Improving the performance of cheap thermal energy grid storage

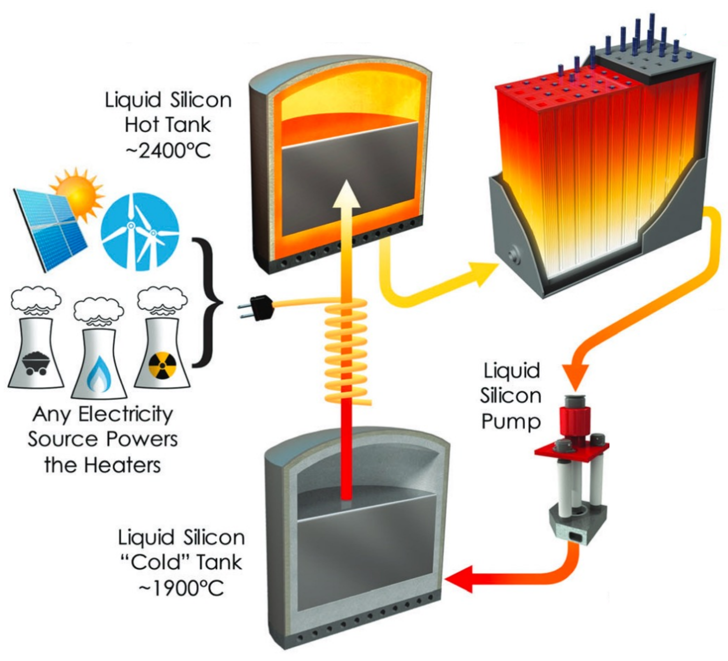
Shomik Verma,[1] Kyle Buznitsky,[1] Colin Kelsall,[1] Alina LaPotin,[1] Michael Adams,[2] Mary Foxen,[1] Bryan Sperry,[1] Shannon Yee,[2] Asegun Henry[1]

[1]Massachusetts Institute of Technology, [2]Georgia Institute of Technology

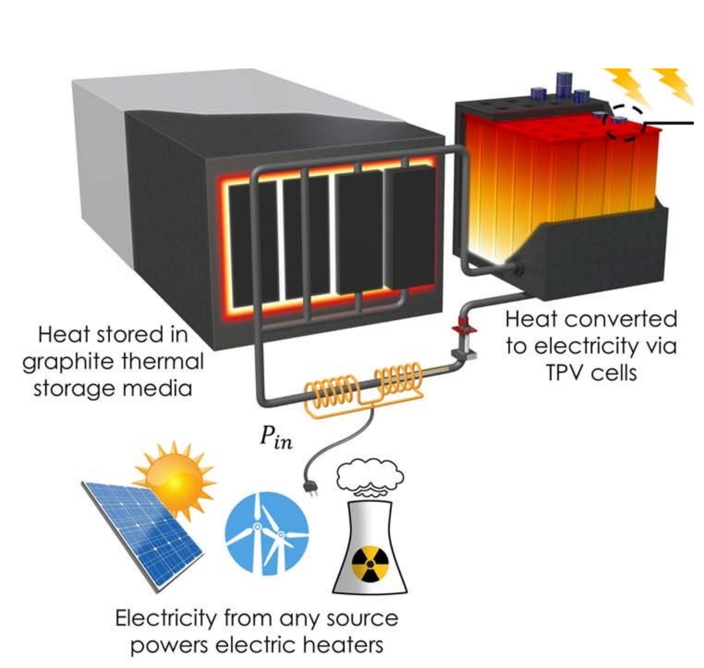
Massachusetts Institute of Technology

We need a cheap way to store intermittent renewable energy

Two-tank design

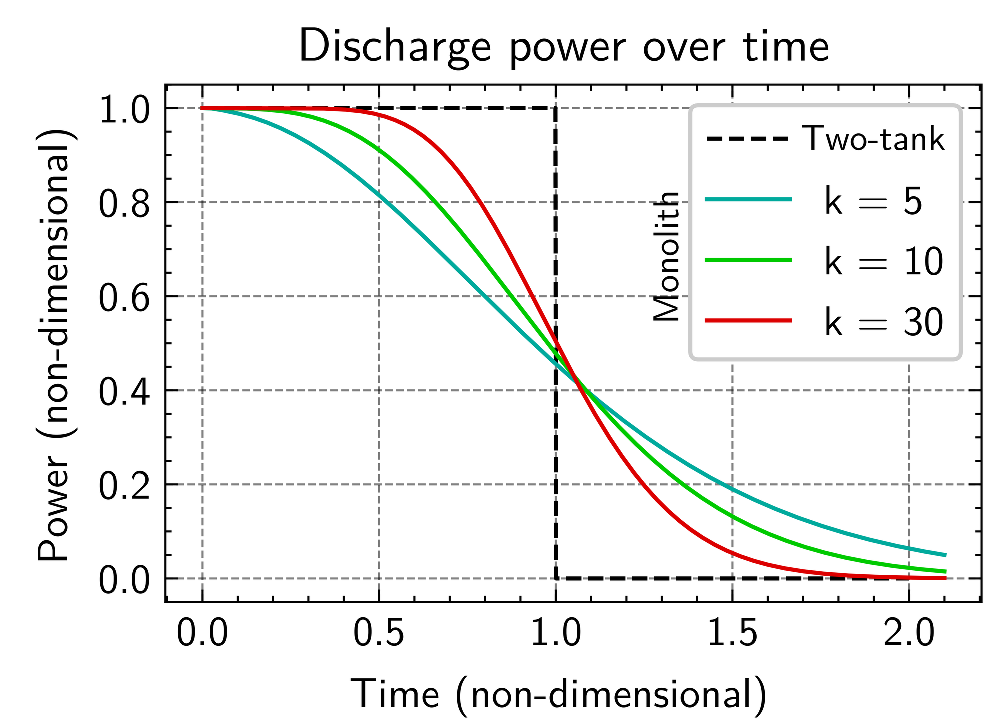


Monolith alternative



- **Thermal energy grid storage (TEGS)** is promising, but
- Previous two-tank design was expensive and inflexible
- New monolith design is cheaper, with $20/kWh energy capacity cost
- However, **performance of monolith design is worse:**
  - Harder to quickly charge
  - Can't uniformly discharge

Need to improve performance of TEGS

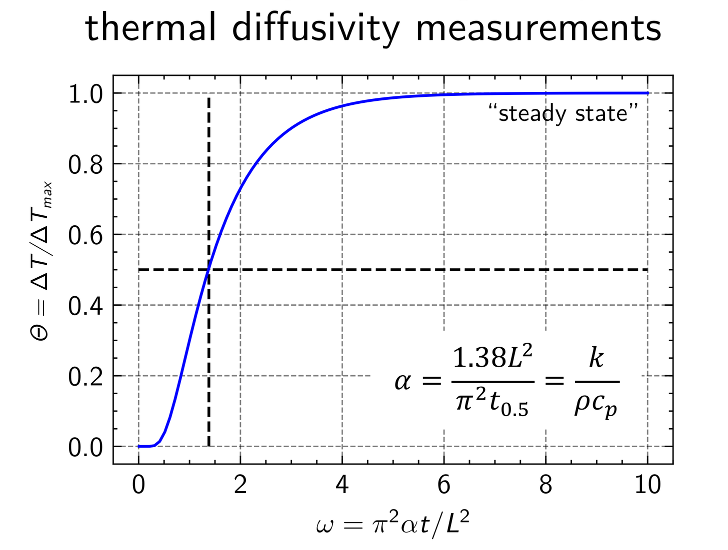


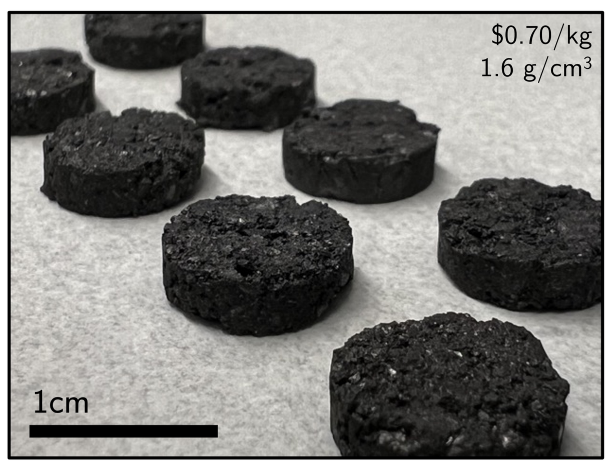
Discharge performance gets worse for lower thermal conductivity

What is the thermal conductivity of cheap storage materials?

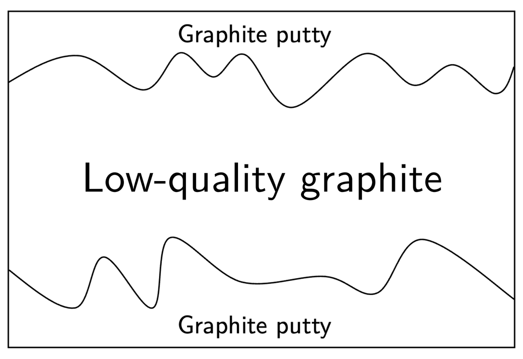
Low-quality (Regenerated) $0.7/kg	Mid-quality (Formed) $1.5/kg	High-quality (Molded) $3/kg

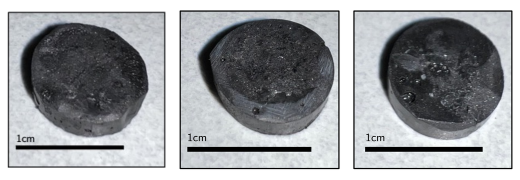
Laser flash analysis for high-temperature thermal diffusivity measurements

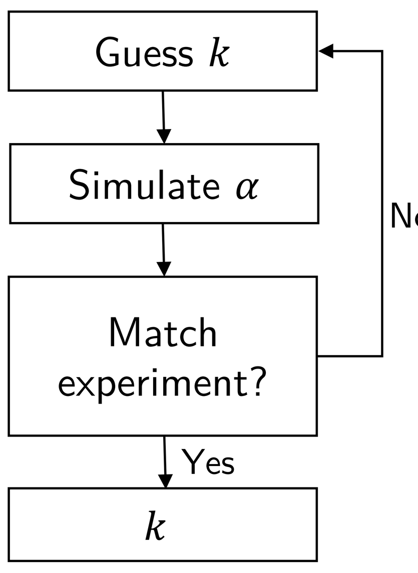




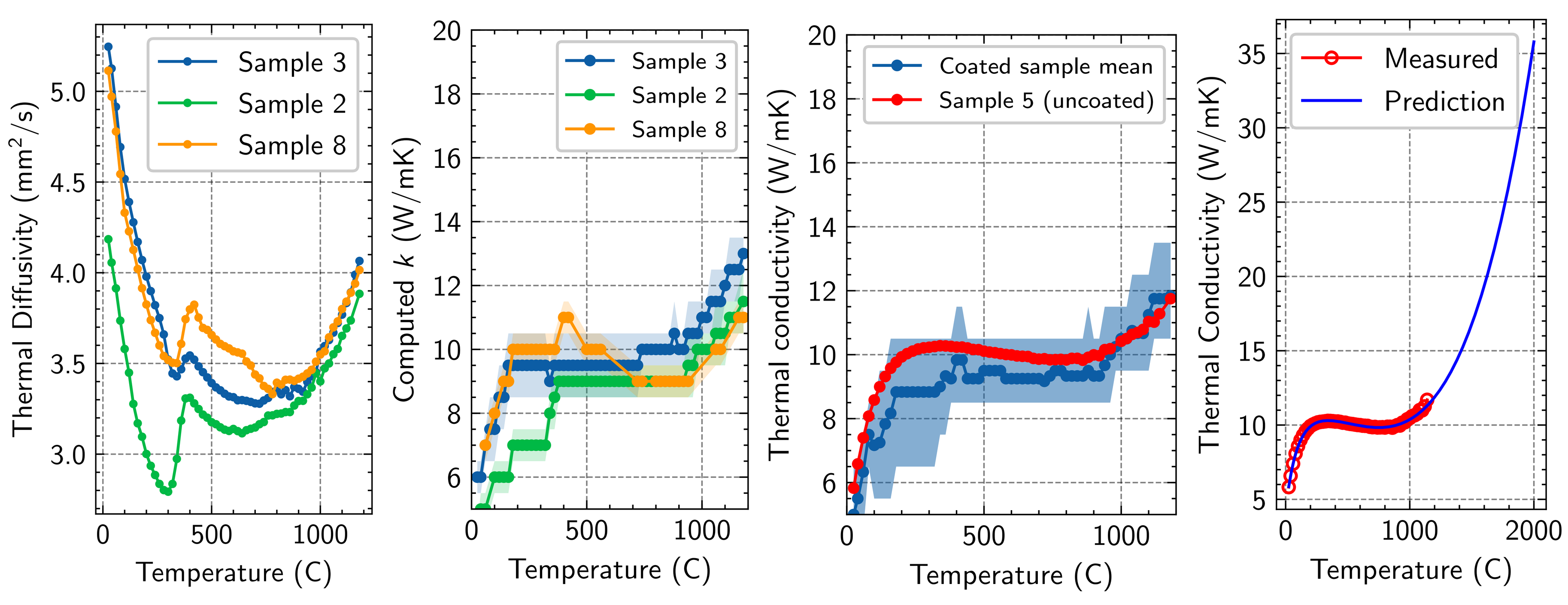
Roughness ~0.5mm (SEM)
LFA requires flat samples
⇒ coating required





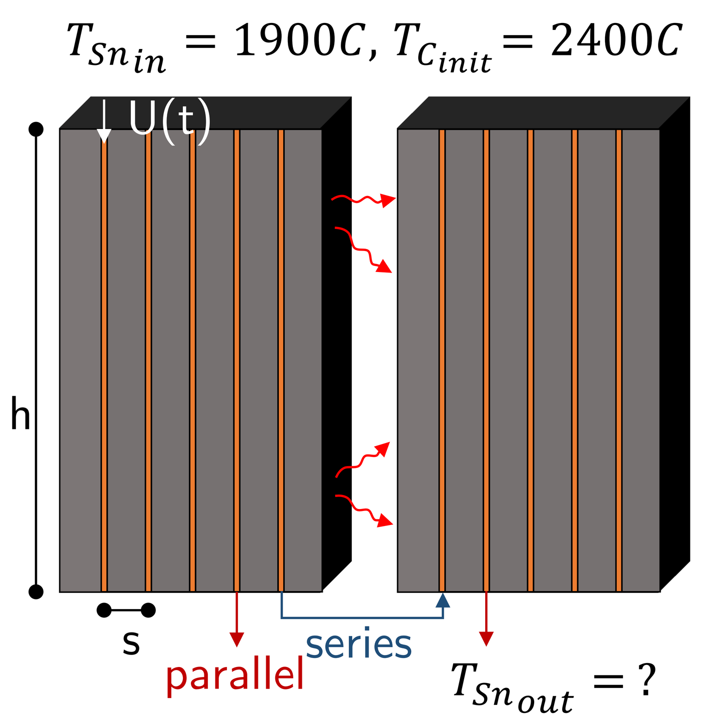


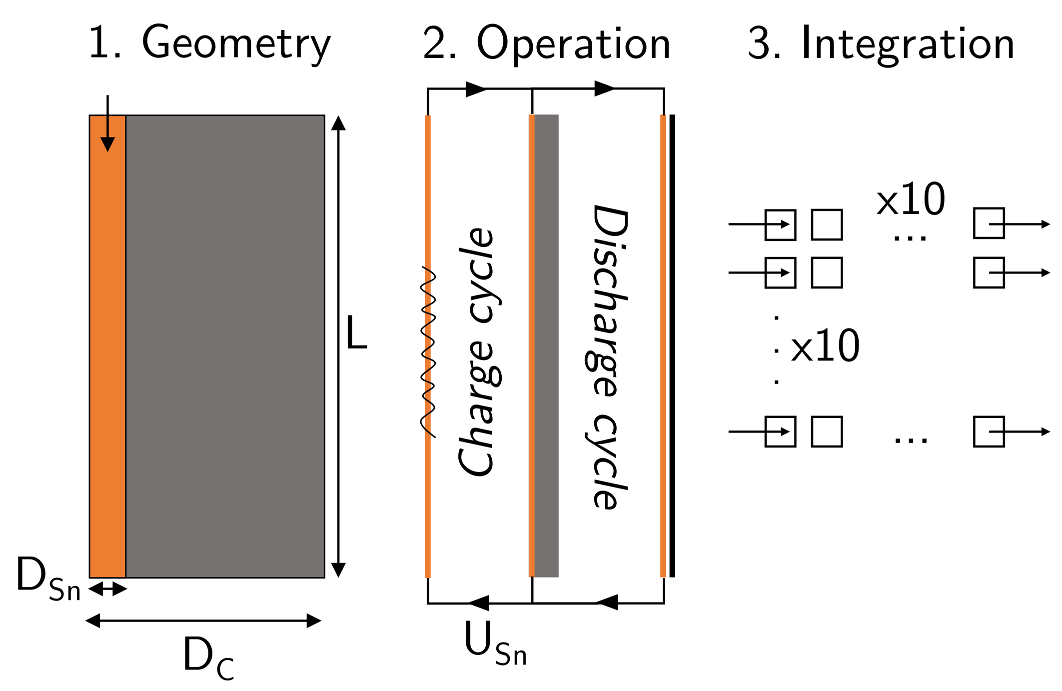
How to back-calculate k from coated sample?

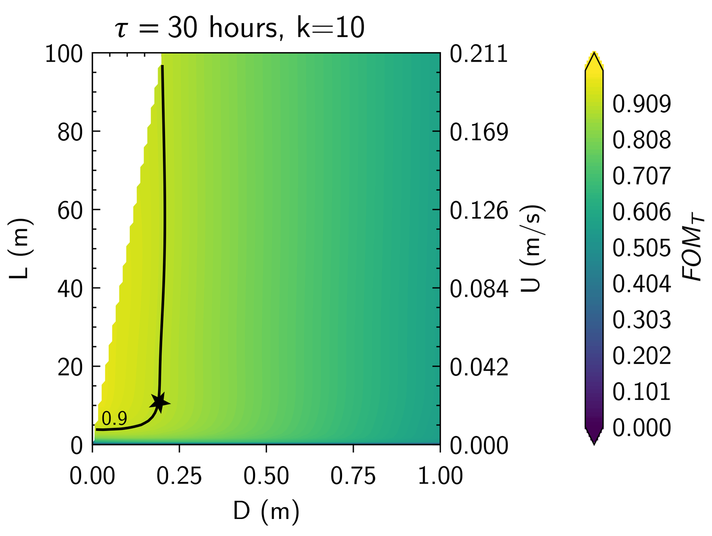


Analysis shows k is ~10 W/mK at 1000°C, but radiation effects can increase k to ~30 W/mK at 2000°C

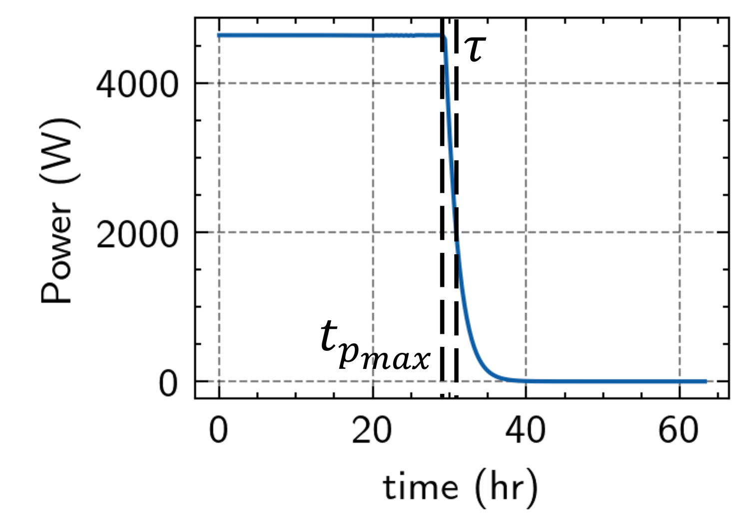
How can we design a high-performing TEGS system given low thermal conductivity?



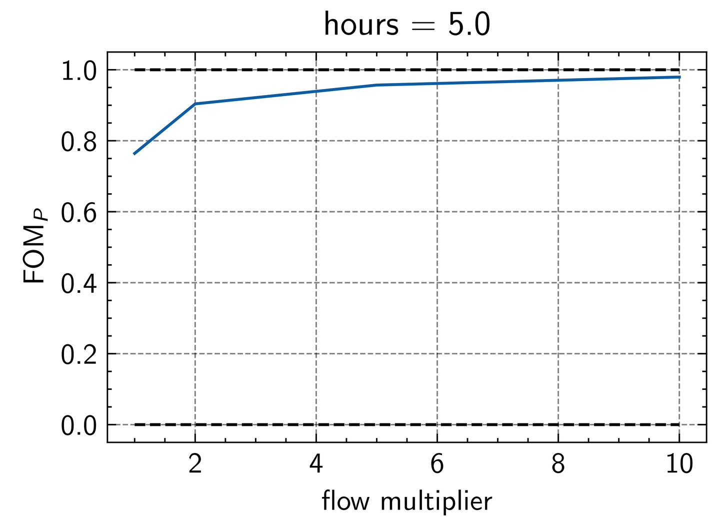




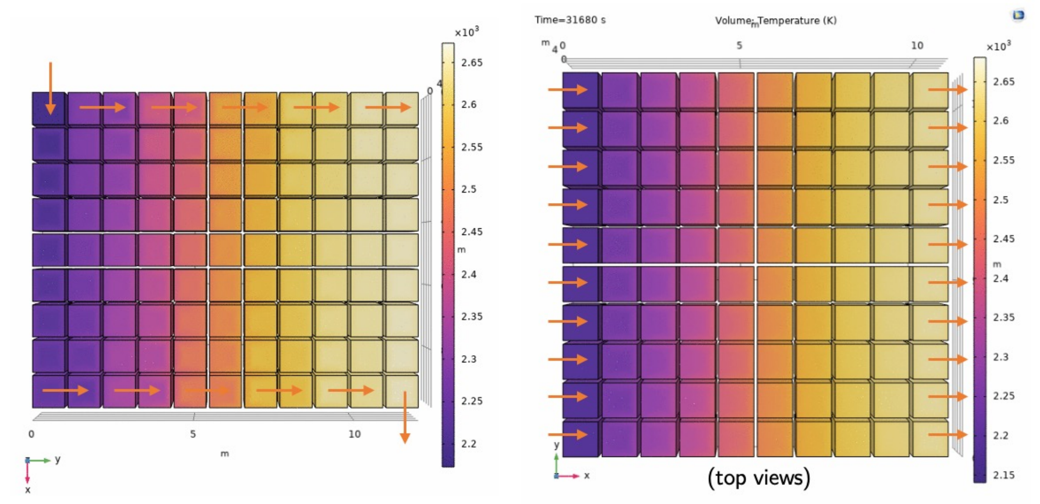
Tin flow length of >10m required



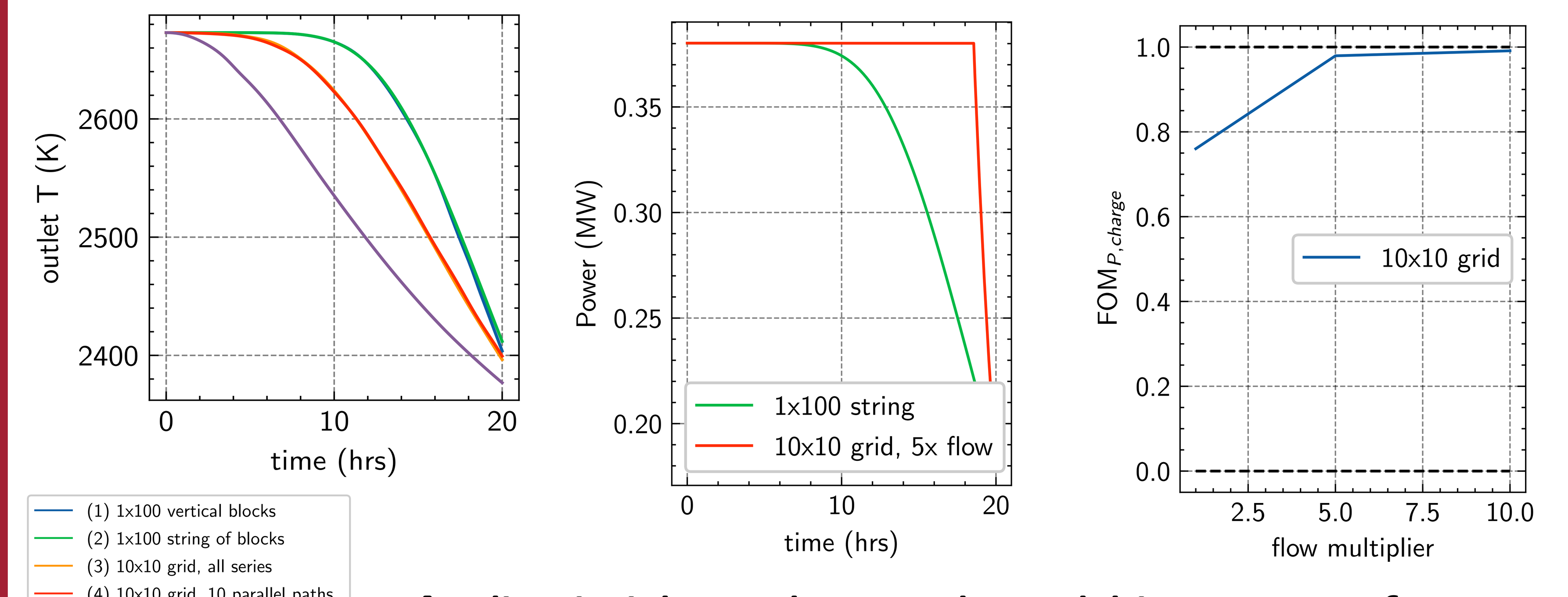
Ramping flowrate as temperature decreases preserves discharge power



Increasing flowrate above nominal helps accelerate charging



Porous media approximation enables large-scale model with radiation



Appling insights to large-scale model improves performance

We have improved the performance of cheap thermal energy grid storage with careful design

- Cheap storage is important to improve reliability of renewable energy
- Low energy capacity cost of monolith TEGS enabled by low-quality graphite
- This storage media can have low thermal conductivity, ~10 W/mK
- We have designed TEGS around this material to achieve high metrics for:
  - Fast charging, enabled by creating an axially-constant tin temperature
  - Constant discharge power, enabled by ramping flowrate as temperature decreases
- Implementation in a full-scale model demonstrates the performance improvements.