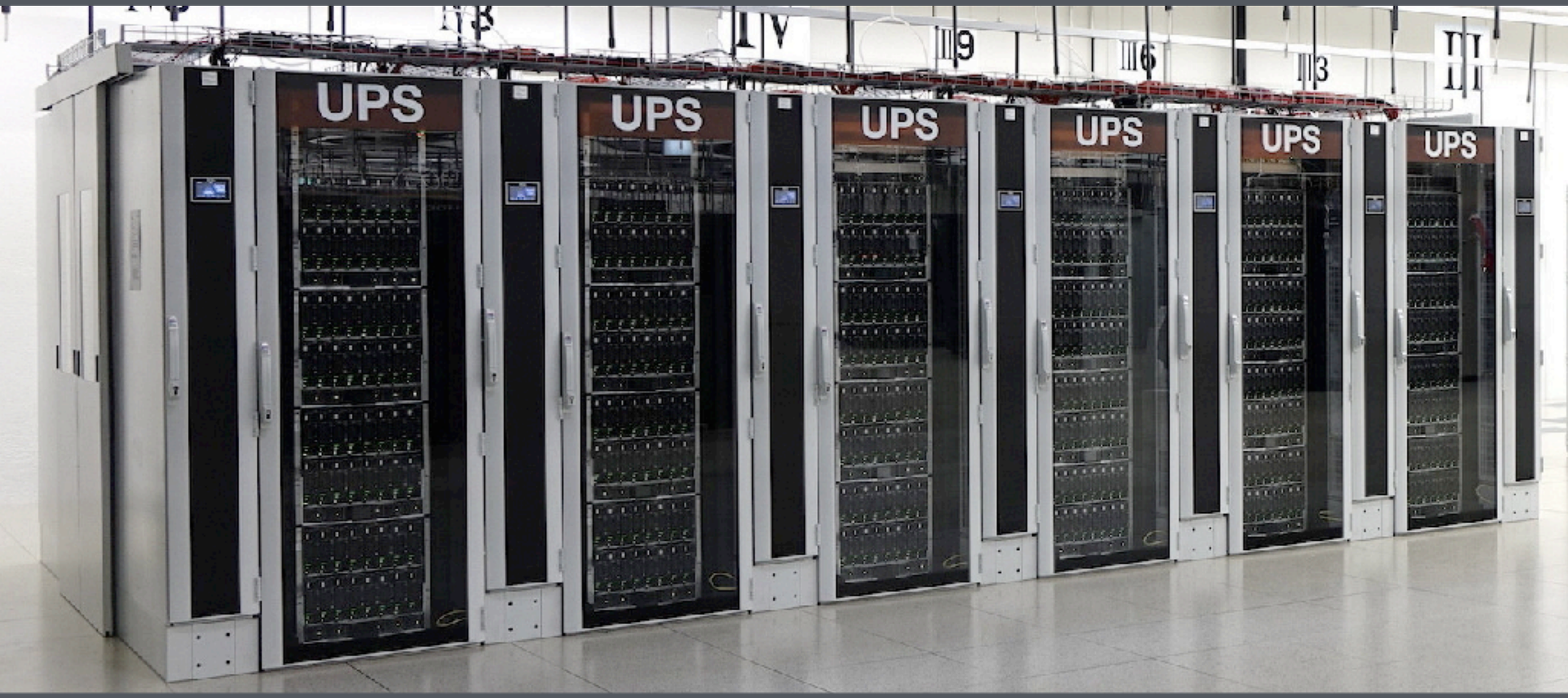
High-performance computing (HPC) for the modelling of energy systems



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1. What is high-performance computing (HPC)?

Nothing magic - lots of computers strung together.
The secret sauce is the software and parallelising our problems.

2. Why HPC for energy modelling?

It is easy to build an energy system model that takes
a long time to solve.

3. How to apply HPC to energy modelling problems?

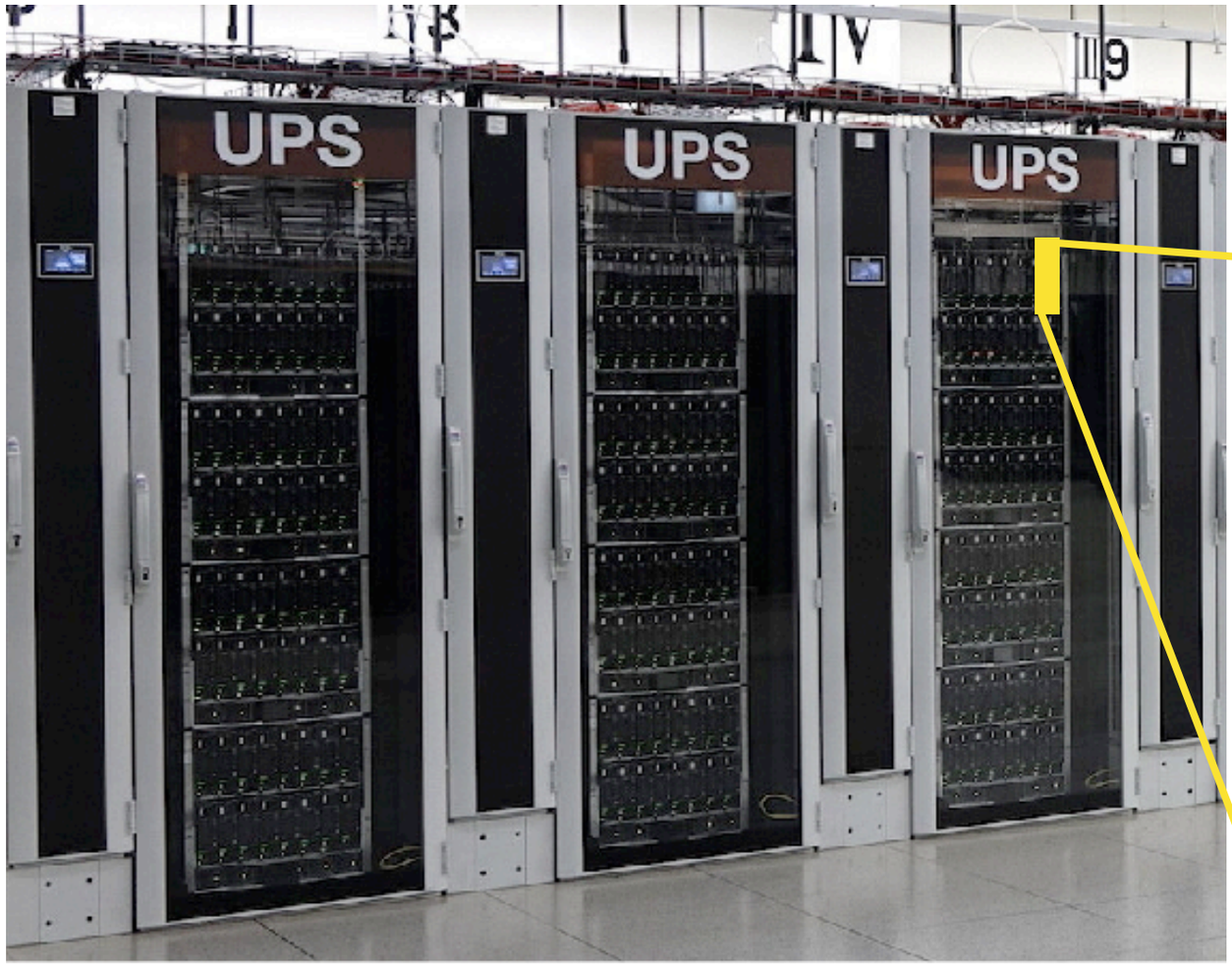
The quickest route to HPC is to take one model and run it many times over with different constraints.

An individual computer's speeds are limited

The solution is to parallelise!

https://jamesaltucher.com/2016/09/tollbooth-collector-happiness-creator/

Lots of computers strung together

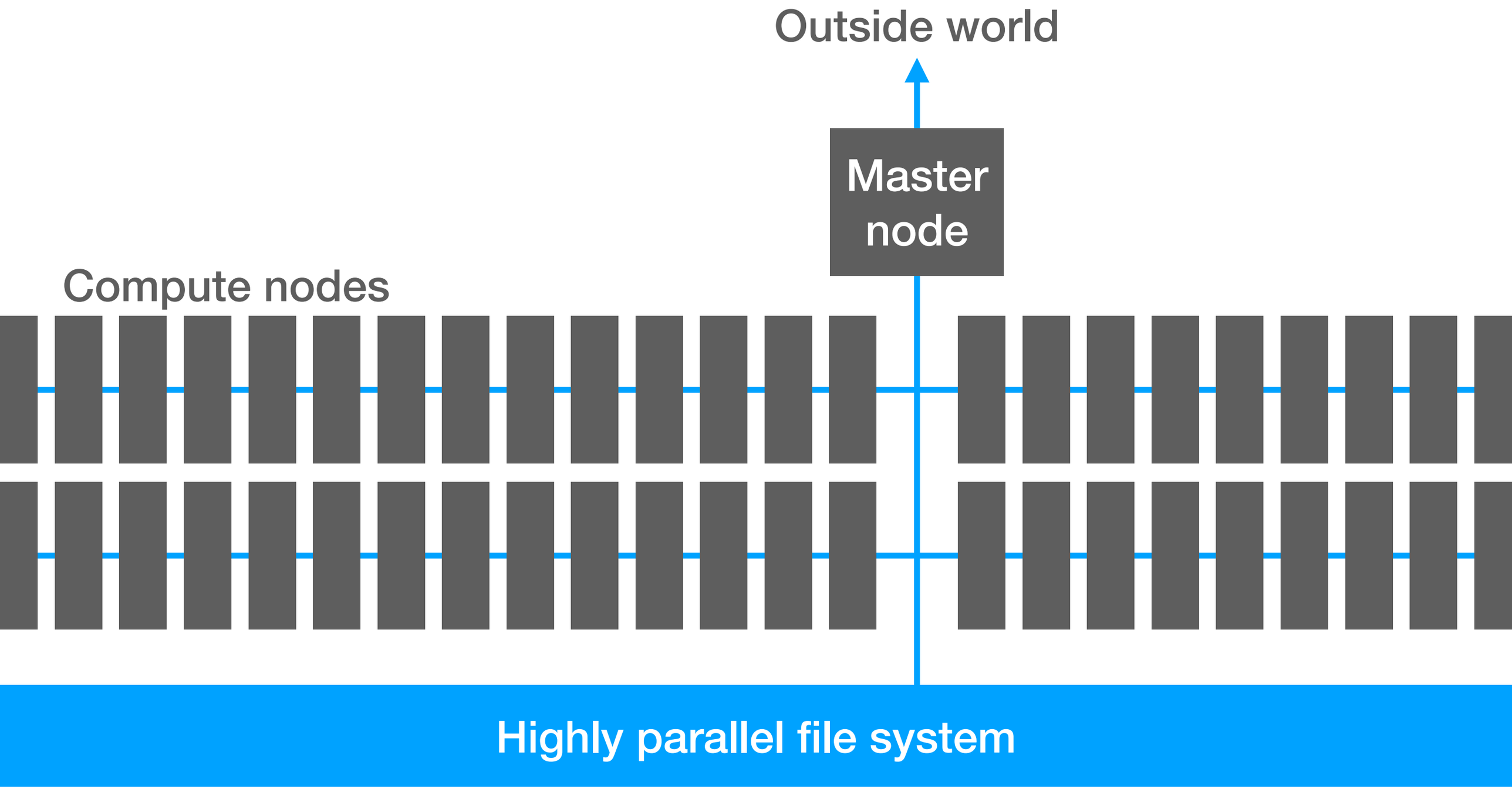


A HPC "cluster" at a university

An individual computer used in HPC

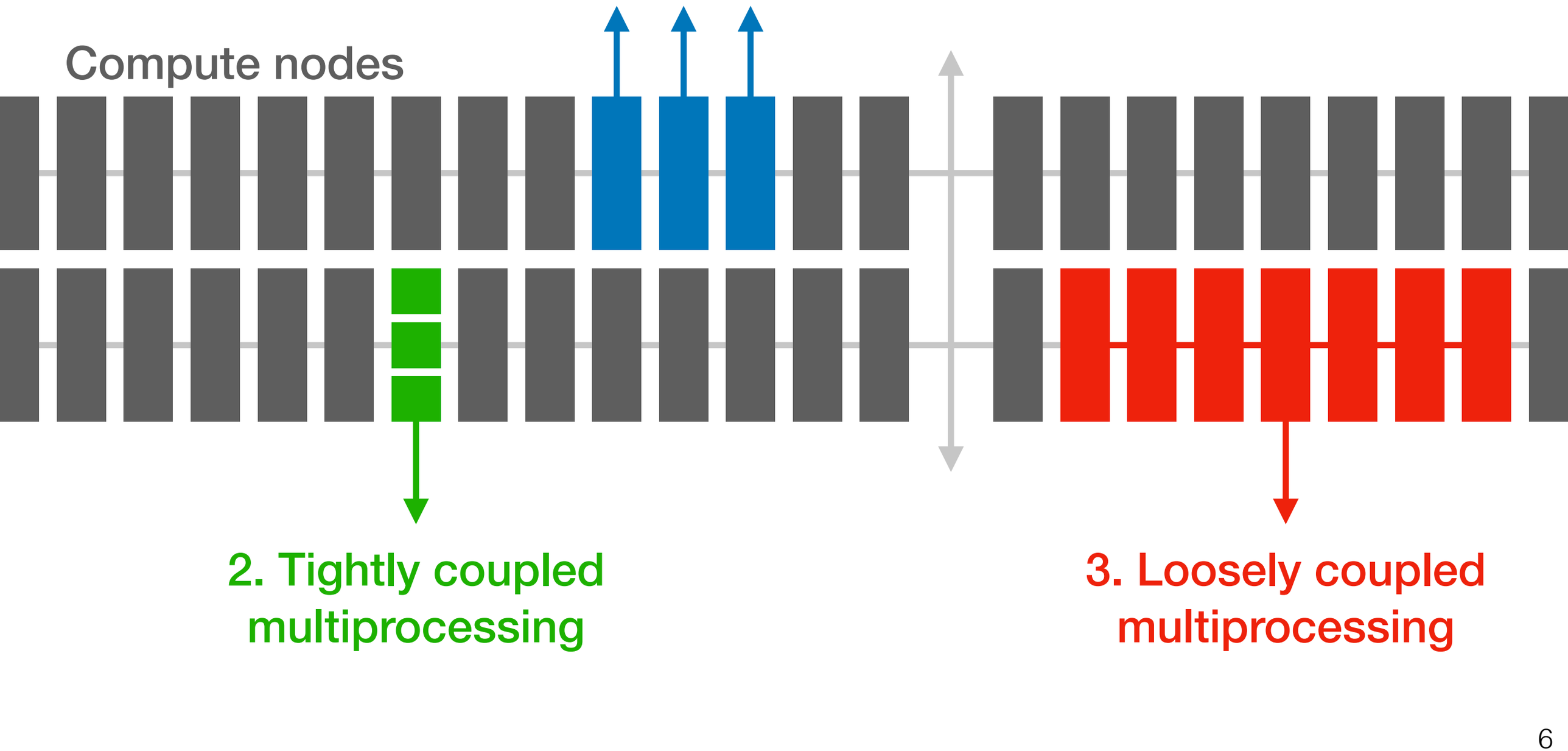
https://scicomp.ethz.ch/w/images/7/76/ETH_Zurich_Euler_II_and_I_in_LCA.jpg
http://www.advancedclustering.com/wp-content/uploads/2017/07/ACTblade-angle-top.png

Lots of computers strung together



The secret sauce is the software and parallelising

1. Simple parallelisation (same program on multiple nodes with different data)



2. Tightly coupled multiprocessing

3. Loosely coupled multiprocessing

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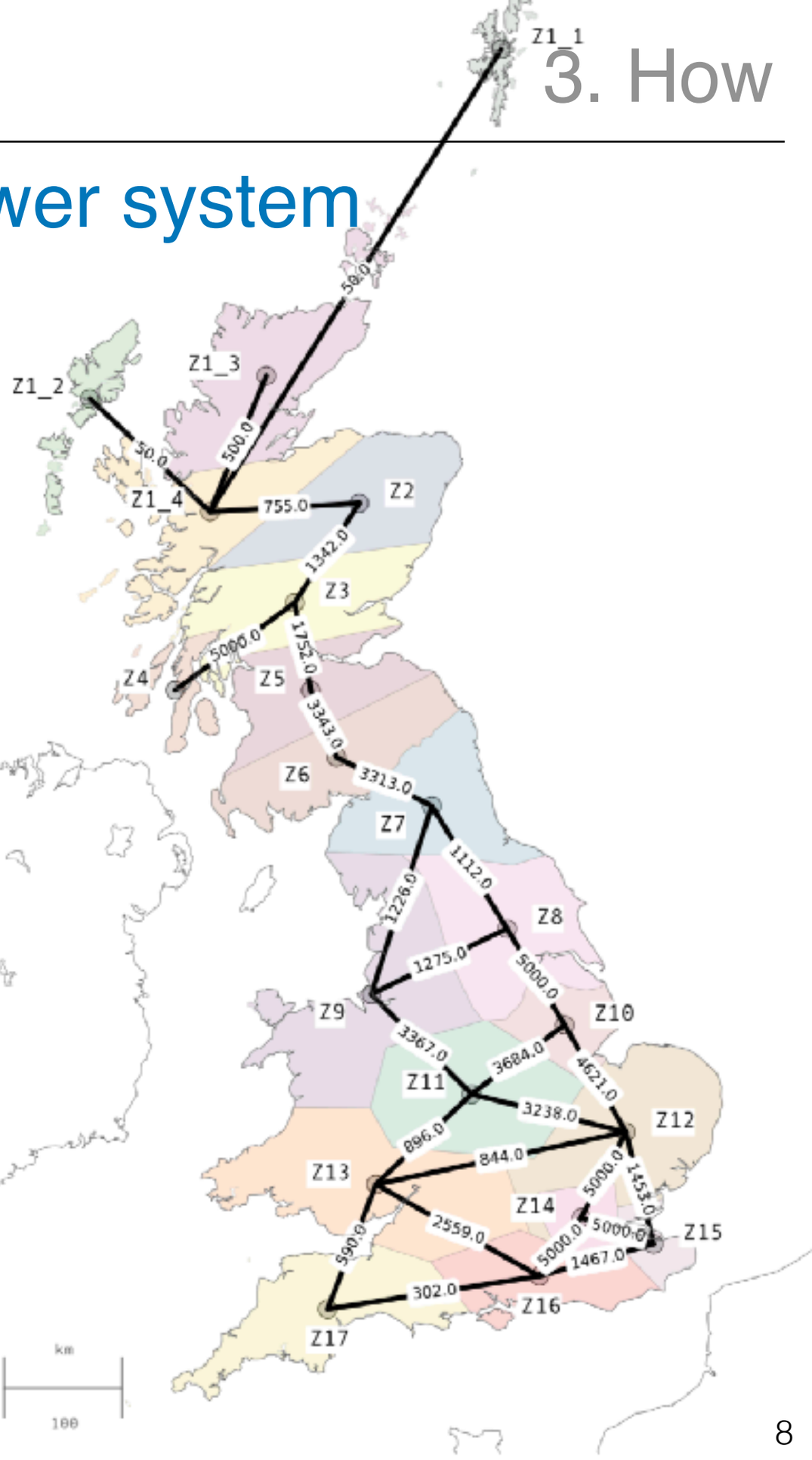
Let's build a model of the UK power system

- Divide into 20 electricity grid zones
- Simulate hourly power generation and demand
  = 8760 time steps
- 20 technologies like nuclear power plants, offshore wind, ...
- Goal: supply electricity demand at least cost (=optimisation problem)



Let's build a model of the UK power system

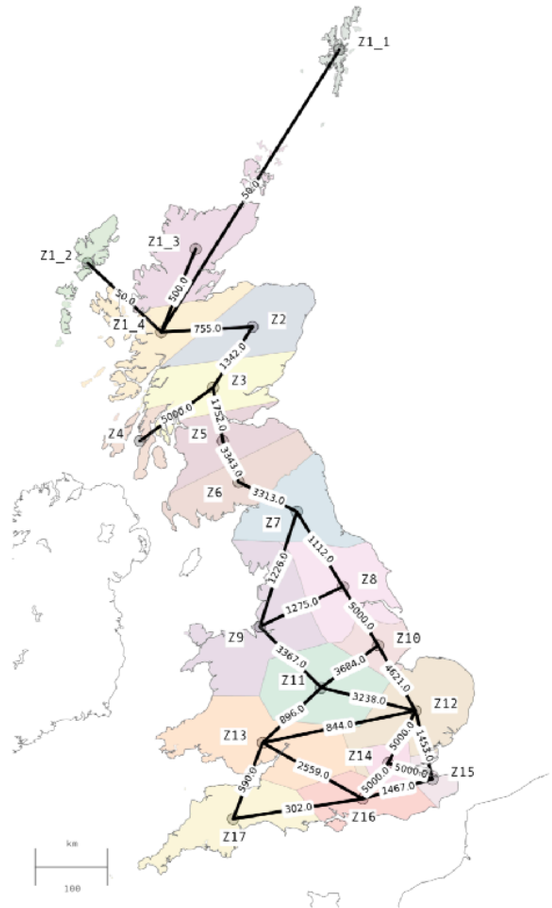
20 zones

* 20 technologies

* 8760 timesteps

* 5 types of constraints =

17.5 million constraints

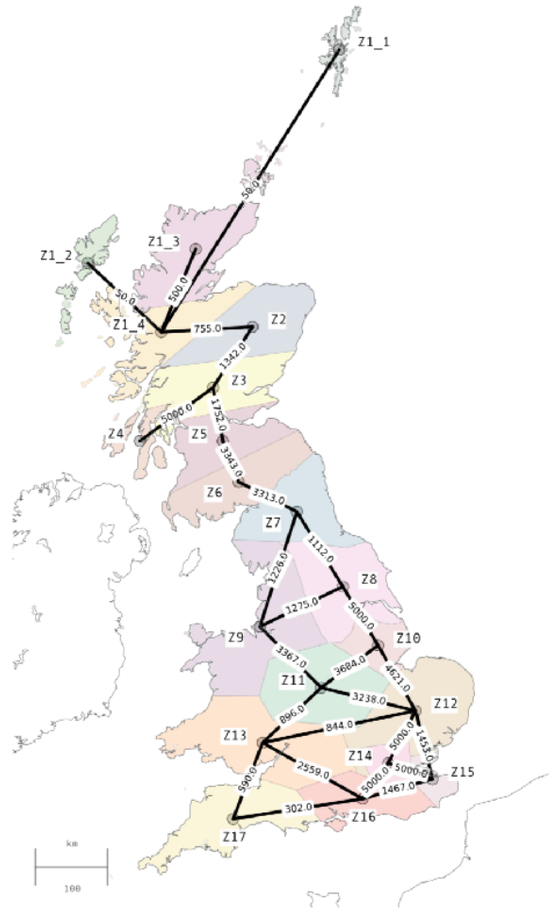


Let's build a model of the UK power system

17.5 million constraints

Assume each constraint
= 1 nanosecond

→ 5 hours!



It is easy to build an energy system model that takes a long time to solve!

1. What is high-performance computing (HPC)?

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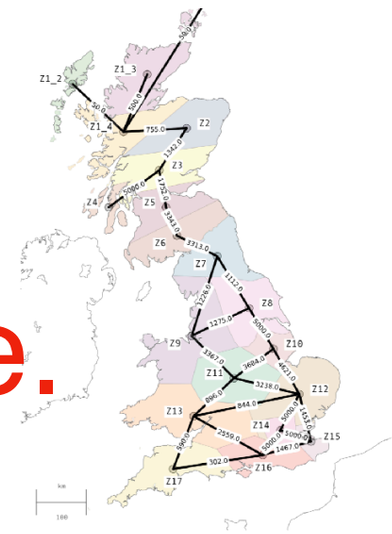
We realised:

It is easy to build an energy system model that takes a long time to solve.

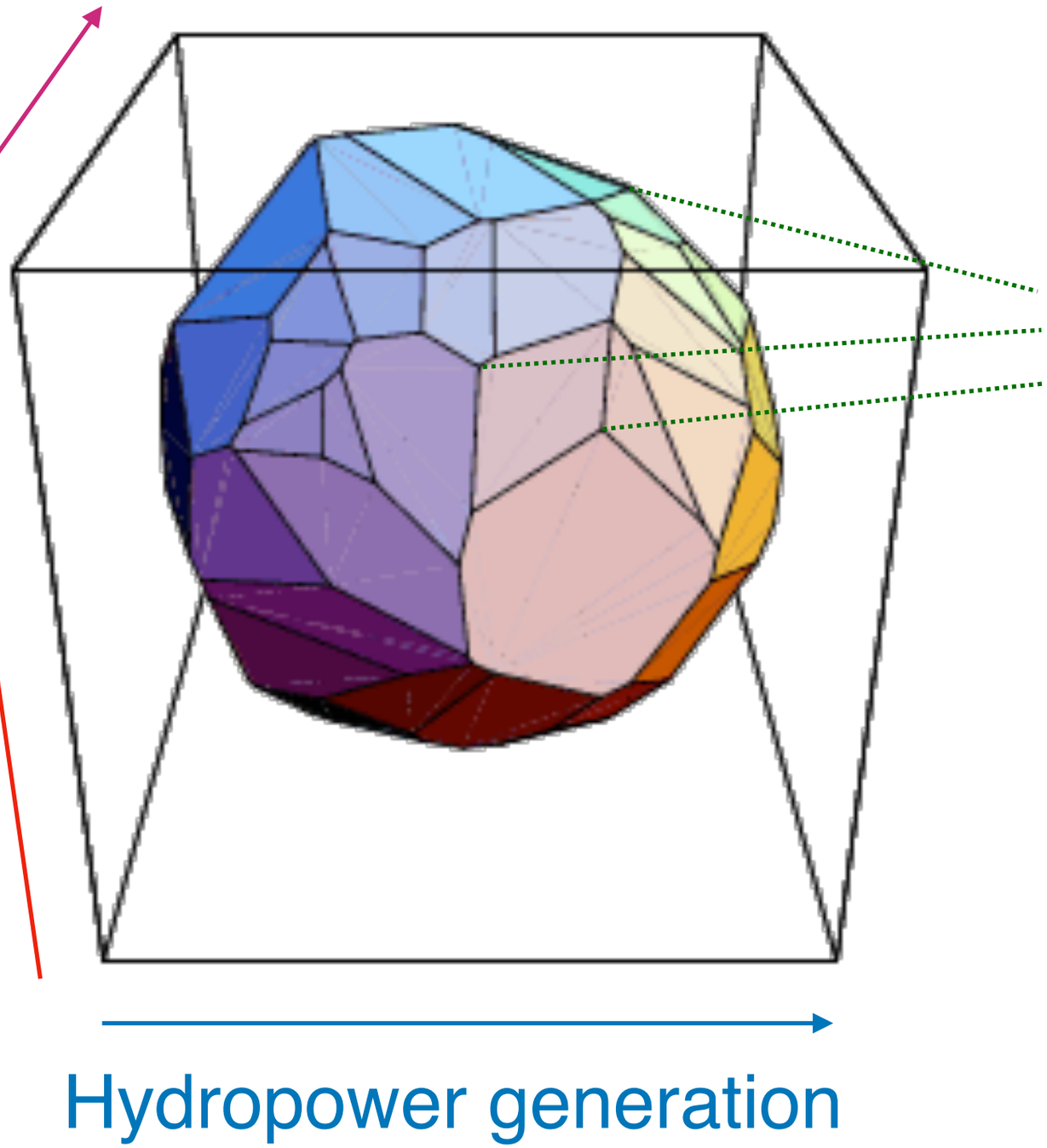


Sounds like a job for high performance computing!

But we have a problem:

Parallelising optimisation problems is not straightforward.

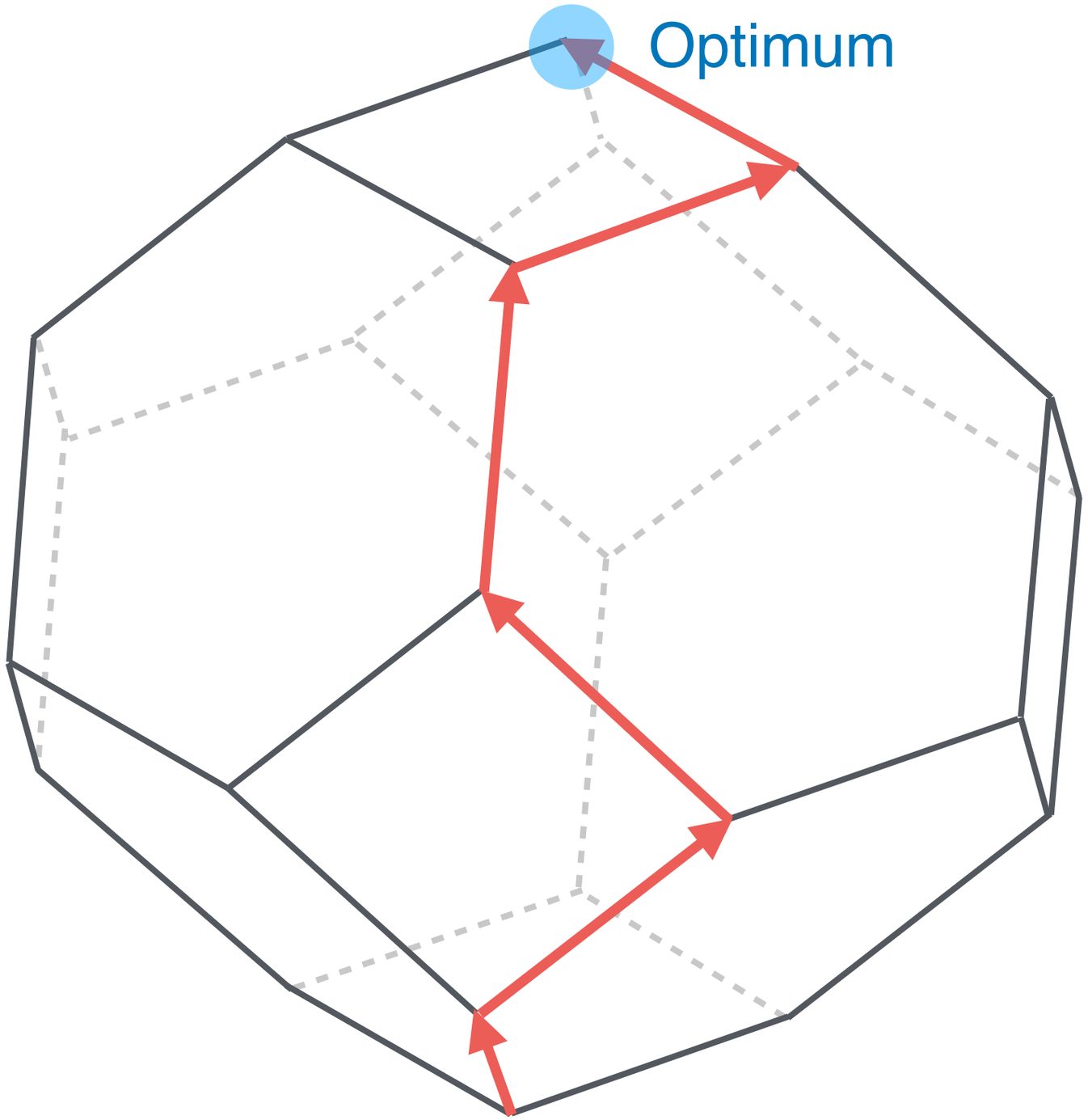
Optimisation problems as "jewels"



We know that optimum is one of the corners, but not which one.

http://mathworld.wolfram.com/ConvexPolyhedron.html

Solving linear problems by climbing towards optimality

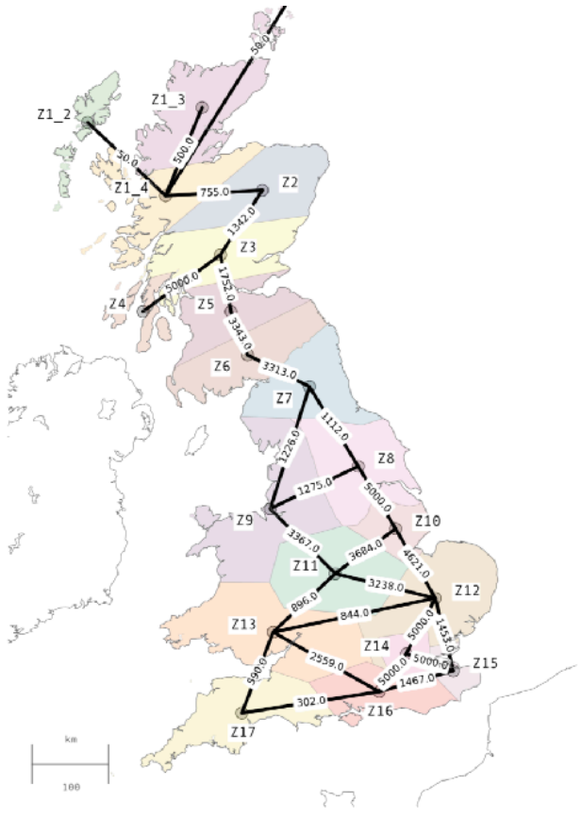


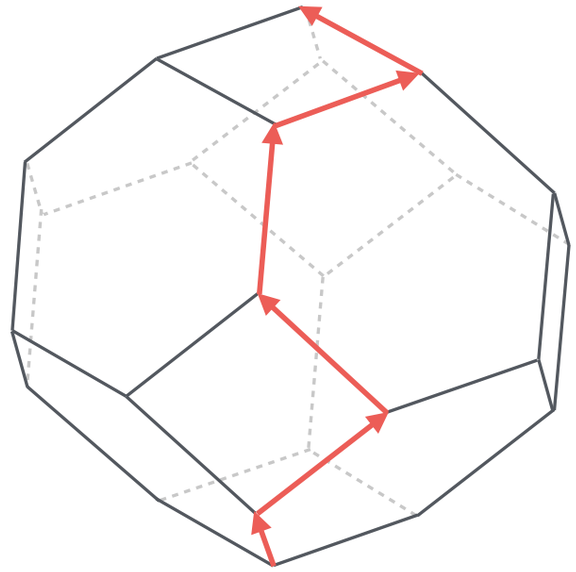
Don't know where the goal is while climbing

→ cannot do this in parallel.

Adapted from: Moore and Mertens, The Nature of Computation, Fig. 9.16

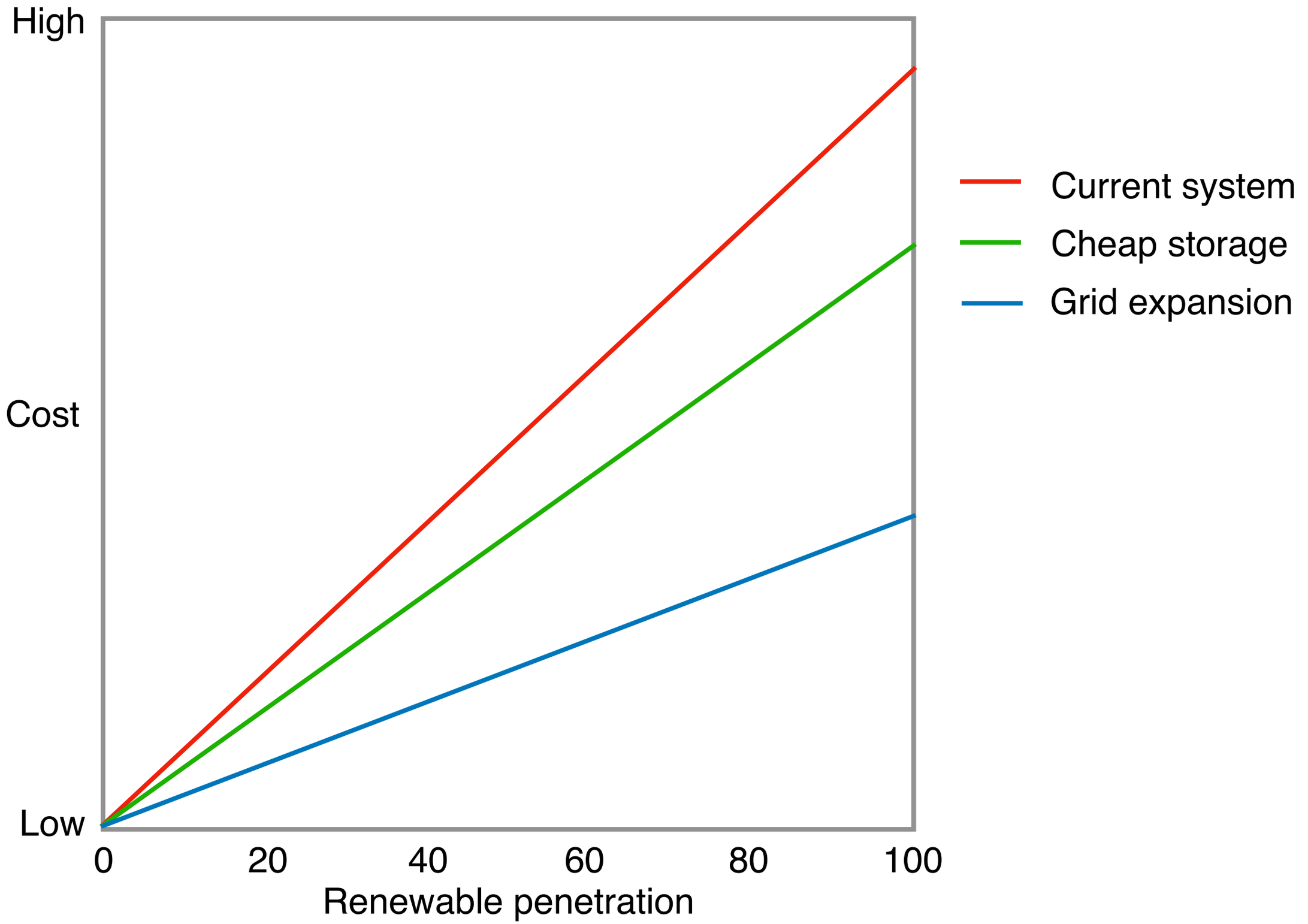
So we cannot easily parallelise this model



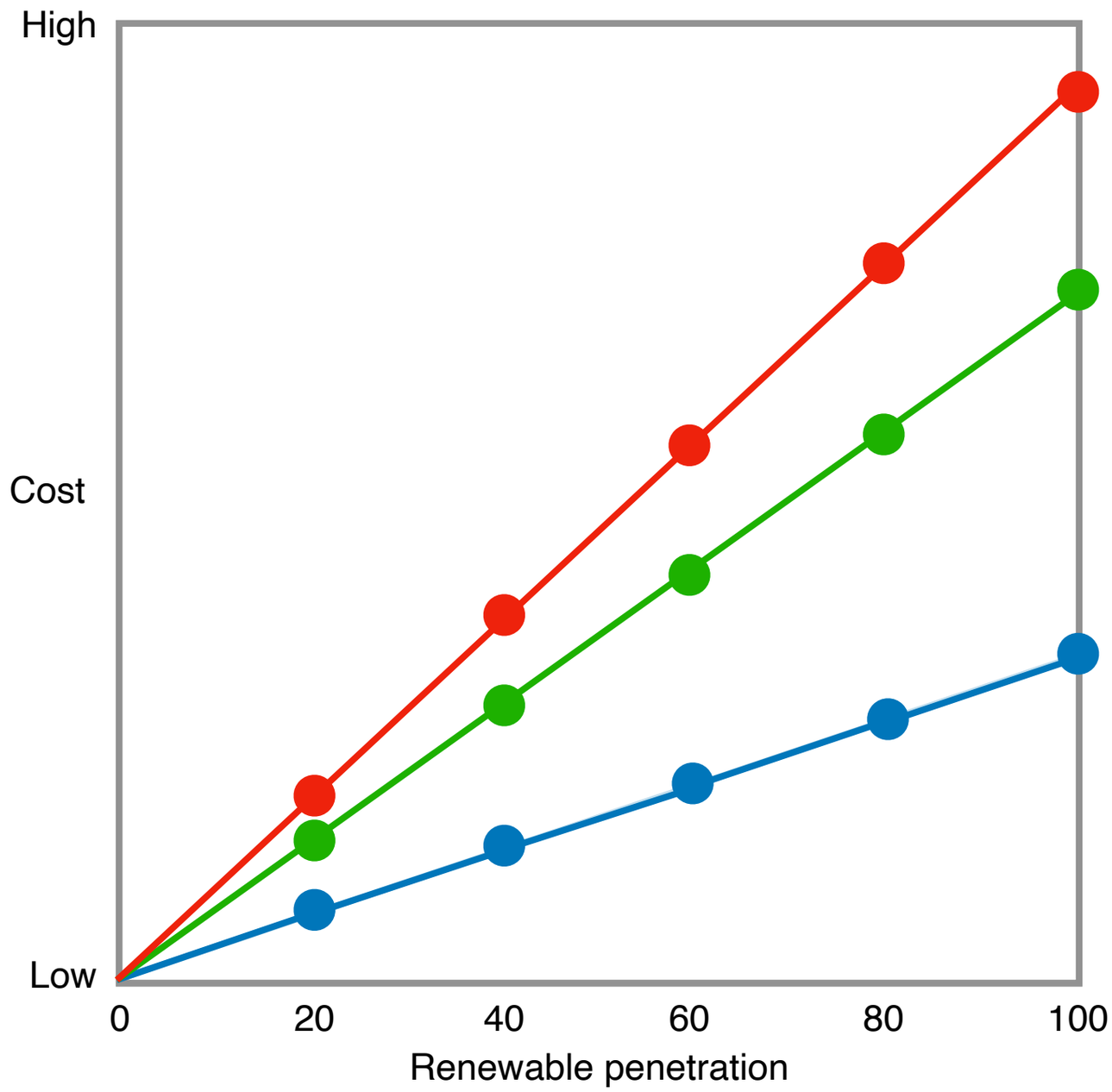


How can we still exploit the power of HPC, without coming up with new algorithms?

An example problem: modelling renewable integration



Running scenarios in parallel



Each point can be solved separately, in parallel.

→ Sensitivity analysis

(not exactly rocket science)

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4. Questions

Or ask by email: stefan.pfenninger@usys.ethz.ch