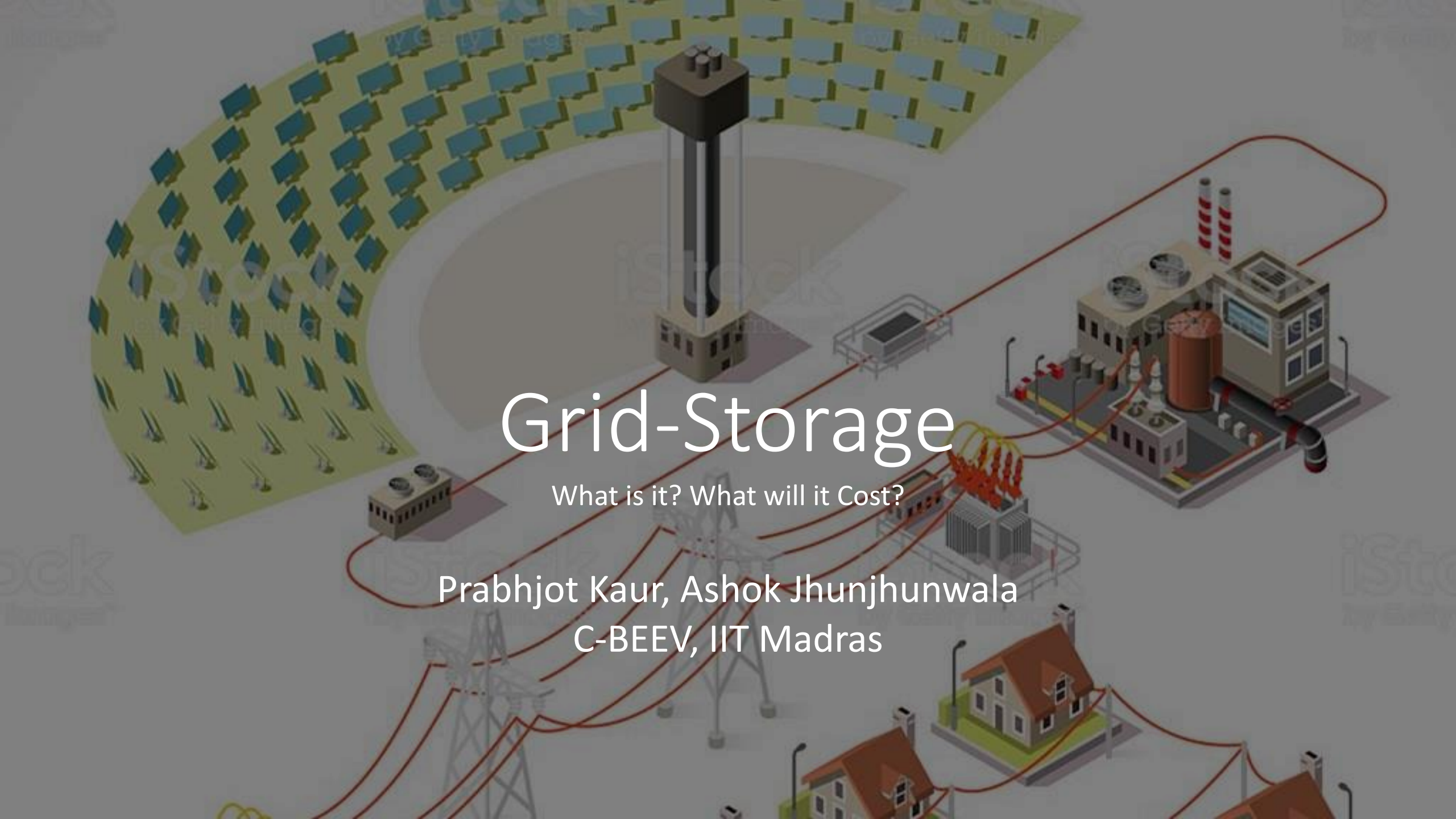

# Grid-Storage

What is it? What will it Cost?

Prabhjot Kaur, Ashok Jhunjhunwala
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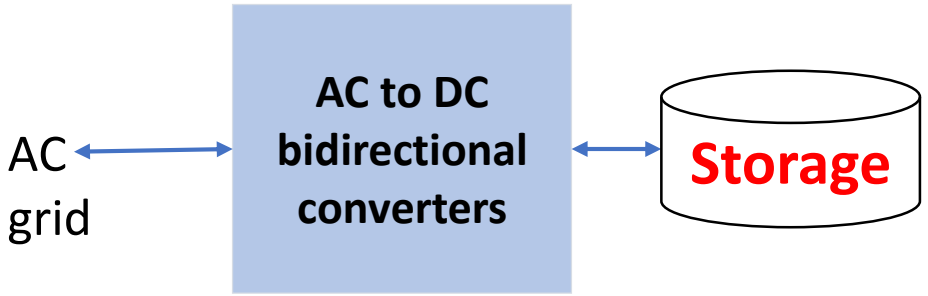
- Solar-based electricity in India costs ₹2.50 per kWh to produce
- Wind-based electricity in India costs ₹2.50 per kWh to produce
- Coal-based electricity costs ₹2.50 per kWh to produce

- 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**

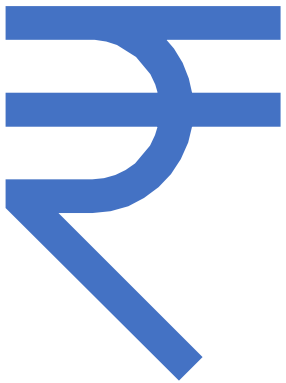
Output determined by GOD (Nature), can not be controlled by humans

**Will need Energy Storage so as to be available ON DEMAND**

# To help renewable usage 24 x7

- 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?

# 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

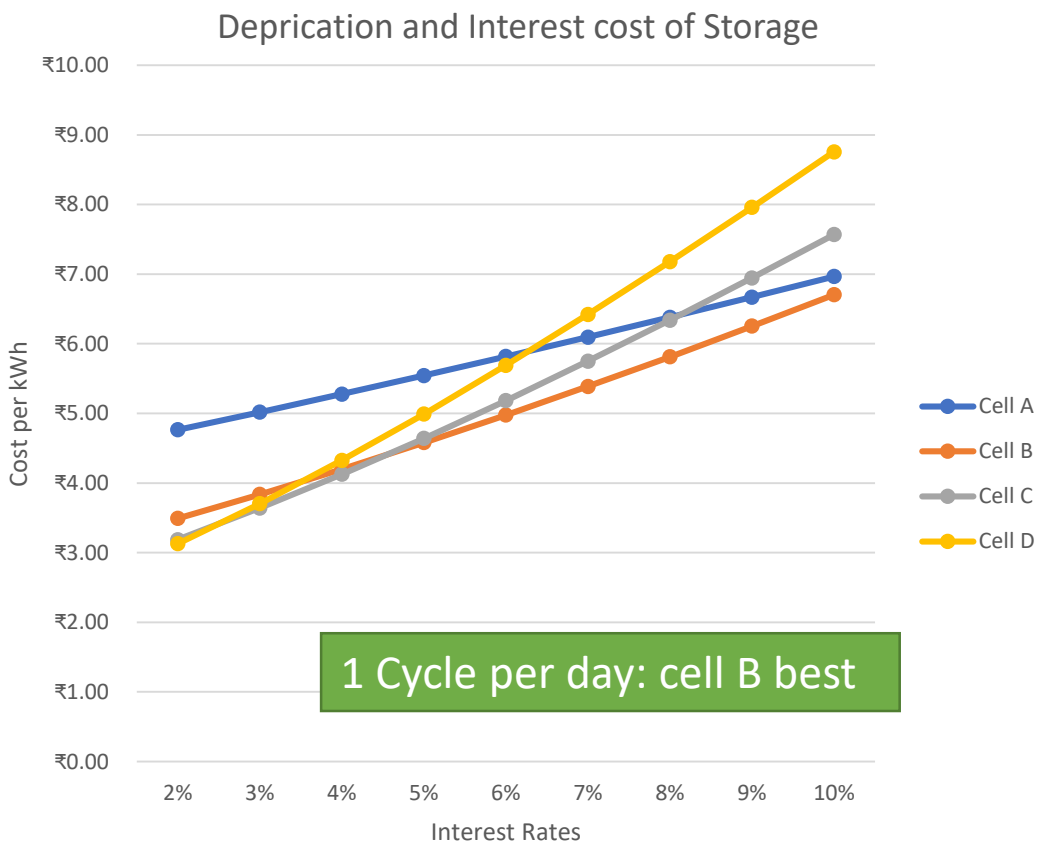
- Depends upon
  - Type of battery
    - Effective number of cycles
    - Capital cost
  - Number of cycles used per day
    - 1 to 3
  - End-to-end Energy efficiency
    - Assume 96%
  - Interest Rates: 2% to 10%

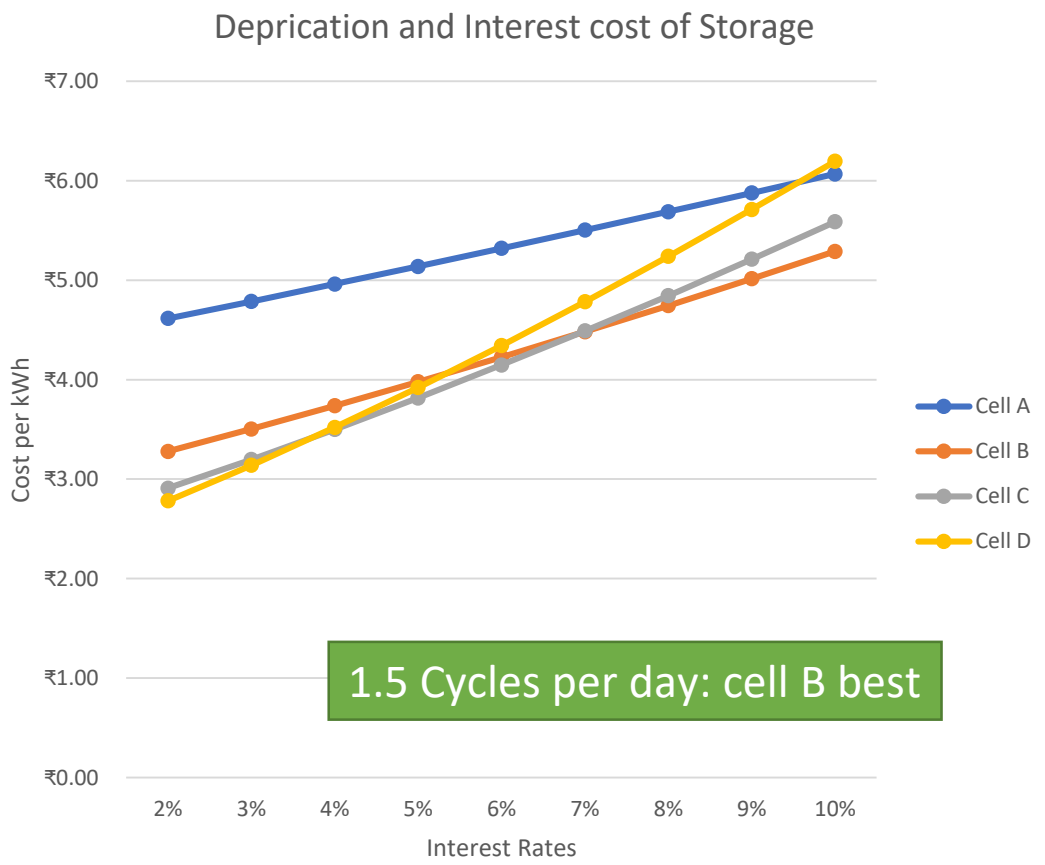
- Consider four type of batteries

| | 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** |

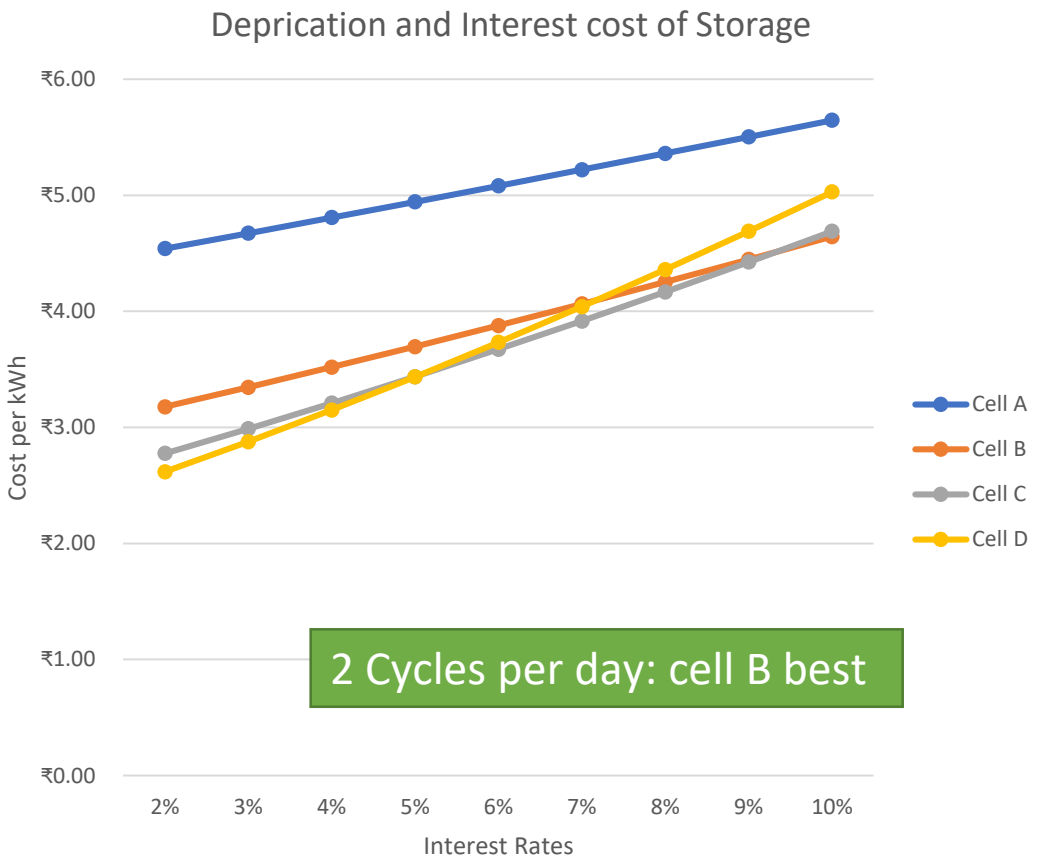
* with today's costs

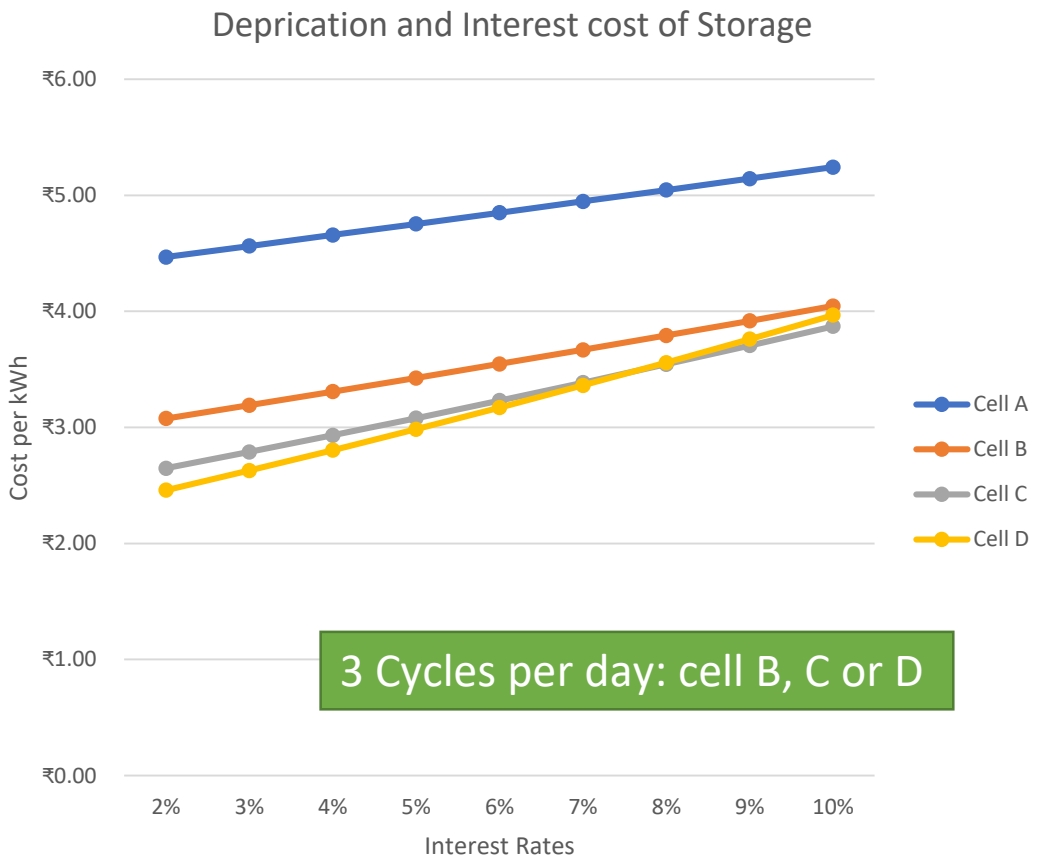
# Cost of Storage per kWh



# Cost of Storage per kWh



# At 10% interest rate Cell B 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

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

- 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 5 to 7 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
- Can such office-complexes use Storage?
  - Yes, if Time of day metering is introduced
  - In fact, in addition to electric Battery-storage, one may also be able to use chilled-water storage
- First Objective: virtually Eliminate diesel generator
  - If ToD is available, one can considerably gain
  - Storage costs payable within a few years
  - Time has to come to act