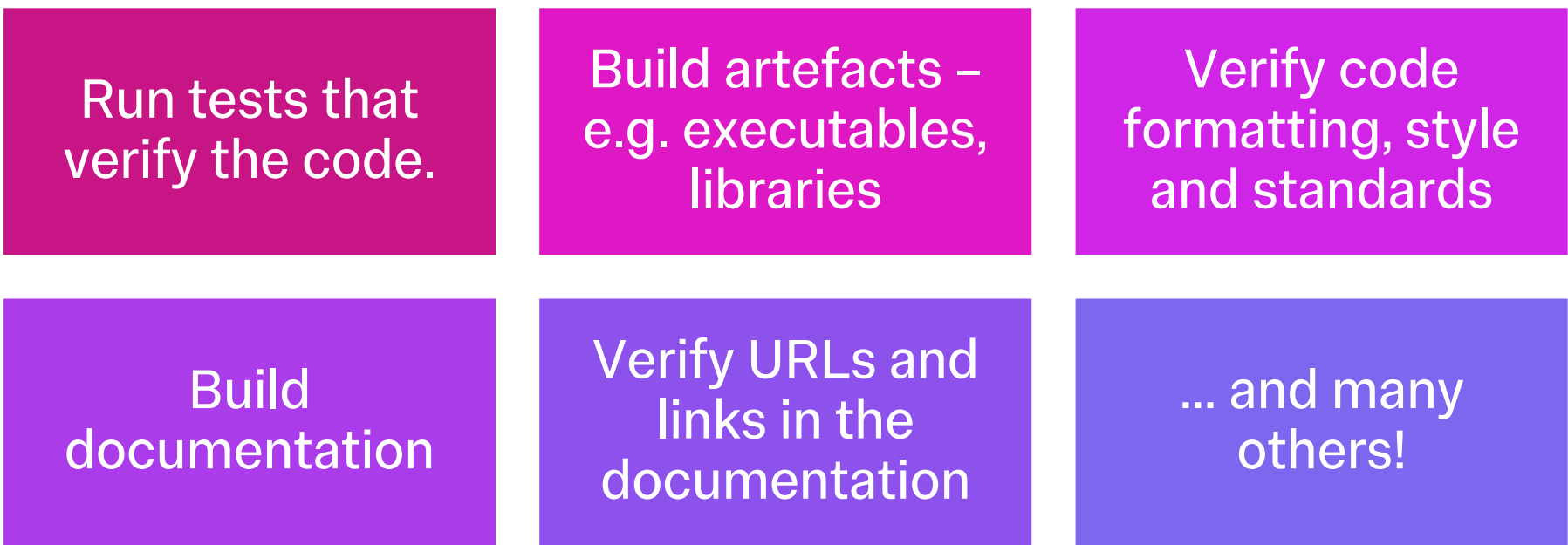


## Environmentally-aware use of GitHub Actions

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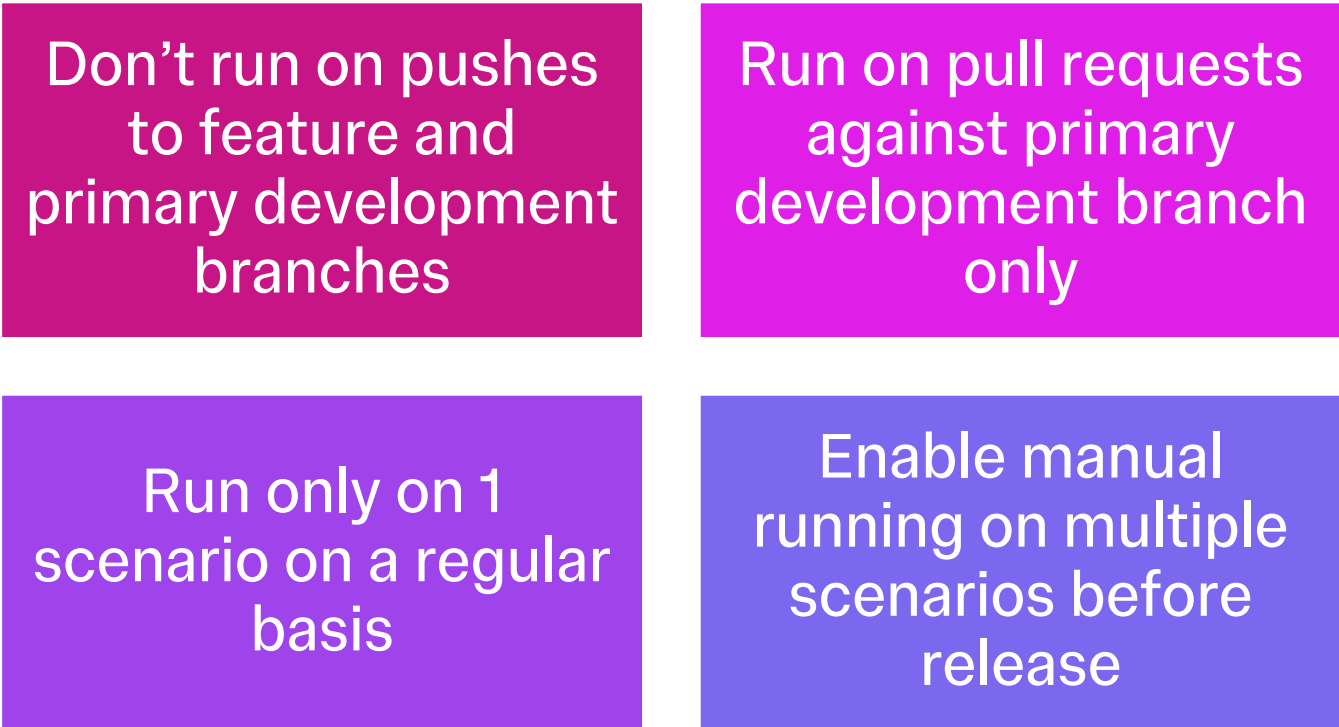
### Continuous integration with GitHub Actions

**Continuous integration (CI)** is the practice of integrating source code changes frequently and ensuring that the integrated codebase is in a workable state.



### Minimize budget and environmental impact

Reduce the number of jobs run in each workflow to only those that are really needed. More advanced steps could include caching and grouping tests by run length.



### Test scenarios

Exemplar workflows running the *Game of Life* under different scenarios in GitHub Actions. Showing the change in whole **workflow time**, effective **costed time** and estimated **energy** used by the workflow.

| Event    | Linux |      |      | macOS |      |      | Windows |      |      | Total Jobs |
|----------|-------|------|------|-------|------|------|---------|------|------|------------|
|          | 3.10  | 3.11 | 3.12 | 3.10  | 3.11 | 3.12 | 3.10    | 3.11 | 3.12 |            |
| Push, PR | ✓     | ✓    | ✓    | ✓     | ✓    | ✓    | ✓       | ✓    | ✓    | 18         |
| PR       | ✓     | ✓    | ✓    | ✓     | ✓    | ✓    | ✓       | ✓    | ✓    | 9          |
| PR       | ✓     | ✓    | ✓    |       |      |      | ✓       | ✓    | ✓    | 6          |
| PR       | ✓     |      | ✓    |       |      |      | ✓       |      | ✓    | 4          |
| PR       | ✓     |      |      |       |      |      |         |      |      | 1          |

Max. Workflow Time = 9.2 min  
Max. Costed Time = 429 min  
Max. Energy = 26920 joules \*

\* Bringing a cup of water to boil to make tea takes about 3 times this energy

### Conclusions

- Continuous integration via GitHub Actions (or equivalent tools) can bring robustness and consistency to your code but it **can be overused without extra benefit**.
- Some small changes in the workflows can help to:
  - Reduce the execution time (a bit)**
  - Reduce the environmental impact (if we all work together)**
  - Reduce the financial cost (a lot)**
- The appropriate refinement is project dependent and **needs to be assessed and tweaked on a case-by-case basis**.

### Hidden costs of continuous integration

The workflows are run on servers, consuming energy in the process

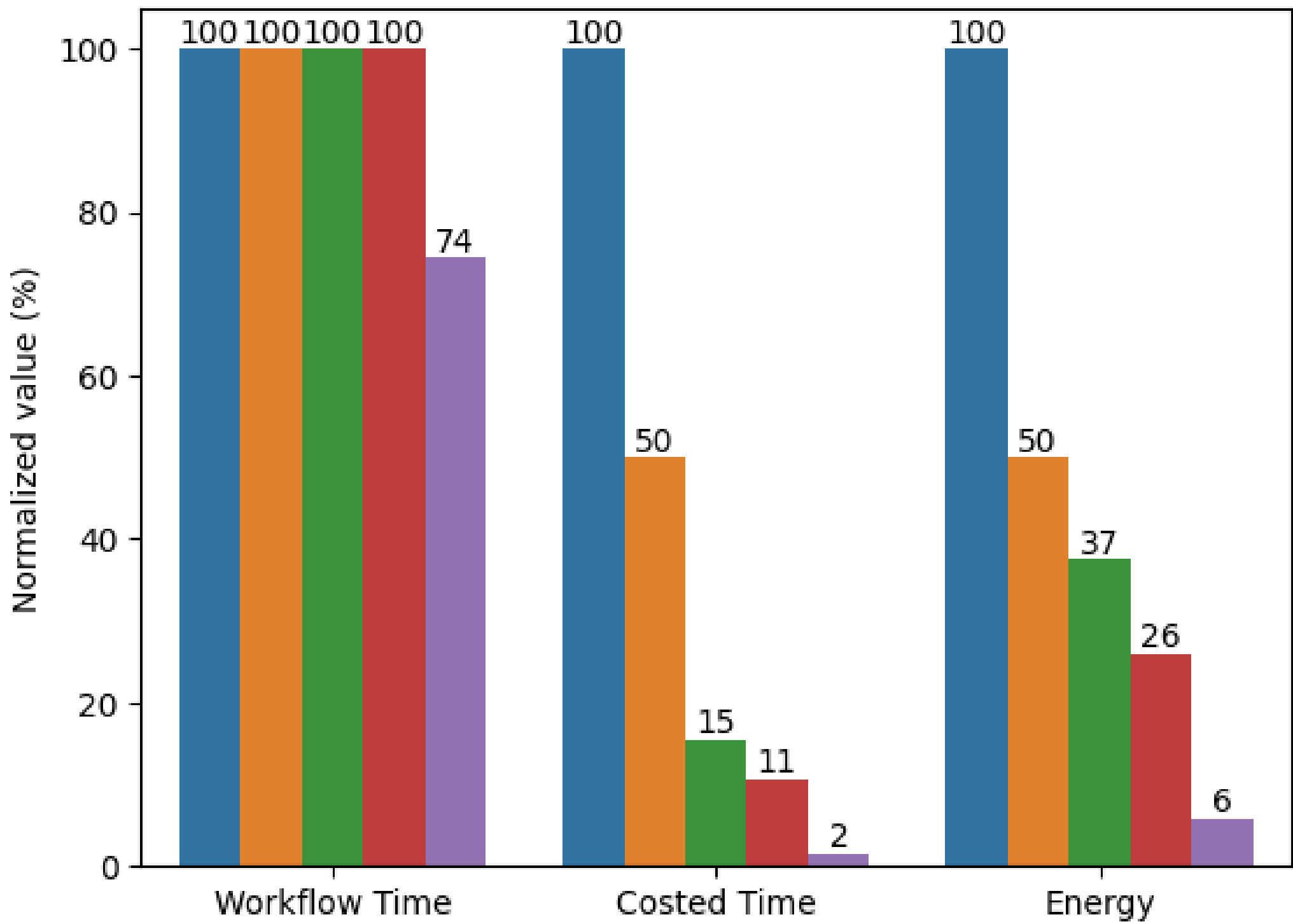
- GitHub runners are carbon neutral... but still they consume energy!
- Running complex workflows **is often unnecessary** and therefore the energy used is wasted and with no purpose.

Running complex workflows takes time

- You might need to wait a long while for them to complete before moving on with your work.
- If you don't wait, what's the point of running the workflows?

Running workflows cost money

- For public repos it does not matter, they are free.
- For private repos, Windows and macOS runners cost 2x and 10x that of Linux runners, respectively
- You only have 2000 min/month for free in your personal account, and Imperial has a **limited quota in the organisation GitHub account shared among all repositories**.



Best-case scenario. Only if all jobs run in parallel.

Time multipliers:

- Linux → x1
- Windows → x2
- macOS → x10

Estimated based on jobs time and energy used in Linux

### References

Exemplar *Game of Life* repository

Adopting a more rational use of Continuous Integration with GitHub Actions

