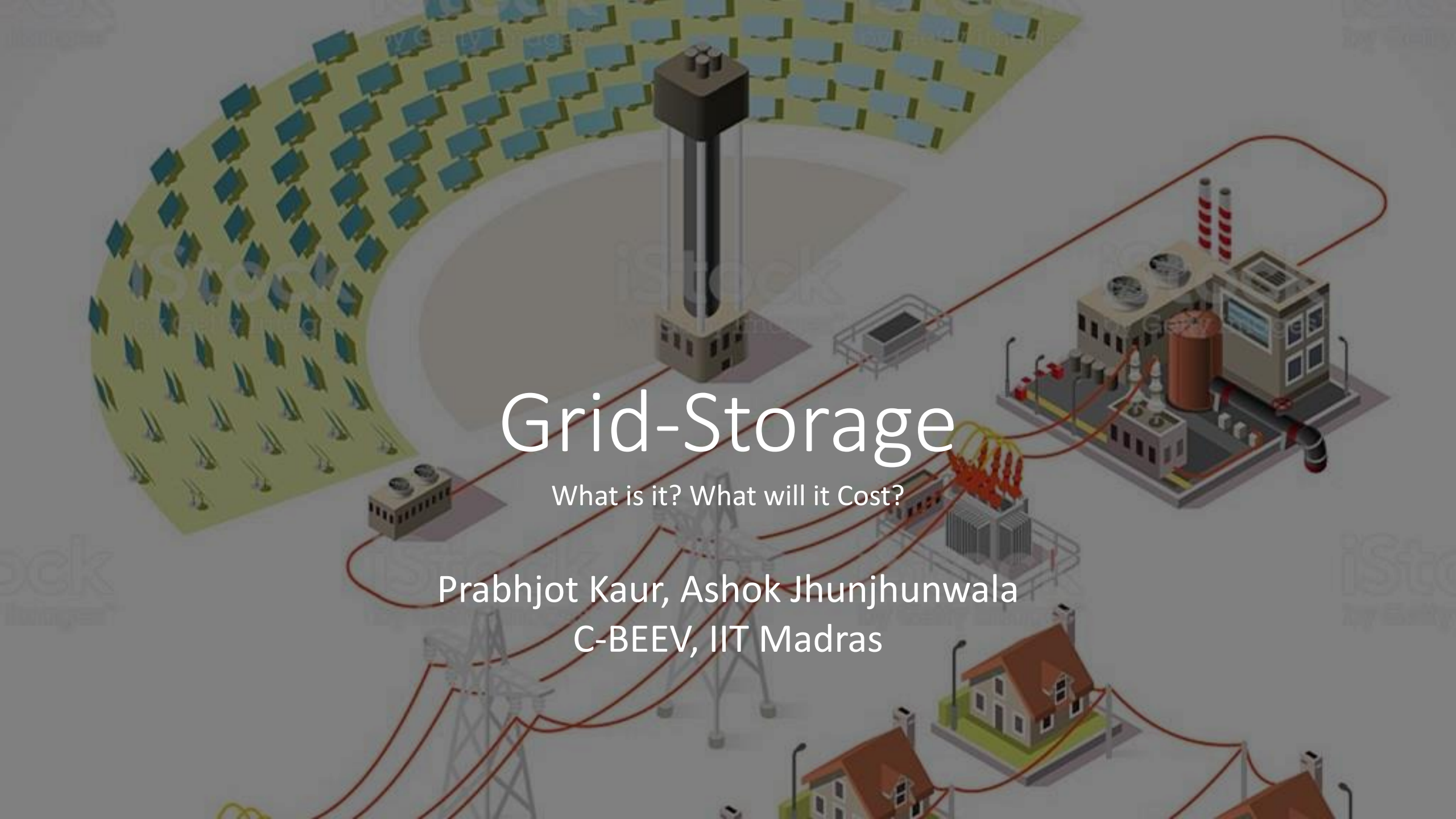

Grid-Storage

What is it? What will it Cost?

Prabhjot Kaur, Ashok Jhunjhunwala
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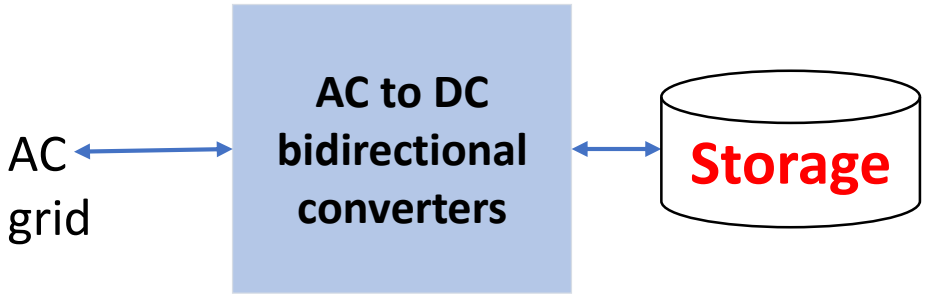
₹70 = $1

- Solar-based electricity in India costs ₹2.50 per kWh to produce
- Wind-based electricity in India costs ₹2.50 per kWh to produce
- Coal-based electricity costs ₹2.50 per kWh to produce

- So what stops us from converting fully to renewables?
  - Solar and wind based electricity not available 24 x 7
  - Output can not be controlled by human being unlike coal-based electricity
- Unless we put energy-storage

Grid Storage a must as renewables grow

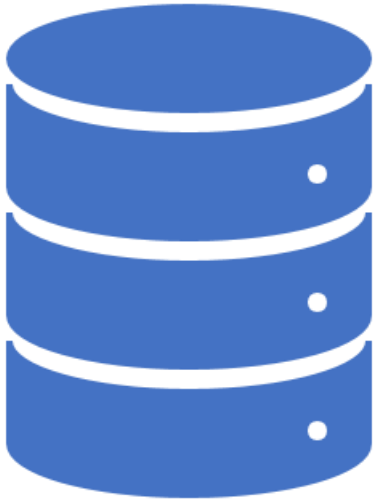


Renewable power source available only in certain hours and on certain days

Output determined by GOD (Nature), can not be controlled by humans

Will need Energy Storage so as to be available ON DEMAND

Two types of Grid-energy Storage



- Short-term storage for frequency control
  - Takes care of sudden demand-supply gap
    - Batteries with fast charging rate and very high number of charge-discharge cycles
- Energy-Storage for enhancing renewables on grid
  - To make renewable provide 24x7 power at low-cost

To help renewable usage 24 x7

₹70 = $1

- Renewable energy in India costs ₹2.50 per kWh
- With storage added, to use when renewable is not available, total cost per kWh of storage must add low amount
  - What is that amount?
- Depends upon
  - Depreciation and interest cost of a battery
  - How many cycles of charge-discharge does battery support
  - And how many cycles of battery charge-discharge will be used per day?
    - Depends upon mix of renewable energy and other energy available
    - Will one charge-discharge battery only once a day, or 1.5 or 2 or 3 times a day?

₹70 = $1

Renewable Usage

How much is S in India?

- Assuming 70% of renewables is used directly when generated
  - Cost is ₹2.50 per kWh (unit)
- 30% of renewable energy passes through Storage
  - Let S be the cost to store 1 kWh in Storage and retrieving it later
  - Generation cost = (₹2.50 per kWh) + S
- Average cost per unit
  - 70% x ₹2.50 + 30% x (₹2.50 +S)
    = ₹2.50 + 0.3 * S per kWh

What is the cost of usage per kWh of Grid-Storage

- Depends upon
  - Type of battery
    - Effective number of cycles
    - Capital cost
  - Number of cycles used per day
    - 1 to 3
  - End-to-end Energy efficiency
    - Assume 96%
  - Interest Rates: 2% to 10%

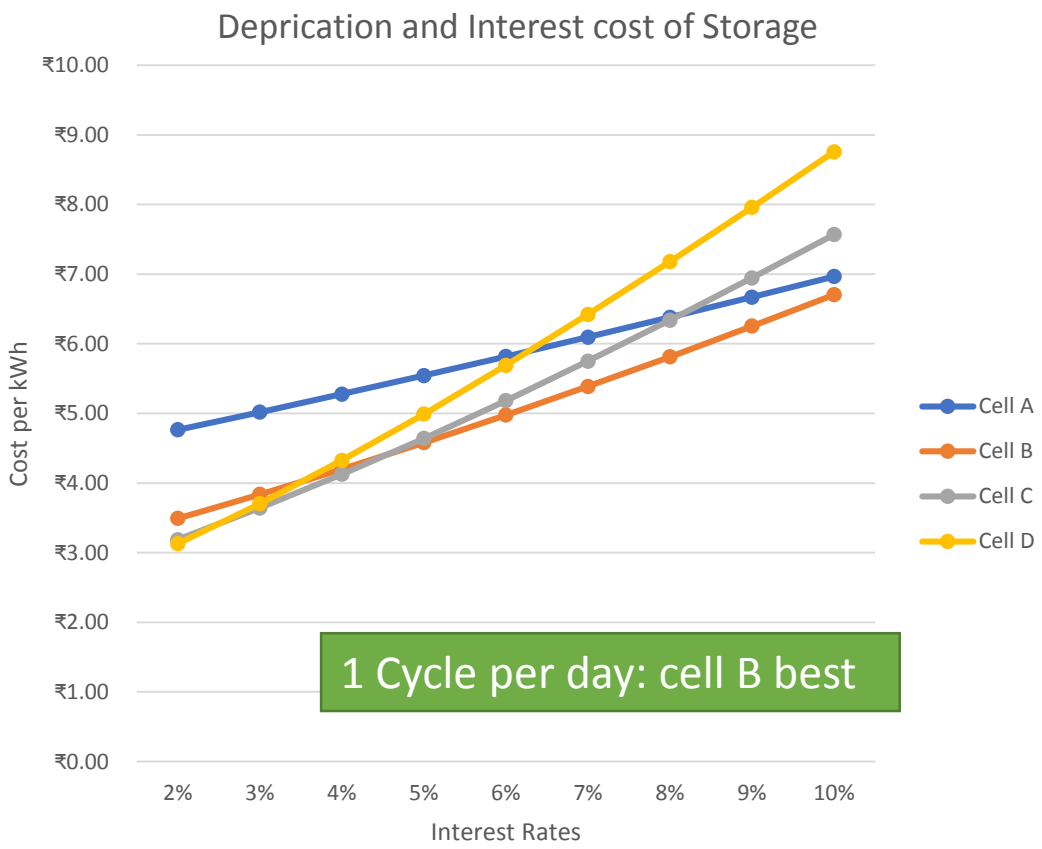
- Consider four type of batteries

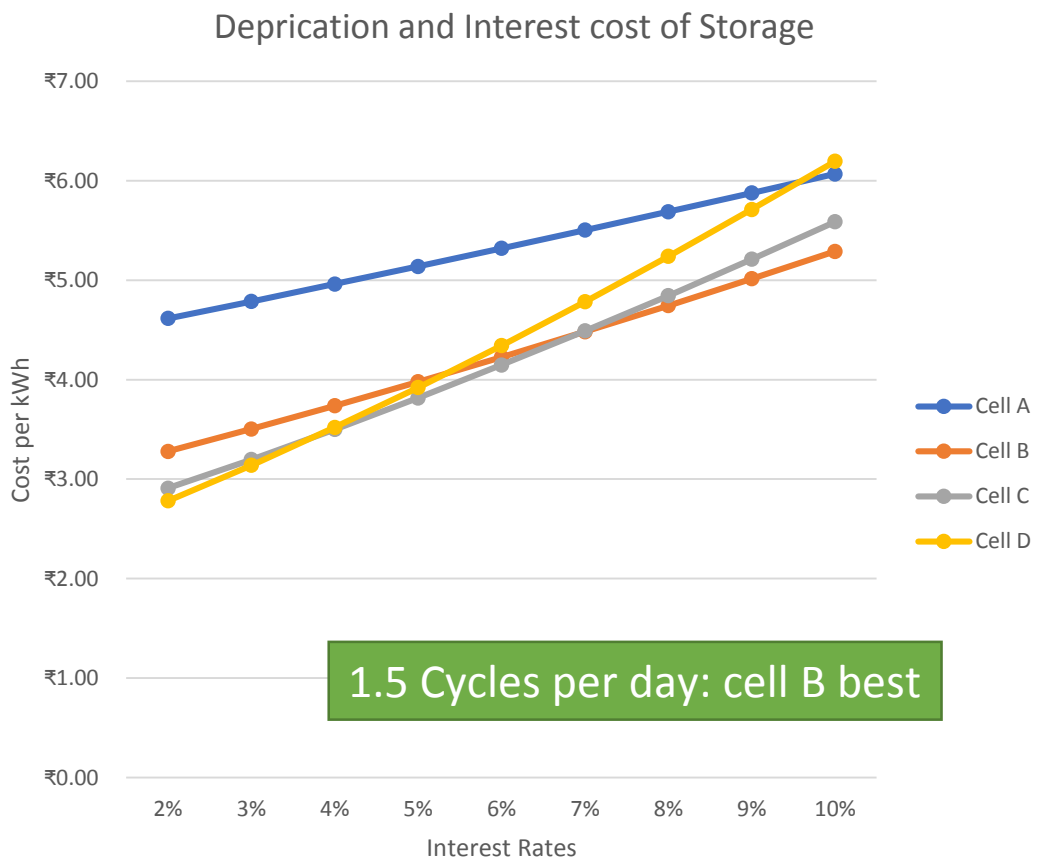
	Cell A	Cell B	Cell C	Cell D
Cost (₹) per kWh	15000	20000	25000	30000
Cycles	3650	7300	10950	14600
Chemistry	**NMC**	**Adv NMC**	**LTO**	**LTO**

* with today's costs

₹70 = $1

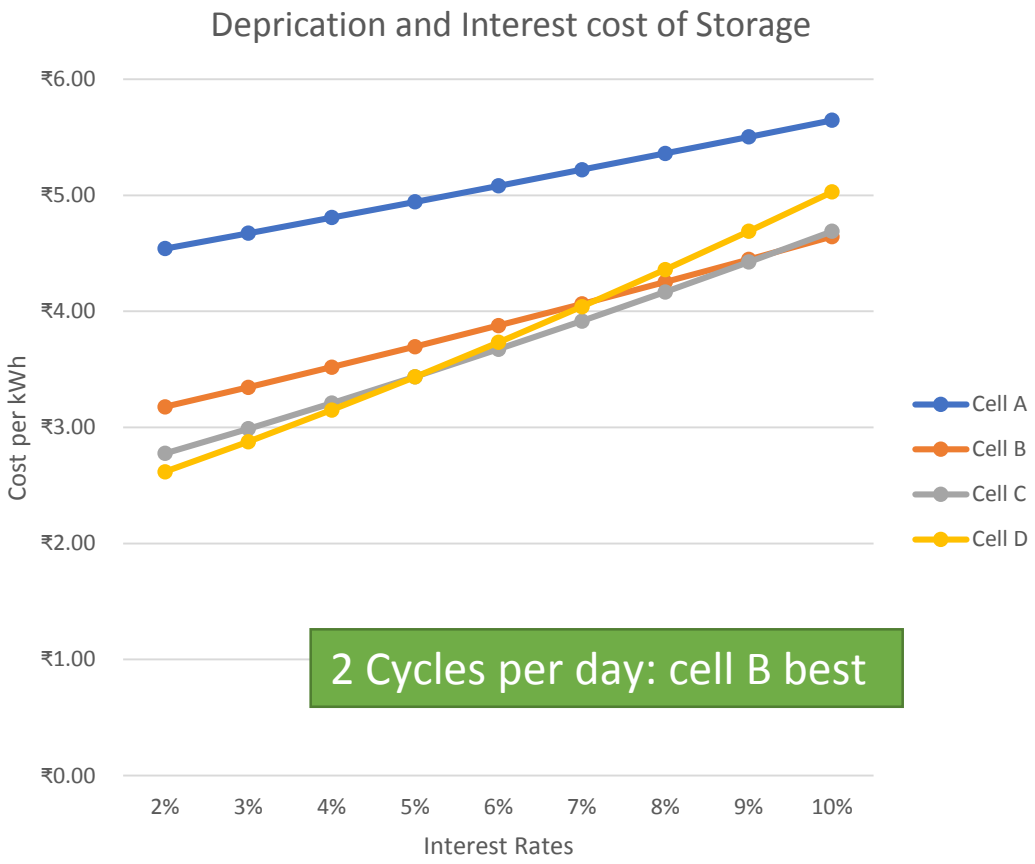
Cost of Storage per kWh

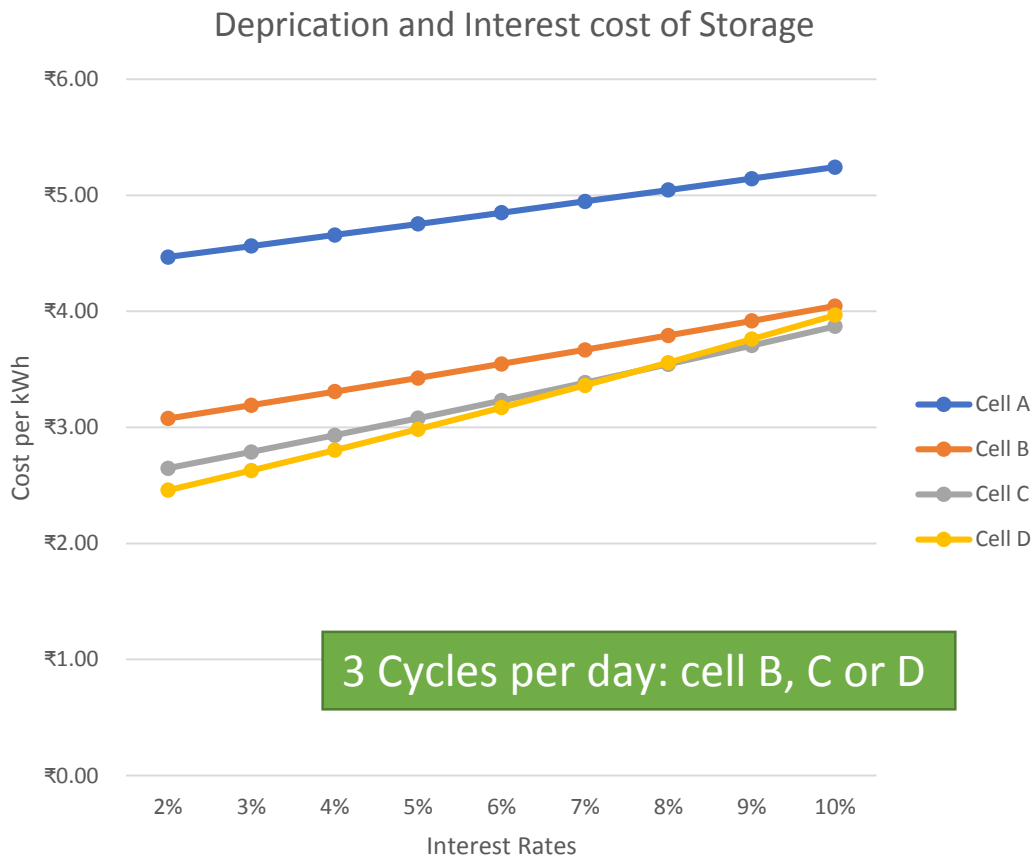




₹70 = $1

Cost of Storage per kWh





₹70 = $1

At 10% interest rate Cell B (NMC) may be best

- 1 cycle per day: costs ₹6:50 per kWh
- 1.5 cycles per day: Costs ₹5.25 per kWh
- 2 cycles per day: costs ₹4.50 per unit
- 3 cycles per day: cell B or C or D costs ₹4 per unit
  - NMC cells with 8000 cycles

- In West at 2% interest rate, Cells C and D (LTO) make sense

₹70 = $1

Total Cost of Storage per kWh

With 70% renewable energy used directly and 30% through storage

- Cost per unit = ₹2.50 + 0.3*S
  - With S between ₹4 to ₹6.50
  - Cost per unit = ₹3.7 to ₹4.45
- Storage adds ₹1.2 to ₹1.95 per unit

If renewable is 50% through storage

- Addition of ₹2 to ₹3.25 per unit
- Renewables with storage: ₹4.5 to ₹5.75 per unit

30% renewables through storage: OK today

- Storage cost to drop by 50% in about 5 years
- Renewables through storage can then go to 50%

Decentralised Storage on Grid

Decentralised roof-top solar used widely today in office-complexes

- Makes business sense: provide power in day-time today

Can such office-complexes use Storage?

- Yes, if Time of day metering is introduced

Today diesel generators are being used as a back-up in all office complexes

- As a first step, storage can be used to eliminate diesel
- Will make economic sense if power-cuts are frequent (and short)
- With ToD metering, office-complexes will recover storage costs in two to there years

To Sum Up

- Storage technologies are fast maturing
  - Will enable us to move to fully renewable electricity in coming years
- Time has come to take first steps to build grid-level Energy Storage

- Short-term goal
  - To build energy storage at office-complex / campus level
    - in addition to roof-top solar
  - Getting rid of diesel generator as a back-up will be first step
  - Time of day metering by DISCOM will help pay for Storage in a few years