



Grid-Storage

What is it? What will it Cost?

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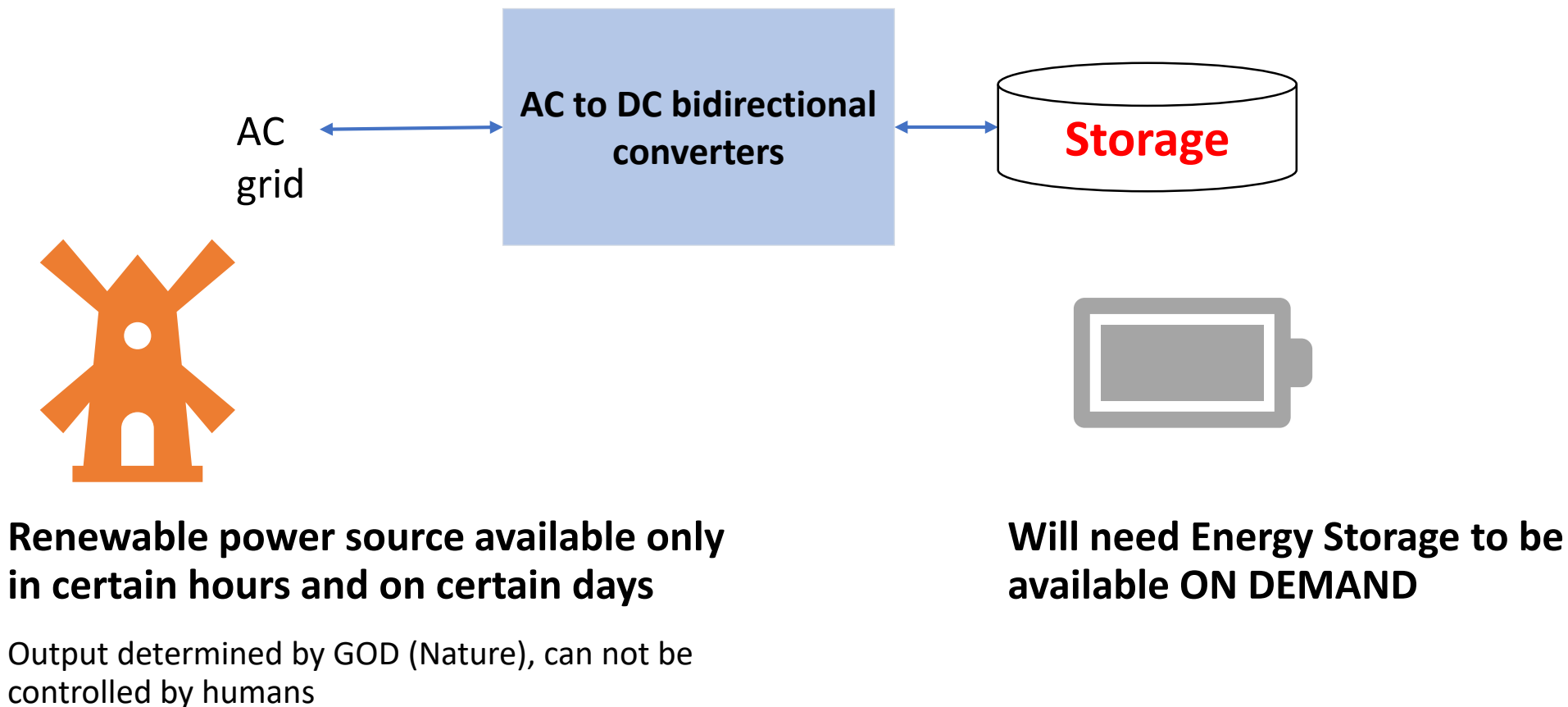
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Today in India

- 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



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 a 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 + S per kWh
- Average cost per unit
 - $70\% \times ₹2.50 + 30\% \times (₹2.50 + S)$
 $= ₹2.50 + 0.3 * S$ per kWh

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

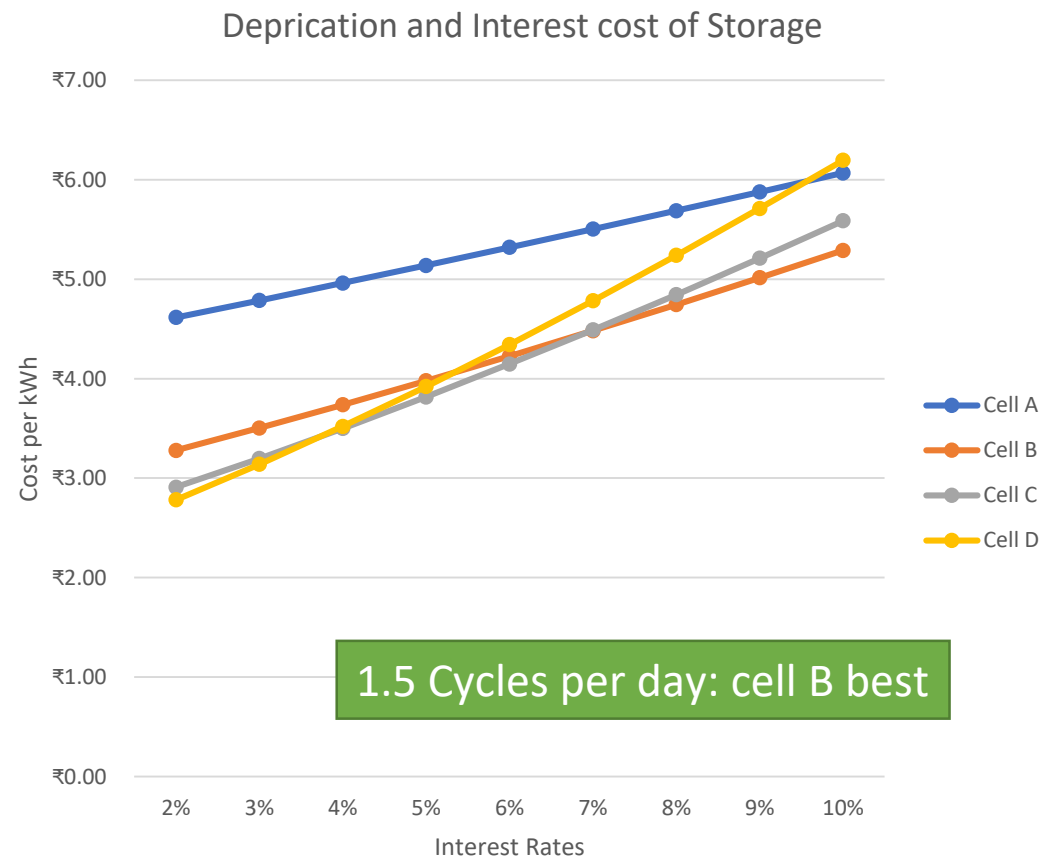
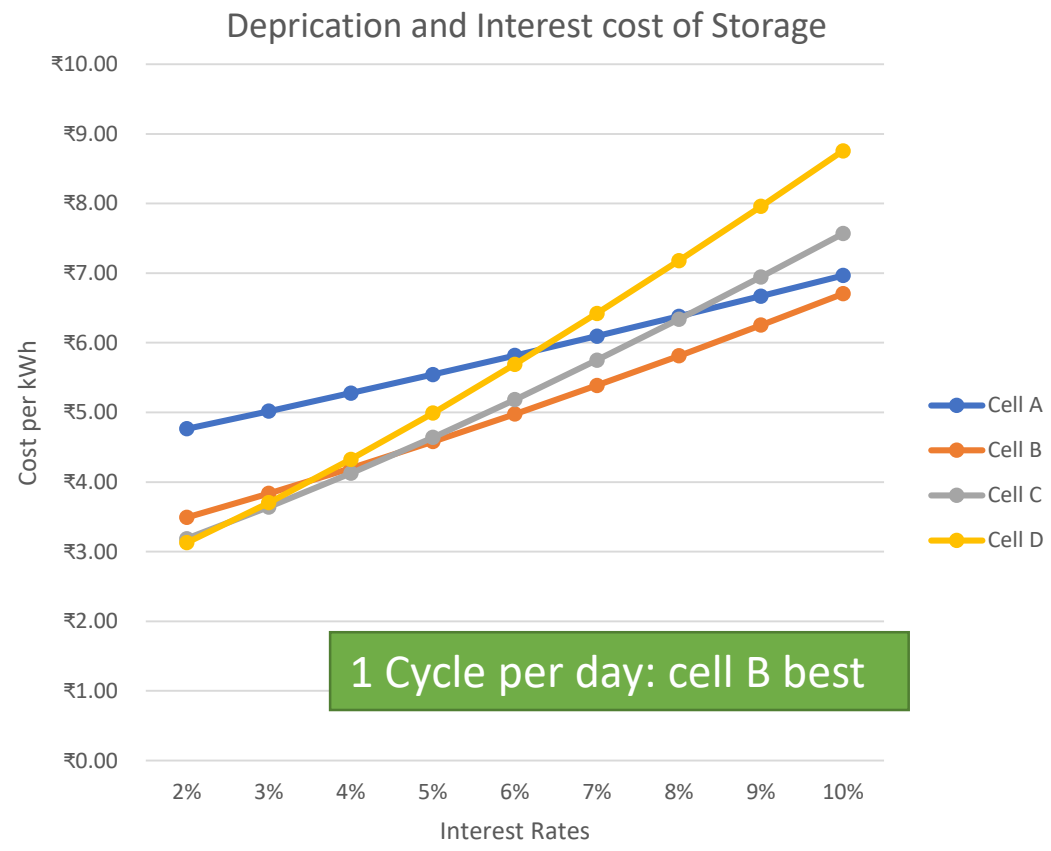
- Depends upon
 - Type of battery used
 - Effective number of cycles
 - Capital cost
 - Number of cycles used per day
 - 1 to 3
 - End-to-end Energy efficiency
 - Assume 96%
 - Interest Rates: 2% to 10%

- Consider four types of batteries

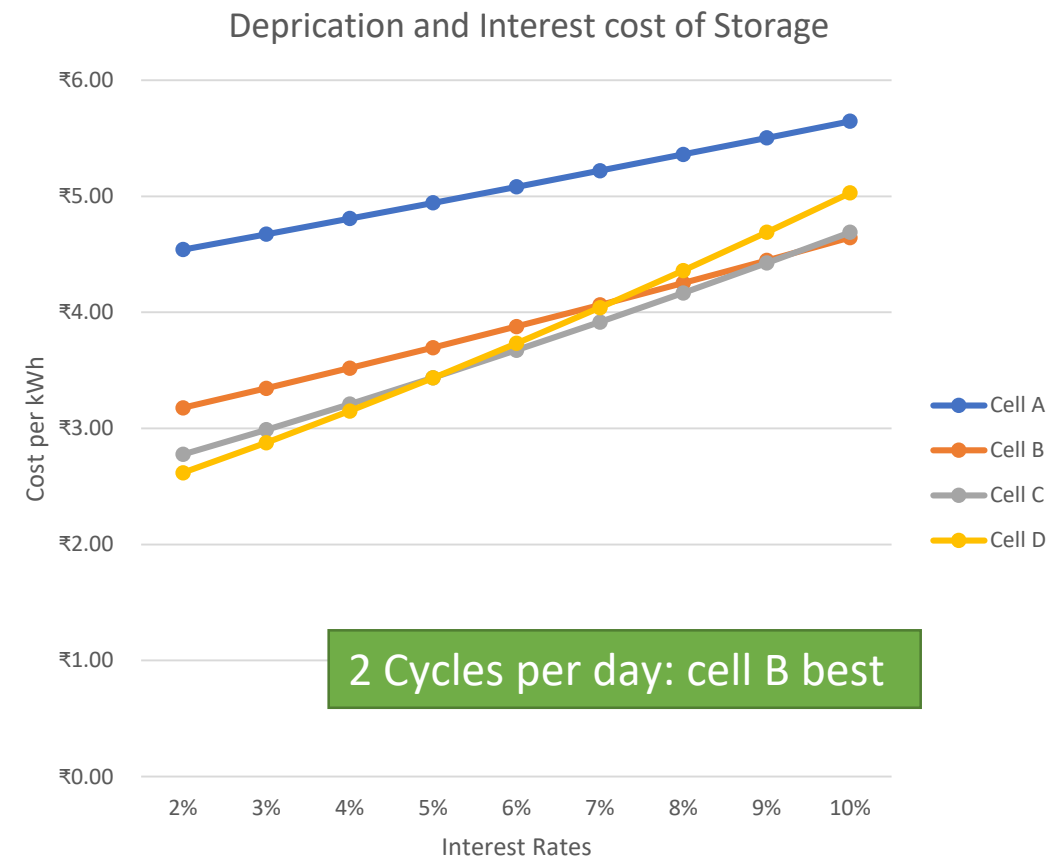
	Cell A	Cell B	Cell C	Cell D
Cost (₹) per kWh	15000	20000	25000	30000
Cycles	3650	7300	10950	14600
Chemistry	NMC	Adv NMC	LTO	LTO

* with today's costs

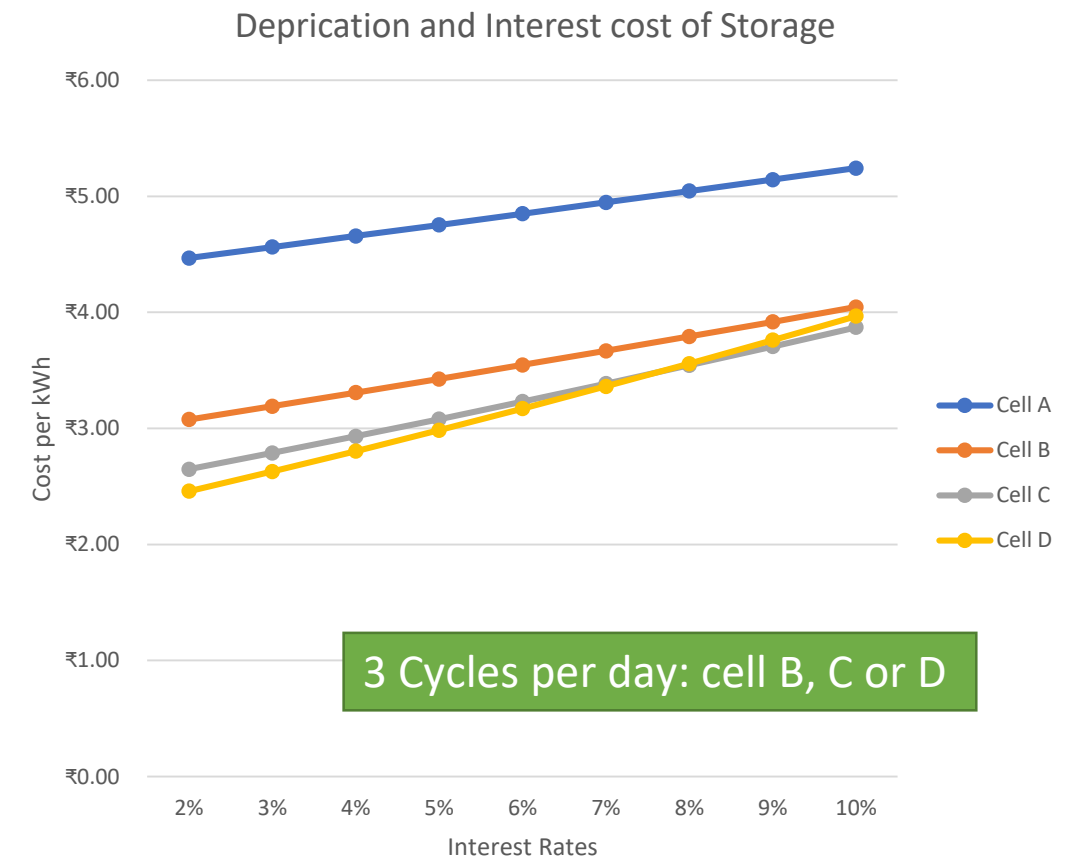
Cost of Storage per kWh



Cost of Storage per kWh



2 Cycles per day: cell B best



3 Cycles per day: cell B, C or D

At 10% interest rate Cell B may be best

- Costs per kWh of Storage
 - 1 cycle per day: ₹6.50
 - 1.5 cycles per day: ₹5.25
 - 2 cycles per day: ₹4.50
 - 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 only **₹1.2 to ₹1.95 per unit to the cost of power**

Total Storage Cost per kWh

- If renewable energy is used now **50%** through storage
 - Addition of ₹2 to ₹3.25 per unit
 - Renewables with storage: **₹4.5 to ₹5.75 per unit**
- But it will take time to build such large storage
 - Storage cost to **drop by 50%** in about 5 years
- 30% renewables through storage: OK today
 - As we build, renewables through storage can then go to 50% if required
 - Solar farms can be set up in Rajasthan deserts with very little rain

Can begin today with decentralised Storage

- Decentralised roof-top solar used widely today in office-complexes
 - Solar and wind power also wheeled to many corporates using grid
 - Makes business sense: provide power in day-time, when usage is highest
- Can such office-complexes use Storage?
 - Will enable usage of stored renewable energy during evenings and nights
- First Objective: virtually Eliminate diesel generator
 - If **ToD is available**, one can gain even more in financial terms
 - **Storage costs** payable within **a few years**
 - Time has to come to act