APPLICATION GUIDE FOR QUANTUM COMPUTING RESOURCES

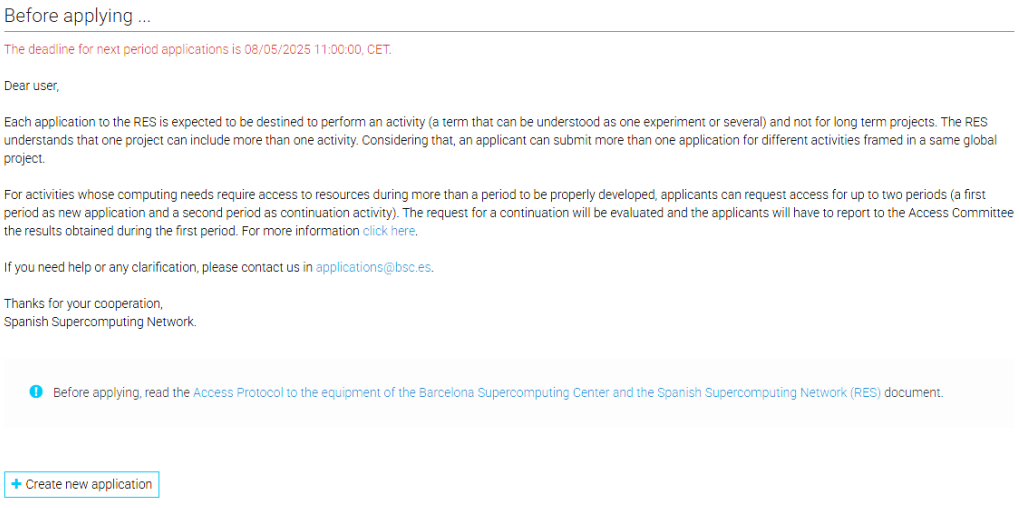
This Access Guide provides a guideline on how to apply to the **currently experimental quantum computing machines** within the RES. Users accessing Quantum Computing (QUANTUM) should expect **evolving capabilities, some unexpected issues and an opportunity to test and contribute** to RES' quantum computing capabilities.

Please note that the available quantum chips at the BSC cluster **may change over time during the RES access period.** Currently, this cluster hosts two chips: one with 5 qubits and another with 10 qubits. A new 20-qubit chip is expected to be installed around June/July. You can find **updated information about the cluster** and available resources at the following link: https://www.bsc.es/supportkc/docs/Quantum/intro

Step 0: Before applying...

The first thing you will see when starting an application is the following text clarifying **the intended use of RES resources**, Please read it carefully, as well as the RES Access Protocol, before continuing your application, and click "Create new application" to continue with the application process.

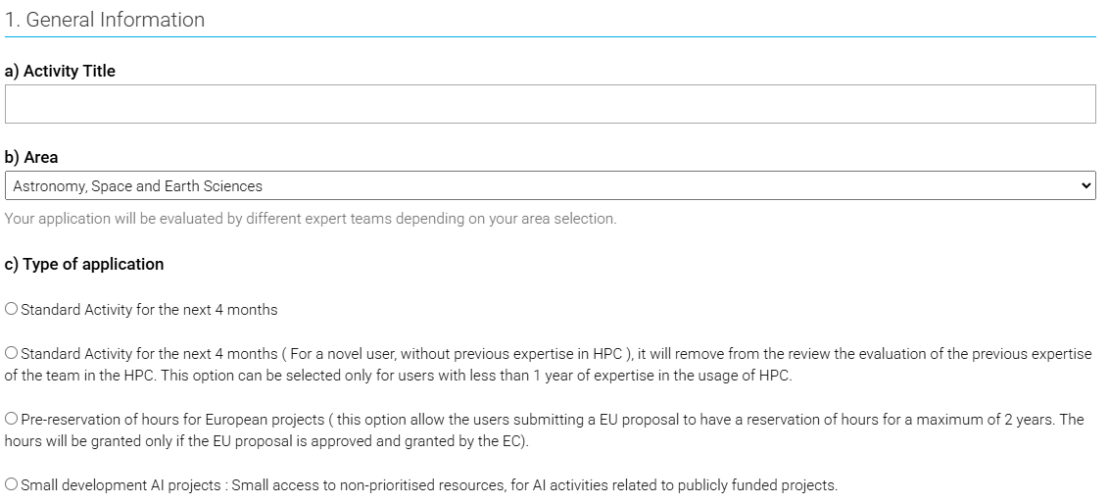
At the BSC, the quantum machine is **mainly intended for chip usage and low CPU demand.** Each quantum job is associated with a 40-CPU node, which can be used to run supporting code, but **the main computation must involve the quantum chip**. **Jobs that do not make use of the chip will not be accepted.** If your application involves hybrid workflows, make sure to request both Quantum and the appropriate classical systems (e.g., MN5-ACC, MN5-GPP). Requesting QUANTUM resources **does NOT exclude you from requesting other machines.**



Step 1: General information

Firstly, you will have to name your activity with **a descriptive, scientifically meaningful name** that encapsulates the core of the research within your project.

Then, you must select **the scientific area that best fits your activity.** If any category fits your project, that means we do not receive enough applications in that category to create a specific panel. In this case, or if you're unsure where to categorize your project, contact us via applications@bsc.es and we will advise you about how to proceed.



1. General Information

a) Activity Title

b) Area

Astronomy, Space and Earth Sciences

Your application will be evaluated by different expert teams depending on your area selection.

c) Type of application

○ Standard Activity for the next 4 months

○ Standard Activity for the next 4 months (For a novel user, without previous expertise in HPC), it will remove from the review the evaluation of the previous expertise of the team in the HPC. This option can be selected only for users with less than 1 year of expertise in the usage of HPC.

○ Pre-reservation of hours for European projects (this option allow the users submitting a EU proposal to have a reservation of hours for a maximum of 2 years. The hours will be granted only if the EU proposal is approved and granted by the EC).

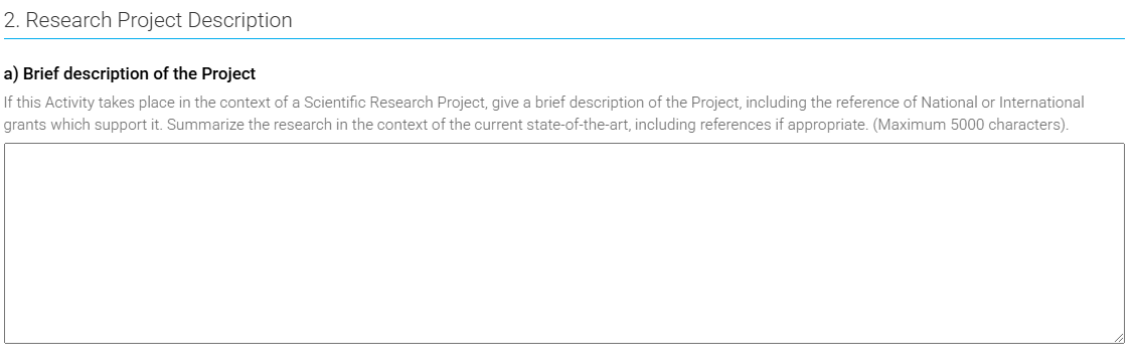
○ Small development AI projects : Small access to non-prioritised resources, for AI activities related to publicly funded projects.

Finally, you will be asked about **the type of activity you want to perform**. In the case of QUANTUM applications, choose between any of them except for the prereservation, which doesn't apply to quantum computing projects. The available options are:

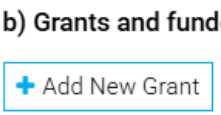
1. **Standard activity:** For accessing your selected systems in a 5-month period. Subject to the limitations established in the access protocol.
2. **Standard activity for the next 5 months (continuation):** To request after completing a standard activity that requires further experiments/simulations. These activities are prioritized for the previously assigned machine, and the application form is simplified.
3. **Small projects/test:** Conceptualized for users that want to test algorithms procedures in a specific machine

Step 2: Research Project description

In this step, you will have to provide some information about the research project and the specific computational activity you want to perform. This is a crucial part of the application, as **it will serve to assess both the scientific excellence of the proposal and part of its technical viability.**

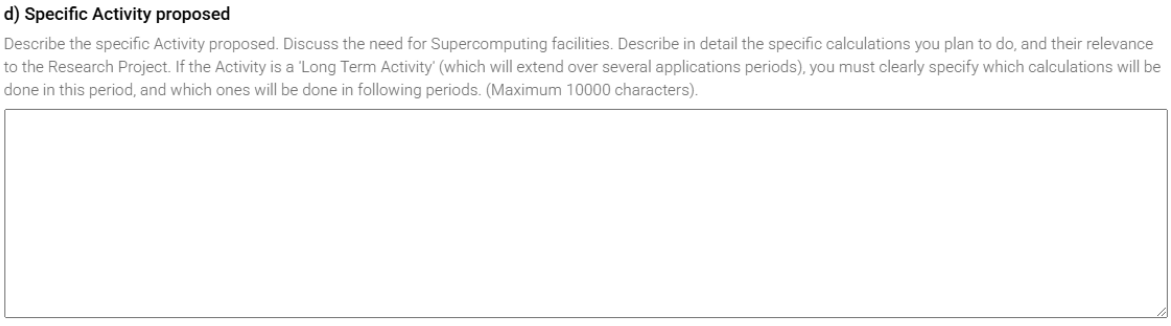


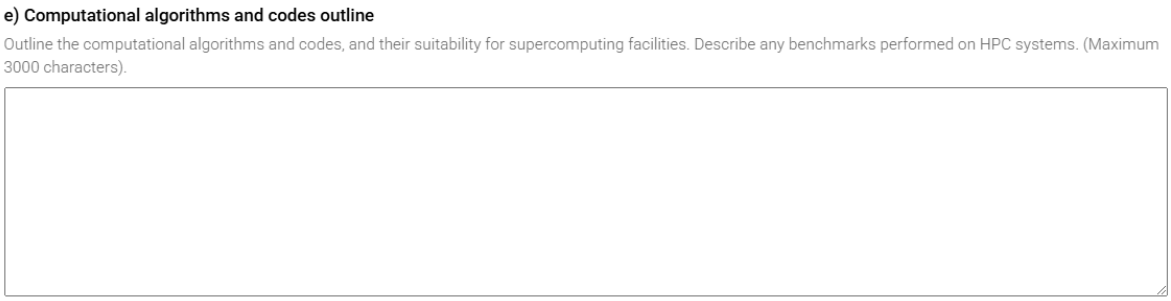
In section 2a you will have to describe **a general outline of your project**: what you aim to obtain and why this project should be granted. You can include references if appropriate.



Then, in section 2b, you will be asked to provide grant references that already back your project, **if applicable**. That will impact positively on your application, but it's **not mandatory** to already have a grant for your project.

After that, in section 2d you must explain **the calculations and simulations you will perform and why they require the use of RES resources**. For QUANTUM activities, you may specify the experiments, the models and/or the simulations you want to perform in detail, so it can be properly assessed by the Scientific and Technical Committees.





Lastly, in section 2e, you must provide **the specific algorithms and methodologies you will use** if granted access to RES resources. This includes **any hybrid quantum-classical approach**, error mitigation techniques or specialized software tools. Specifically, for projects targeting the BSC quantum chips, you must also include technical details such as:

- Number of qubits required
- Maximum circuit depth
- Number of shots
- Gate set used *
- Estimated duration of the longest job *

As a reference, **a typical job with a circuit depth of 1000 and 10,000 shots takes around 20 seconds to execute.** Providing these details is essential for assessing the feasibility and resource impact of your proposal.

More technical information about the available chips and the quantum cluster — including **benchmark results** and reference execution times for circuits with different depths and configurations — can be found at: https://www.bsc.es/supportkc/docs/Quantum/intro

Step 3: Software and libraries

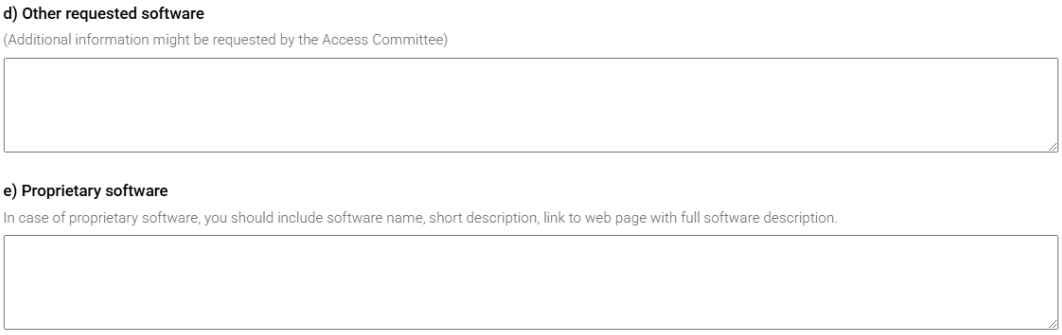
In this step, you will have to **detail every single piece of software** that you will need to use if given access to RES resources. For QUANTUM projects, you just need to detail software in section 3d), and **IGNORE** sections 3a), 3b) and 3c).

For instance, at the BSC, quantum computing workflows are based on Python, **using the Qibo and Qililab libraries**. If you already know that you will need additional or specific software for your quantum workflows, **please include it in this section 3d).** However, you may also request specific libraries later, depending on your project's evolving needs.

If you intend to use other libraries or frameworks, please note that you will need to convert your **quantum circuits to be compatible with Qibo, as it is the execution backend used for quantum jobs at BSC.** Additionally, Qililab supports pulse-level control, allowing users to define custom pulse sequences for advanced experiments.

More information about Qibo and Qililab can be found at:

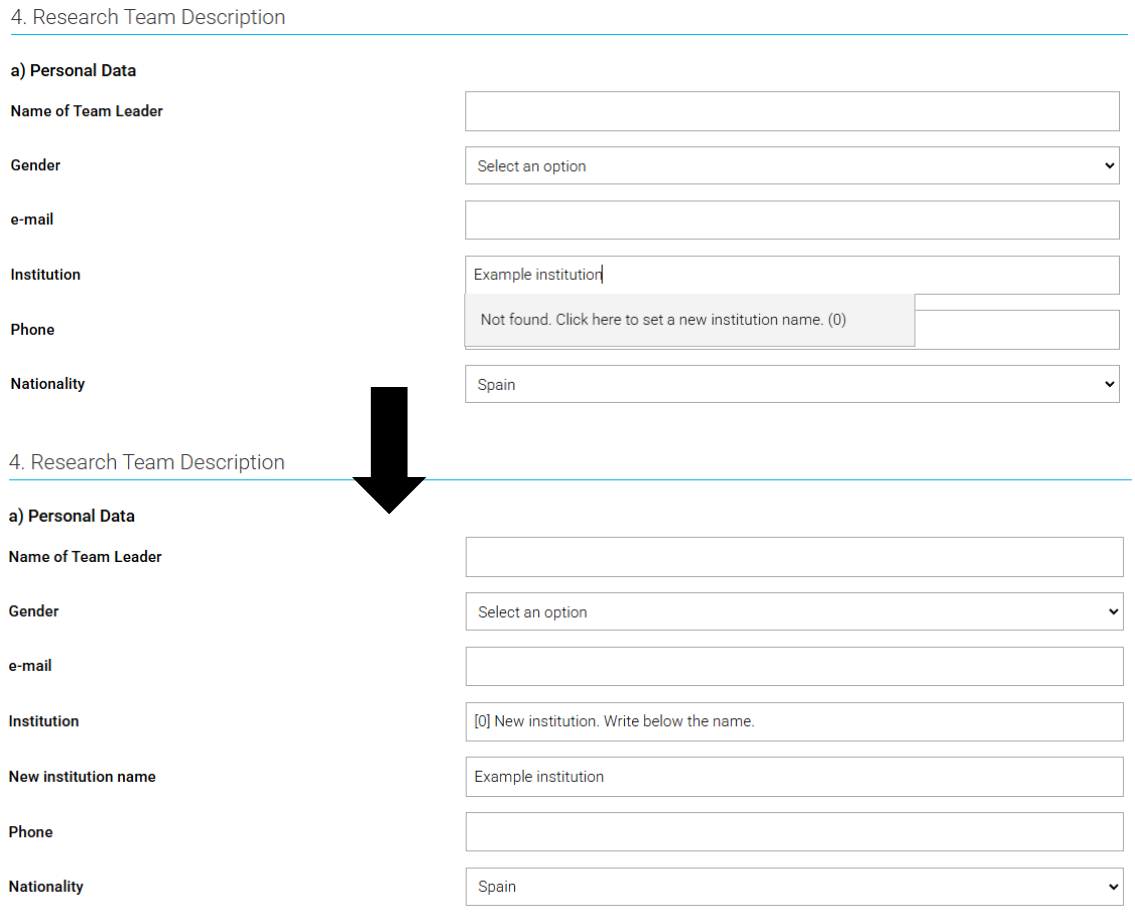
https://qibo.science/qibo/stable/
https://qaas.readthedocs.io/projects/qililab/en/latest/



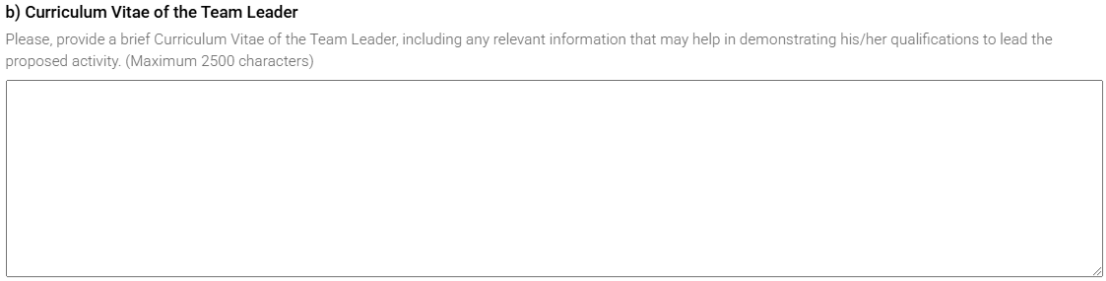
Step 4: Research team description

In this step, you will have to provide information about the research team that will be using the resources you are applying to. Note that in this step **you are not creating accounts to access the supercomputer**, but just listing all the people involved in the project. Access accounts will be created later, once you have been granted RES resources.

The Team leader is the person requesting the resources, even if they have a supervisor (i.e in a TFG/TFM). It could be the case that your institution is still not registered in our database. **You can add that institution manually**. Just click in the 'Not found' message to open a new field when you can manually enter your institution's name, as shown in the images below.



Following with the team leader information, you will have to provide a brief CV of the team leader or any other member of the team that is relevant to the application.



Apart from the team leader, you will have to list every other member involved in this activity. You can include any member taking part on the project, including supervisors or any other member. Please, write their names, instution and e-mail in the following format:

- *John Smith, Example Institution, john.smith@exampleinstitution.com*
- *Juan Pérez, Institución de Ejemplo, juan.perez@institucionejemplo.com*

c) Names of other researchers involved in this activity

Include only name, institution and e-mail.

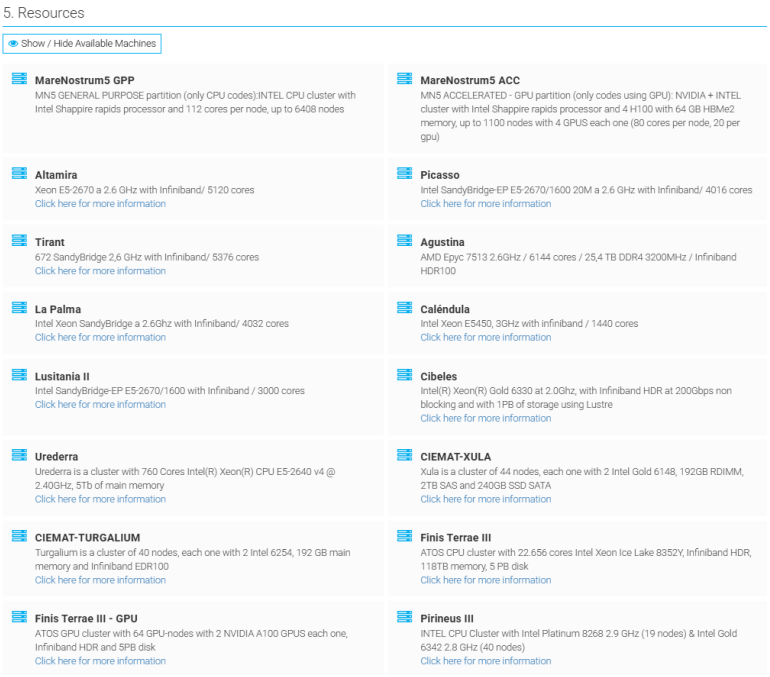
Finally, you will be asked to provide up to 5 relevant publications from **any member of the research team**, not necessarily the team leader. That's not mandatory, but will impact positively in your request in the case they can be provided.

d) Relevant publications

List the five most relevant publications, in the last five years, from the members of the research team that guarantee the scientific quality of the proposed Activity and demonstrate the qualifications of the team to complete it.

Step 5: Resources

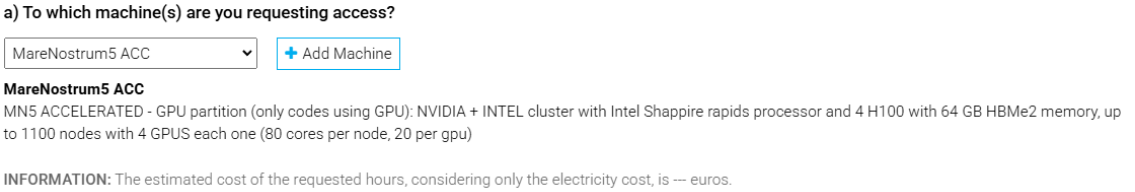
Following next, you will find **the core section for the technical review** of your activity. Firstly, you will be shown the list of **all RES eligible machines**, with **their key technical features** and a link to more detailed information about it. You can show/hide this list at your convenience.



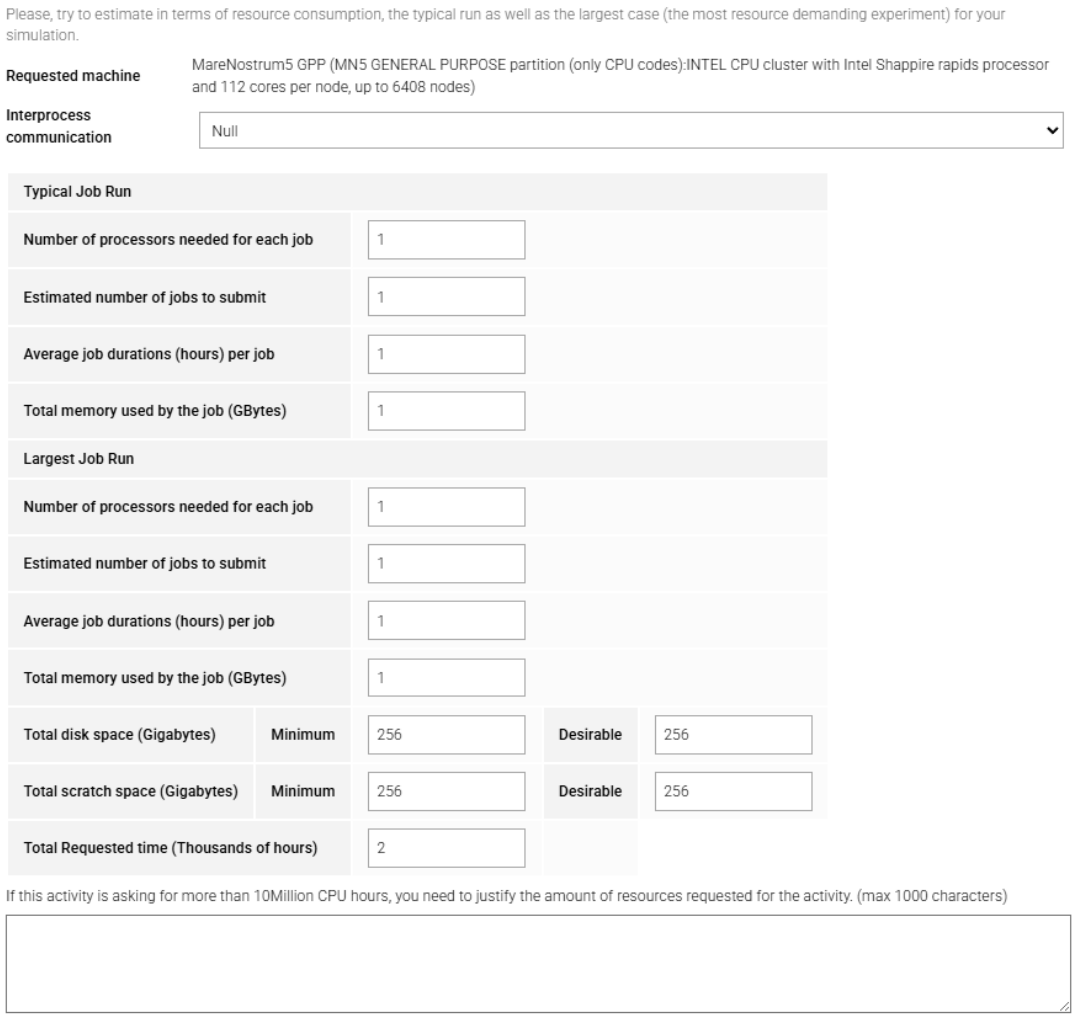
The information on the "More information" link is the most up-to-date available, but you can find fundamental information about **MareNostrum5 Ona** below:

Two superconducting, digital quantum chips: one with 20 qubits and another with 10 qubits. Each chip is connected to a compute node with **40 CPU cores (Intel Xeon Platinum 8352Y)** for classical pre- and post-processing.*
****Chip availability may vary.***

After checking the available machines, you will have to establish **which machine/s you want to request resources to.** Please remember that you can add more than one machine, if your activity requires them, with their own resources request each, **even if they use different resources** (QUANTUM, classical CPU, classical CPU+GPU).



Once you have selected your desired machine, click on the button “Add machine” to **open the “Resource Request menu”.** The menu was originally designed for HPC activities, so the terminology refers to HPC concepts.



For QUANTUM projects, almost every field of this menu **must** be set to 1, as shown in the upper image. The are only 3 required fields:

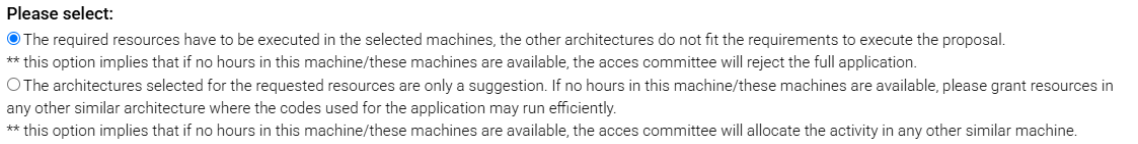
- **Total requested time**: **Estimate the time the system will be blocked from operating it yourself**, not only the “quantum time” required for running your project. This estimation will help to allocate QUANTUM projects more efficiently and perform recalibrations better and **MUST be written in hours**, not kilohours. If you estimate a use of 2 hours, just write “2” in the “Total Requested Time” field. **REFERENCE:** A typical job with a **circuit depth of 1000** and **10,000 shots** takes around **20 seconds** to execute. Running 1000 independent jobs of this type would take approximately **5 hours and 30 minutes in total**. However, most of this time is spent on connection overhead. If multiple circuits are executed without closing the connection between jobs, the total runtime can be significantly reduced. More details on optimized execution strategies will be available on the official website.

- **Total disk and scratch space**: You have to set **a minimum amount of 256GB** in both the “Minimum” and “Desirable” fields. If you expect to need more than this storage, please **estimate how much you’ll need and open the fields accordingly.**

When you have added the machines you need for completing the proposed activity, you must select one of the following options. This step is really important, as it can greatly affect to your assigned resources:

- If you select "Only selected machine" (first option), your request will only be able to be assigned to your selected machine. **This option is only suitable if your activity needs an specific architecture or computational requirements**. Have in mind that this can imply that **your application might be fully rejected if no computing time is left in that machine**.

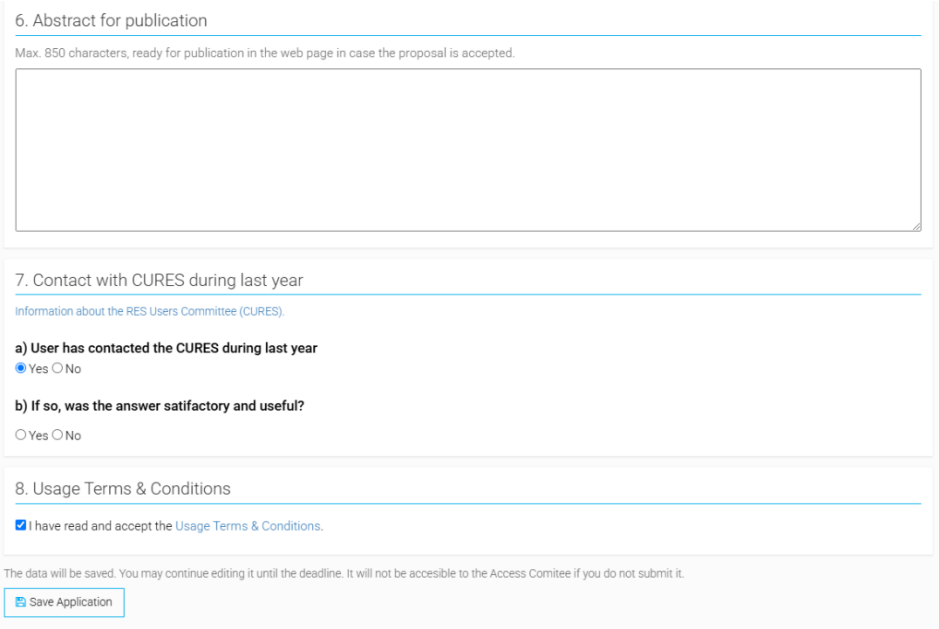
- If you select "Any machine" (second option), your request can be assigned to your selected machine, or to any similar other if that machine's resources have been exhausted. **This option is suitable if your activity can be run in different machines,** but you have a preference for a particular one. Your activity **might be assigned to another machine** if no computing time is left in your preferred one.



Also note that the option you select will apply to all the machines you have selected; either CPU systems, CPU+GPU systems or QUANTUM machines.

Steps 6, 7 and 8: Abstract, CURES and Usage Terms & Conditions

Once you arrive to this point, your application is nearly finished. You only need to provide a brief abstract of your project to publish in our website, answer two questions regarding the RES Users' Committee (CURES) and read and accept our terms and conditions. Once you have done so click "Save Application".



Last steps: After saving your application

After clicking “Save Application”, your application will be saved but not sent. Your application will be accessible in your RES intranet profile with a temporary identifier.

You can edit your application, and we encourage you to do so, as many times as you need before the deadline.

When you are ready to send your application, just click “Submit Application”. This can’t be undone, and you will no longer be able to edit your application. Be sure you don’t need to make any changes before submitting it!