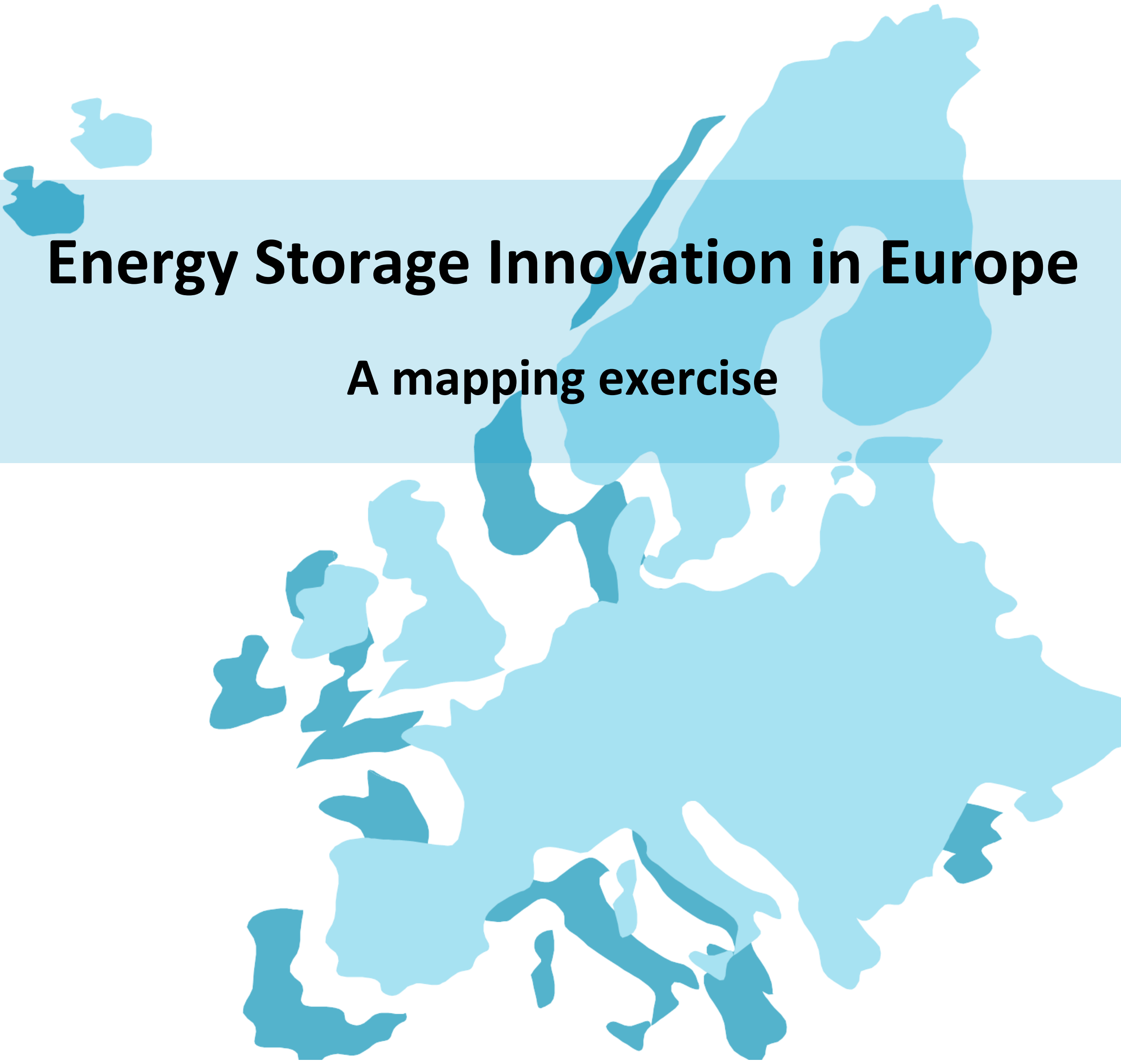
Energy Storage Innovation in Europe

A mapping exercise



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Acknowledgements

When the idea for a member states Initiative on storage mapping grew in the fall of 2012, it sounded very straightforward. The European Electricity Grid Initiative (EEGI) had, after all, already done a similar kind of exercise when several Member States made an overview of projects on distribution grids.

The experience indeed turned out to be very valuable in streamlining the entire process. Nonetheless the effort was huge. This was to a large extent due to the relatively early stages energy storage is in right now. This effort therefore heavily depended on the insights and knowledge of many experts who shared their time and knowledge on the activities in their countries. The list is too long and we would risk forgetting people if we tried to mention them all. So to all contributors of our expert group: we are more than grateful for your contributions and guidance.

A major word of thanks should also go to Henrik Dam at the European Commission, DG Research. Henrik, together with his colleague Patrick Van Hove, did a lot of work behind the scenes in supporting the process and linking the entire exercise to other important developments on energy storage.

Finally the colleagues within GRID+, the de facto secretariat of the EEGI, were the ones providing the overall support and practical support for this. This team has been putting smart grids developments on all radar screens for the past two years. By making this mapping possible, they added another major blip to them.

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Executive Summary

This report presents the very first overview of research, development and demonstration projects on energy storage in Europe. A total of fourteen countries are covered, together with activities sponsored directly by the European Commission. Over the past five years almost one billion EURO has been invested in this field spread over 391 distinct projects.

This mapping provides an overview by looking into the technological orientation of each project and by mapping at which level it is related to the electricity grid (from generation of transmission to distribution and end users). This will inform further decisions on the role of storage in grid development and the interactions between both.

Globally speaking, national funding amounts to close to 800 million; the EC's share hovers around 200 million and is thus very sizeable in comparison to the average share of European funding in R&D. The bulk of the budgets is spent on electrochemical storage (mostly batteries), Power-to-Gas and thermal storage.

The field of energy storage is clearly a fledgling one. Most efforts are still in a research stage, with some of them reaching first pilots. Very few projects have advanced to the demonstration or pre-commercial stage. Those that have done so are considerably larger than the rest of the sample. It is worth exploring the link between financing schemes based on grid tariffs and the number of more advanced and large projects, that seems to be present.

In terms of focus, most projects tend to be found at distribution level or with end users. As the few very large developments/demonstrators are going on at the transmission and the generation level, the distribution is somewhat less skewed when considering the total amounts of investment involved.

Beneath the global analysis a wealth of insights on individual countries is presented. Overall there seems to be some tendency to regional specialization throughout Europe. Southern Europe is entirely focused on batteries. Mechanical storage (CAES, but mostly pumped hydro) is concentrated in a few countries (NO, AT and DK). Power-to-gas and chemical storage are resurging, with outspoken activity on this topic in Western Europe (where Germany is leading the pack). At the same time, the difference in pace between more Western and Eastern member states is remarkable and may merit more European attention in the future.

Overall this report presents pioneering work and underpins the growing importance of energy storage in a more sustainable energy future. Given its pioneering nature, the sample can be improved further in future iterations of this survey. This will only further increase the value of the work.

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1. Background

1.1. The importance of storage for smart grids

The development of smart grids has for a long time hinged on concepts of flexibility and demand response. The boom in renewable sources is at the origin of this movement. Sources like PV or wind tend to have far more unpredictable and less controllable power output profiles than traditional power plants. This means grid balance between supply and demand will depend more on adjusting demand, shifting it over time as required. This flexibility can be achieved by influencing behaviour of individual electrical devices and components. There is a limit to the unbalance that can be absorbed this way, however. In the end grid balance will therefore depend more and more often on the availability of buffer/storage capacity available in the network. By providing temporary buffers for energy, grids will gain additional capacity to absorb peaks in demand or supply for a longer period of time. This capacity will play a crucial role in further increasing the amount of renewable (and often variable) energy sources in our system.

It is therefore fair to say that storage is one of the final – if not the final – technological frontiers in the development of smart grids.

1.2. Taking stock: storage mapping

In recent years the crucial importance of storage solutions for smart grids has been recognized. Most strategic plans and roadmaps now spend considerable time outlining the need for storage and its development. It will also be a topic of major importance in upcoming funding schemes, like Horizon 2020. Industry has regrouped itself in specialized associations and the research field have created a joint programme on the topic. All this means storage is getting attention the way it never has before.

The many visions on the future of storage and grids made it clear that we have no structural insight in the current state of development. There is no single overview of efforts that have already been spent and the state of development in Europe. Both member states and the European Commission have been investing heavily in this field, often parallel to each other and with limited global knowledge on the outcomes. There are, in effect, no coordinated mechanisms for storage development support that make it possible for European and national governments to work alongside industry in major common programs (so-called Public-public-private partnerships, like Technology Platforms or Joint Technology Undertakings).

This mapping exercise aims at plugging the knowledge gap on storage development for the very first time. It brings together data on storage development projects in fourteen EU member states and associated countries, in addition to data on projects sponsored directly by the European Commission. This reveals a rich and detailed picture of the state of play and suggests a few directions for future work. It is not, however, a roadmap . The study is taking stock of what has been done over the last three years. It does not sketch a path forward based on common insight and strategies (although the authors sincerely hope this work can contribute to informing future roadmaps).

As this is a unique, first-of-its-kind effort there are obviously shortcomings that can be addressed in future revisions. The networks that were used to extract the raw data are still forming and evolving. The granularity and completeness of information is evolving together with them and will, over time, yield every more advanced and precise insights. Storage development itself will also become more common and more institutionalized in many countries. The statistical basis for data will therefore improve as well, further enhancing the results than can be extracted.

1.3. The scope of storage in smart grids

When talking about storage in a smart grids context, this study uses a fairly broad definition that captures many solutions, technologies and developments. They must be, at all times, be connected and related to the electricity grid one way or the other.

The core concept is expressed in Figure 1.

Figure 1: The storage concept - a black box

A storage solution is considered a black box that takes in electricity – and is as such connected to a grid – and releases energy in some form. This can be electricity again, but it can also be heat. In all cases, this will have an influence on the balance between demand and supply in the grid. This is obvious when energy is released again as electricity and thus adds to the overall supply (e.g. a battery, pumped hydro). When energy is released/used as heat, it means no electricity needs to be used at that point in time to generate the heat and thus overall demand is suppressed. A classical example would be a heat pump with an integrated thermal (water or PCM) buffer. Electricity is used to operate the heat pump at one point in time; energy is stored as heat and released when required without the heat pump having to use electricity again.

The projects that are analysed in this study are also at a level of detail that is of interest to somebody looking at electricity grids. A lot of storage development is, in essence, materials R&D. Although this is crucial, this mapping exercise is more geared towards establishing components and systems that enable the kind of black boxes depicted in Figure 1 and discussed above. Underlying materials technology is only taken into account if it directly contributed to this objective.

1.4. Unique position of the European Electricity Grid Initiative and GRID+

The mapping exercise is an initiative of several member states, with the support of the European Commission and the main industrial organisations in the field of smart grids. Over the past four years, these actors have been meeting in the so-called European Electricity Grid Initiative or EEGI. This group was created after smart grids had been identified as a core technology in the Strategic Energy Technology – plan (SET-plan). The goal of the EEGI is to develop and implement the agenda for smart grids in Europe. Through a series of vision and strategy documents, complemented by implementation roadmaps and work programmes, the EEGI has been directing sizeable investments into electricity grids.

Apart from setting the agenda at the European level, the EEGI has made forays into linking its vision for Europe to the policies of member states. In 2011 it focused on an inventory of activities in member states and the extent to which they coincided with the priorities of the EEGI strategy. It also made a start in labelling new initiatives that are in line with this strategy and in identifying existing projects that have a potential to be scaled up and replicated in other countries. The storage mapping exercise is part of this growing portfolio of activities to link national and European developments on smart grids.

EEGI as a body is supported by GRID+. This consortium of experts acts as a kind of secretariat to it and takes care of the day-to-day running of the platform. GRID+ itself can draw on the vast expertise of TSOs, DSOs, energy professionals and R&D-players, bringing together the most active and experienced people in this field. It is the GRID+ consortium that practically manages the storage mapping and the database behind it.

2. Approach

Mapping implies bringing together, from many different sources, what has been done. It is therefore substantially different, as indicated before, from "roadmapping". The latter means looking forward and sketching a future based on a number of assumptions.

The methodology used for this study is fully adapted to the idea of mapping. It focuses on data collection and synthesis, with a goal of discovering overall patterns and drawing conclusions from them. It refrains from developing scenarios or expressing preferences – those are activities typically connected with roadmaps.

2.1. Methodology

The study was carried out with the input of three groups, each playing a distinct role.

1. The EEGI team itself had the role of steering board. It was available for setting the overall agenda, fixing the scope and appointing members of the other groups.
2. The expert group consisted of representatives from each participating country. They were appointed by their governments for their knowledge and overview of the activities on energy storage in their respective countries. Their role was crucial in assembling the data. In total experts from 14 countries took part.
3. The working group consisted of four people from the GRID+ consortium. They played a crucial role in setting up the outline of the study, ensuring the consistency of the data gathered and carrying out the analysis.

Data were gathered, analysed and synthesized in four phases.

- Initial overview:

In the initial overview phase, expert group members provided a first snapshot picture of the situation in their countries. This way common ground was created among all experts and realistic expectations on the data that would be needed were created. It also provided an opportunity to let all experts work with the same grasp of the scope and the level of detail for this study.

The initial overview happened in January 2013.

- Surveying:

The bulk of the time in was spent in developing and then filling out an appropriate survey in all countries involved. Given the different levels of progress, thematic focus or even statistical material across Europe, this was not evident. The survey that was developed therefore aims to capture aggregated information, while still maintaining a level of uniform insight.

The surveys were used by the expert group to record all projects on energy storage in their respective countries that have been on-going since 2010 (i.e. they must still be running or should not have ended before 2010).

- Clustering:

The individual records were in a first stage clustered per country to reveal insights into the number of projects; the overall budgets involved; the technological focus of the projects; the nature of the projects; and their evolution from research to market introduction. The result is a series of comparative pictures of all countries involved. They are included in this report.

- Thematic analysis:

Finally the data were used for a more thematic analysis, so without taking into account the differences among countries. The main focus was on clustering the data according to the storage technology involved on the one hand; and to the level in the grid the storage solution was used at. This classification presents three major advantages. First of all, it has been used before - although for different purposes and with a different content – in the roadmap of the European Association for the Storage of Energy and the European Energy Research Alliance. It therefore offers an interesting comparison between the status of development today (the mapping) and the desired focus in the future (the “roadmapping”). Secondly, the link between storage and grids is very direct by using this classification. The scheme reflects the general scope that was set for this study. Finally, it is useful to draw comparisons between the activity of all member states taken together on the one hand and the projects sponsored by the European Commission on the other.

2.2. Dataset

The mapping has resulted in a dataset of close to four hundred projects, with more still being added. This is a unique and valuable resource, as it covers information that is in principle not available at one single level in Europe (it is either at a member state level or at the EU level).

After consolidation, the database contains 391 distinct projects for a total value of EUR 985,85 million.

A number of characteristics are recorded for each project; the main ones are discussed here as they may help in interpreting the results.

2.2.1. Total project budget

It is the total amount of investment from the source that is mentioned. In case of co-funding (public money complemented by private funds) – which is the case in almost all projects reported – this number refers to the total public funds invested.

2.2.2. Specific storage-related budget

Many projects are not storage-dedicated as such. It is often only one element in a larger setup. Therefore the portion of the budget that is dedicated to storage as such is also included. This number can vary from (close to) zero to the whole of the 'total project budget'.

2.2.3. Source of funding

Three potential categories of funding are considered here.

- Public – national indicates full or partial funding from national governments. Projects here are typically the result of calls under public support schemes.
- Public – European indicates full or partial funding from the European Commission. The standard here is a 7th framework project.
- Private – The project is fully funded by private parties. Because of this private nature, there are few projects of this type in the database.

2.2.4. The level the storage solution is implemented at

Storage solutions can appear at several levels in the grid, from centralized to dispersed. Five possibilities are recorded here.

- Generation refers to storage at sites of central large generation units
- Transmission indicates large(r) storage solutions that support the transmission grid
- Distribution looks at more dispersed storage supporting a distribution grid. This could, for example, be at a substation or at the level of a single neighbourhood.
- End user. This is the most dispersed option, encompassing small units at the level of individual end users.
- Not available. A number of projects (especially more fundamental ones) cut across levels or develop things that are applicable to more than one level

2.2.5. The technologies being used

The division used here is in line with the categorization developed in the joint energy storage by EASE and EERA published in 2013.

- Mechanical. Technologies like pumped hydro, CAES
- Chemical. Technologies like Power-to-gas
- Electrochemical. Supercapacitors and batteries
- Electrical. This is shorthand for hybrid storage systems
- Thermal. All technologies that store energy as heat. Encompassing latent storage, phase-change materials and thermochemical materials.

2.2.6. Main project objective

This is, regardless of the stage of development, the main goal of the project. It is of course obvious that some objectives are more natural in projects that are earlier in the innovation chain (eg. Technology development) whereas others will be more commonly found in later stage projects (eg. Up-scaling of validated solutions)

- Technology development;
- Proof of Concept;
- Business model validation;
- Up-scaling;

2.2.7. The state of development of a project

This parameter tracks how far a project is from the market. It is an indication of the 'readiness level', although we explicitly refrain from referring to the formal definition of Technology Readiness Levels.

It is important to realize this is a pioneering piece of work. None of the data was available before in the integrated way presented here. This also means that the quality of the data – both in terms of breadth of issues covered as in terms of completeness – can be improved further in the future. This is a main task for GRID+ and the European Electricity Grid Initiative, the managers of the database.

A first major update of the database is foreseen in Fall 2014.

3. Structure of this report

The report consists of two parts.

The first section is dedicated to a thematic mapping, depicting the situation in the whole of Europe. A distinction is made between work funded at the national level and projects that get EC support.

Two main parameters are explored in a variety of ways. On the one hand the level of connection to the grid appears. On the other hand, the technology type used is brought into the picture. Both dimensions are very relevant for today's developments and provide cues for further support policies.

The second section is devoted to an analysis at the country level. It develops the same kind of insights as the first section, but for each country individually. The main difference is that the data used for the country-specific analysis exclude all EC-funded projects. The latter are by definition international and cannot easily be assigned to a single country without introducing distortions. A separate treatment of European projects is already part of the first section, so no information is lost.

4. Thematic mapping

4.1. Introduction

The analysis of the situation in each individual country paid a lot of attention to two parameters: the type of technology being developed and the level storage is implemented at. Both dimensions were explored at length for each country, highlighting both the number of projects and the total investment involved.

This section of the report takes a more aggregated approach and looks at the parameters from a more overall level. On the one hand this means it does not dwell on a single country, but groups all of them in a single, large cluster.

On the other hand it implies involving EC-funded projects in the analysis. Such transnational projects were reported by several member states, but it would have been incorrect to assign them to the reporting country. Neither would it have been appropriate to assign them to all countries involved, as they may not be subject of this overview. In all cases more detailed information than what is available at this level would have to be available to do so. Therefore all EC-funded projects that were reported were taken out of the national results and treated as a separate group. In this section of the report we will treat them in more detail and also compare them to the totality of national projects.

4.2. Structure of the thematic mapping

The overview drills down from a general overview to more detailed results in three steps.

The first step is looking at a single dimension at the time. It considers either the technology or the level of implementation and shows the distribution of projects and budgets over them.

The second step then brings both parameters together and yields a set of synthetic, yet insightful overviews of the storage landscape in Europe.

The third step heightens the level of detail even further by adding other dimensions: either the research objective of the projects or the level of development they are at. Moreover here the fractions of a budget dedicated specifically to storage are shown separately. This last step yields a set of diagrams that are fully comparable with the ones used in the country analyses. They are indeed the ultimate clustering of all the information available in the database.

4.3. Global overview

4.3.1. By level of implementation

Considering only the level of implementation, Figure 2 shows clearly that the highest number of projects is not bound to a single level of implementation. More than 200, the bulk of them nationally funded, are in this case. They are, however, relatively modest projects as the total budget spent on them is in line with the funds made available for distribution of end user level projects (of which there are fewer). This can be seen in Figure 3.

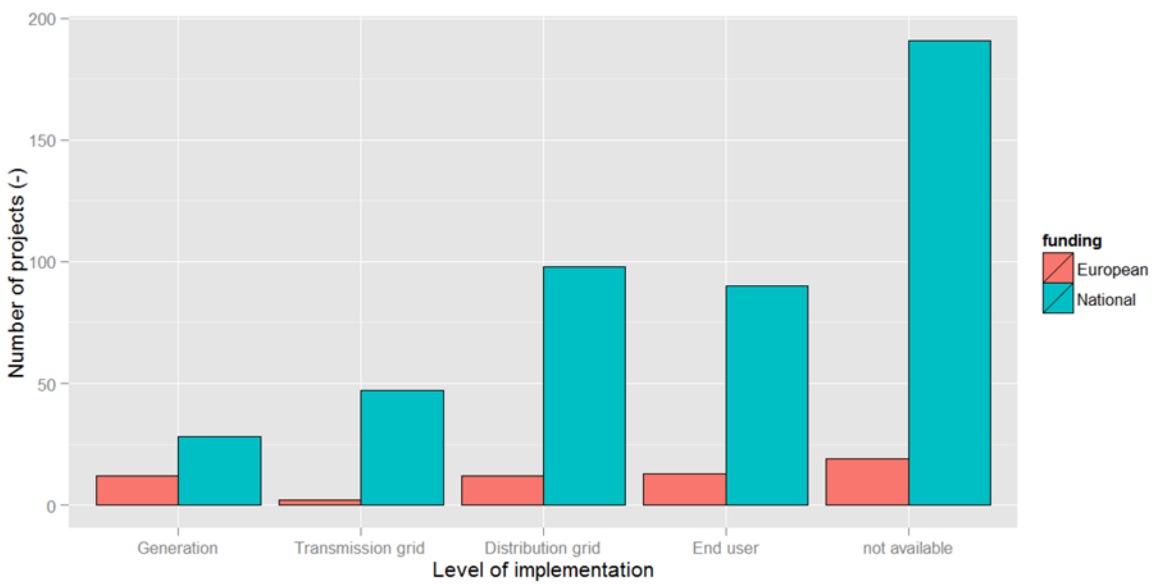

Figure 2: The number of projects according to their level of implementation

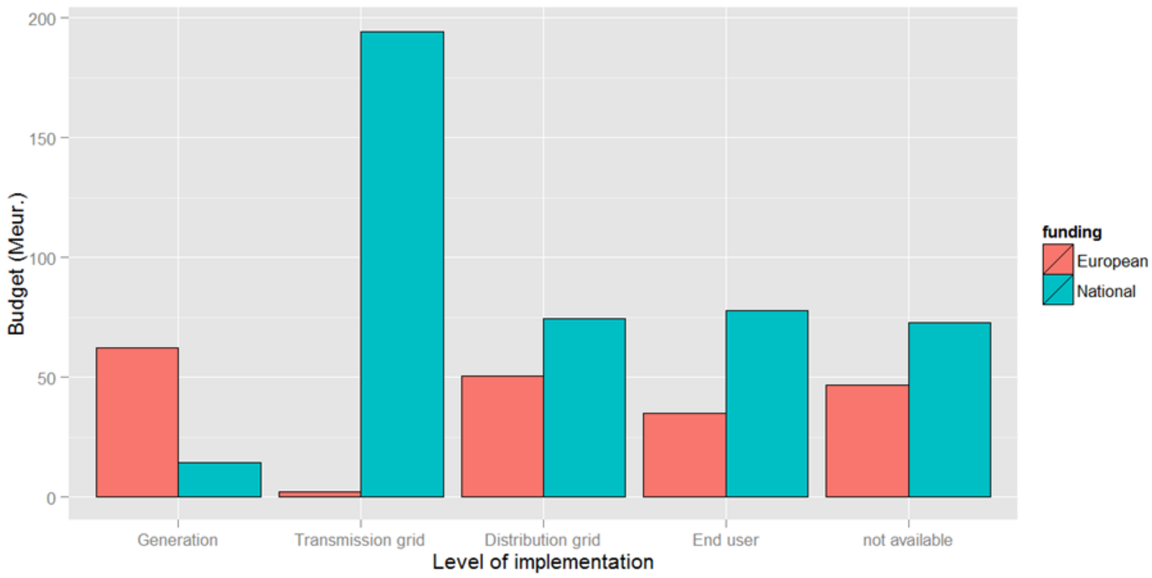

Figure 3: Project budgets according to level of implementation

The opposite phenomenon is seen for the transmission and – to some extent – for the generation level. Here a smaller number of projects account for (very) high budgets. The very large budgets are mostly due to one or two extremely large projects, mostly in the UK and Norway. In those cases this is explained by the fact that part of the tariffs need to be used for development/pilot projects.

Overall the preponderance of national funding is obvious. Globally the budgets made available by national governments or support schemes is larger than the ones acquired through EC-funded projects. When looking at the connection levels, it is remarkable how generation-level storage is the one category where European funding is dominant. Nonetheless the funding by the EC is considerable in this area. Globally speaking, EC funding makes up about 5% of (public) innovation spending in Europe. In this overview it is closer to 20%.

4.3.2. By technology

The second major dimension in this overview is the storage technology that is involved. The five types considered (mechanical, electrochemical, chemical, electrical, and thermal) are in line with categorizations used elsewhere, most notably in the roadmap presented by EASE in 2013.

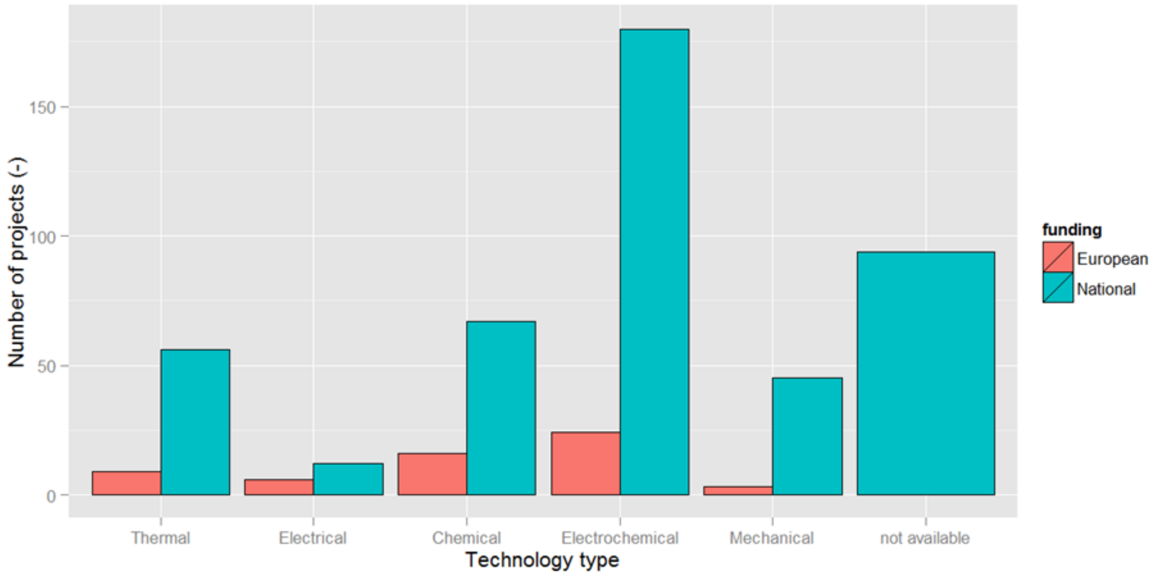

Figure 4: The number of projects according to technology type

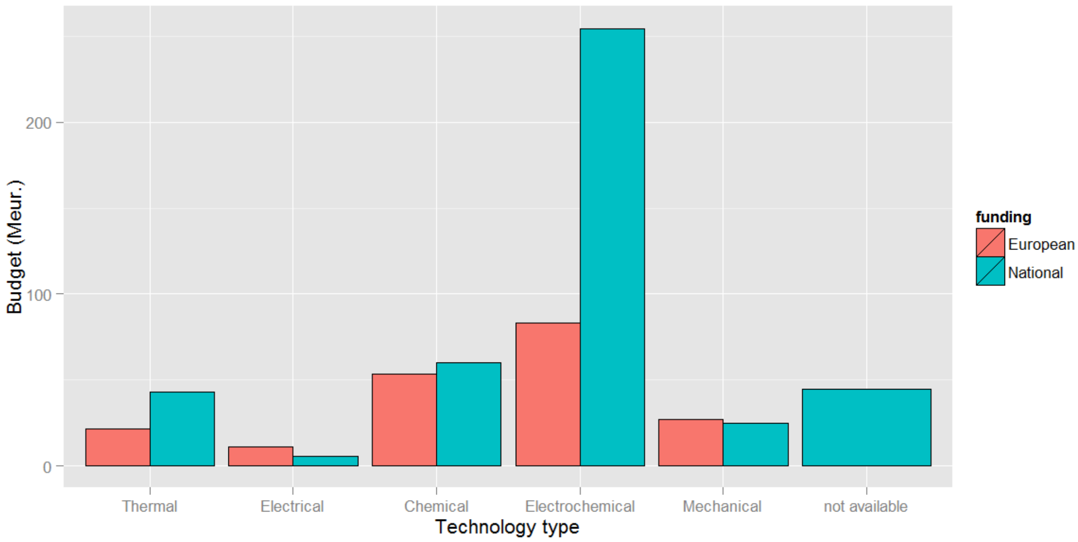

Figure 5: Project budgets according to technology type

Obviously the large share of national funding is evident from this graph as well. It is revealing, however, to see how European and national funding are more or less in line with each other in all categories, except for electrochemical storage (which is almost exclusively dedicated to batteries). Funding in this area dwarfs that of all other categories (including the non-technology specific one) taken together and it is also the one area where national funding is outspoken. This encompasses – again - the effect of a few giant projects financed through tariffs, but Figure 4 reveals, the number of projects funded is also far higher than those on other technologies. Europe is clearly betting on batteries.

A noteworthy, albeit distant, second in terms of budgets is chemical storage. The (re)surgence of Power-to-Gas developments and demonstrators in countries like Germany explain this strong showing.

A final point worth noticing is the effort spent on projects that are cutting across technologies or are not technology related in the first place. This type of activity is supported exclusively by national funds in this sample, but still close to 100 instances have been recorded (as seen in Figure 4). A comparison to the budgets reveals that such projects are – maybe not surprisingly – relatively modest in terms of funding.

4.4. A synthetic view

This section raises the complexity of the overview somewhat by combining the dimensions that were treated separately until now. All graphs now show the level of implementation on the horizontal axis and the technology involved on the vertical one. The content of the graphs consists of either the number of projects or the budgets. All in all there are six overviews:

- two for the whole of the projects (Figure 6 and Figure 7);
- two for the group of nationally funded projects and (Figure 8 and Figure 9);
- two for the EC-funded projects (Figure 10 and Figure 11)

Each time both the number of projects and the budgets are shown. It is clear that adding the contents of (2) and (3) will equal the contents of (1).

4.4.1. Entire sample

The overview clearly shows the dominance of electrochemical storage. It is interesting to note that the large majority of such projects cover distribution, end user level or are cross-cutting. A total of 180 such projects have been found, fully 46% of the total of 391 projects in the sample. In terms of budgets they account for EUR 176,8 million or 18% of the total budget of 981 million. It is still very significant, but less overwhelming.

The outliers caused by the huge implementation projects are now visible as electrochemical projects at the transmission level.

All in all, there are 70 projects that are generic both in terms of technologies covered and in terms of the level of storage implementation. In terms of budget they only represent 4,6 million, however.

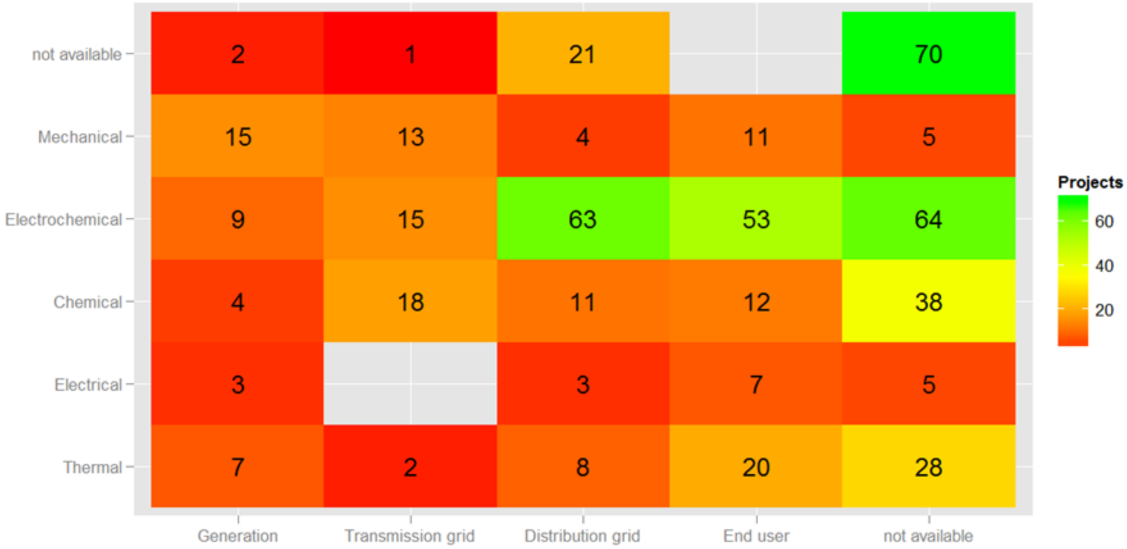

Figure 6: Number of projects - Entire sample

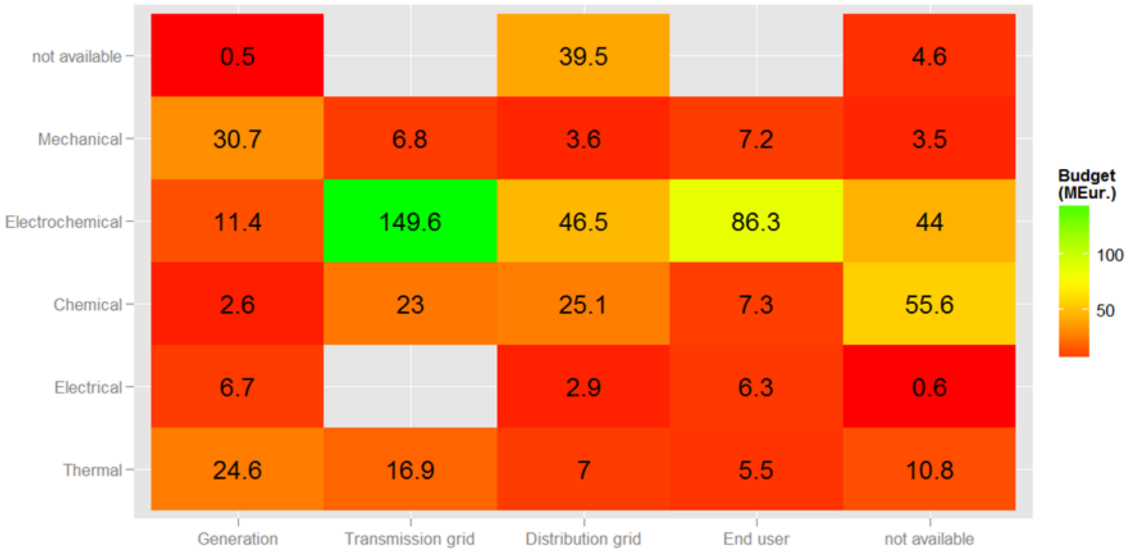

Figure 7: Project budgets - Entire sample

4.4.2. Nationally funded projects

Looking at the subset of nationally funded projects, it is clear they cover almost all combinations of technology type and connection level, much the way the overall sample does. There is one instance, on electrical storage for distribution grids where a project has been recorded, although a budget figure is missing for it.

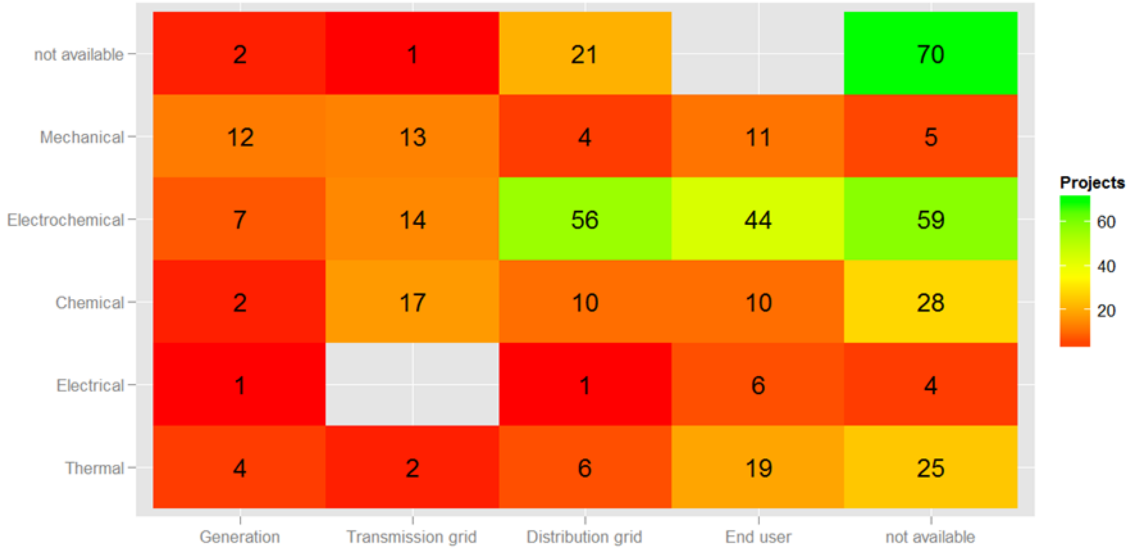

Figure 8: Number of projects - Nationally funded projects

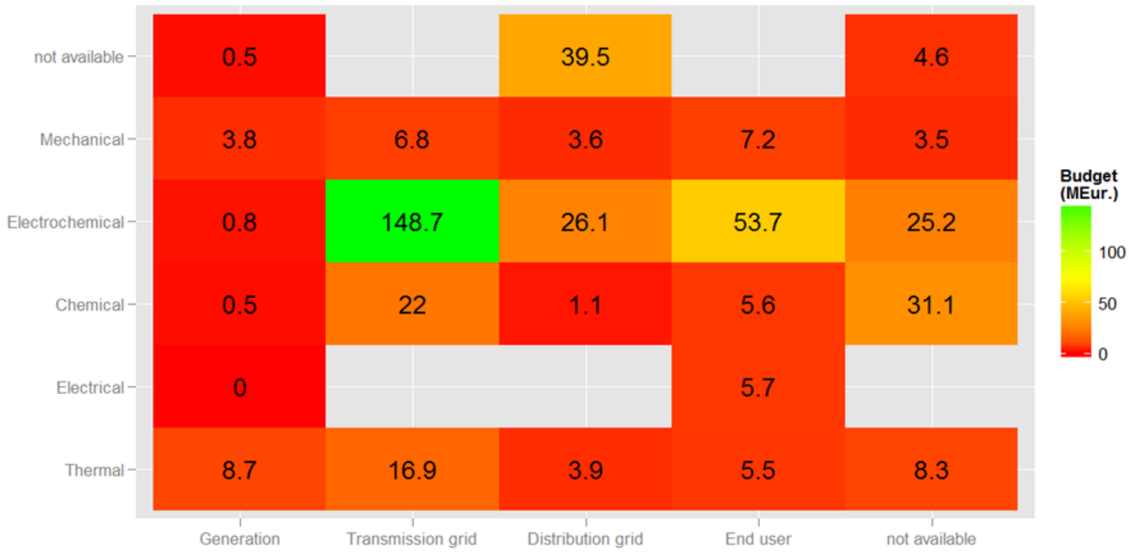

Figure 9: Project budgets - Nationally funded projects

4.4.3. European Commission funded projects

The overview of projects sponsored by the EC reveals a somewhat more selective picture. The dominance of electrochemical and chemical storage is still there, although the discrepancy is not as huge as in the national projects group. This is explained by the absence of extreme outliers. At the same time there is an outspoken support on mechanical storage. It is too soon to generalize as this involved only a few projects. At the same time there are more categories that are not covered by the European projects. All this could suggest that the EC is keener on supporting projects in selected areas that may be a bit further down the road (like power to gas).

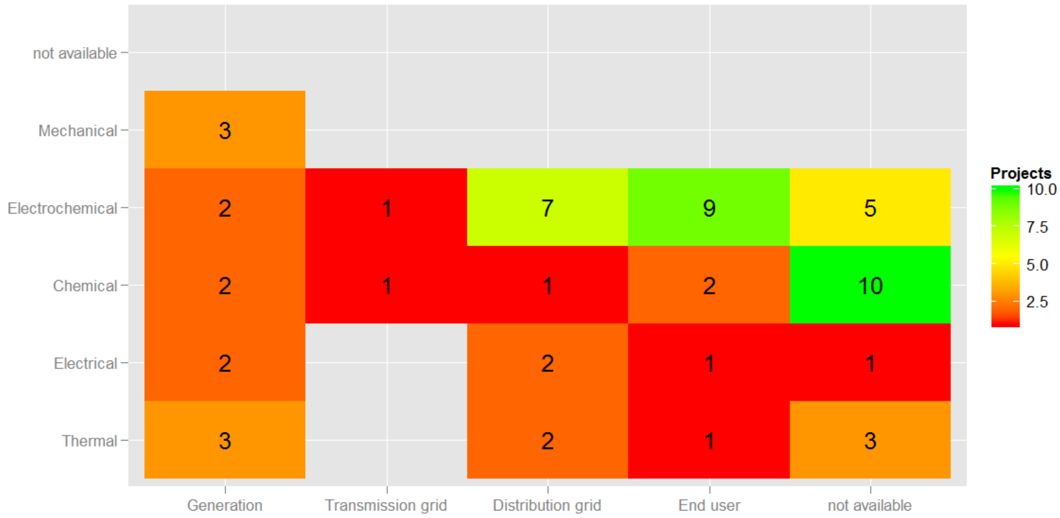

Figure 10: Number of projects - EC funded

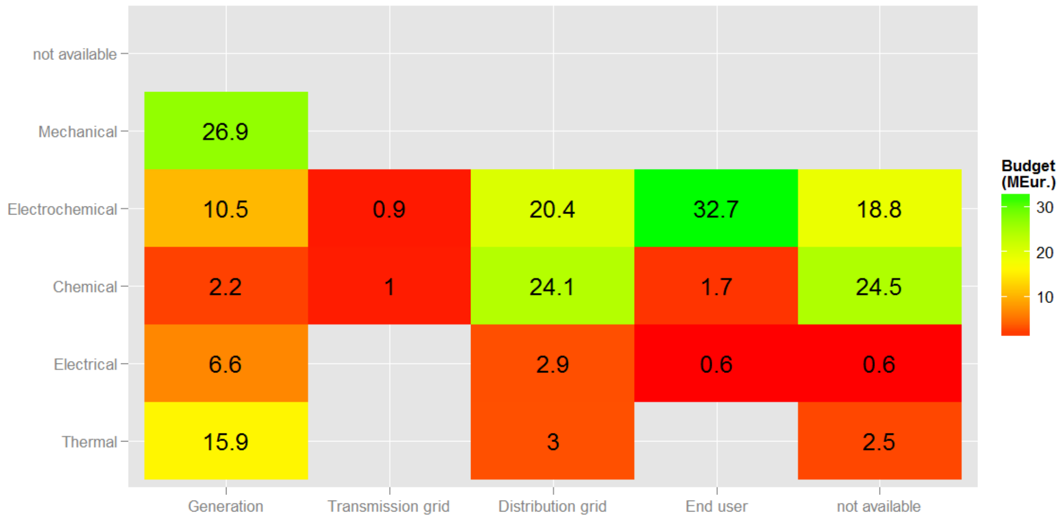

Figure 11: Project budgets - EC funded

4.5. A most detailed picture

The final level of detail adds insights into both the nature of the projects (their objective) and on the progress towards marketable results. The resulting overviews offer a complex and fine-grained insight, but still quickly convey a sense of how the entire project landscape is structured.

There are four overviews:

- A general insight into the number of projects, based on the two parameters treated before plus the objective of the projects.
- The same insight, but expressed in terms of overall budgets
- The same insight, but expressed in terms of specific storage-related budgets
- A general insight into the number of projects, based on the two parameters treated before plus the advancement of each project towards marketable results.

The four overviews are the same ones that will be discussed for each country individually. They contain, however, also the data on the European projects. The results per individual country exclude those for reasons explained above.

4.5.1. Project objectives: distribution of projects

Figure 12 immediately reveals that the bulk of all projects is concerned with technology development. The focus on the other objectives (building a proof of concept, validating the business model, up-scaling a validated solution...) is dispersed at best. Only for electrochemical storage at distribution and end user level can we see a more or less full coverage of all of them.

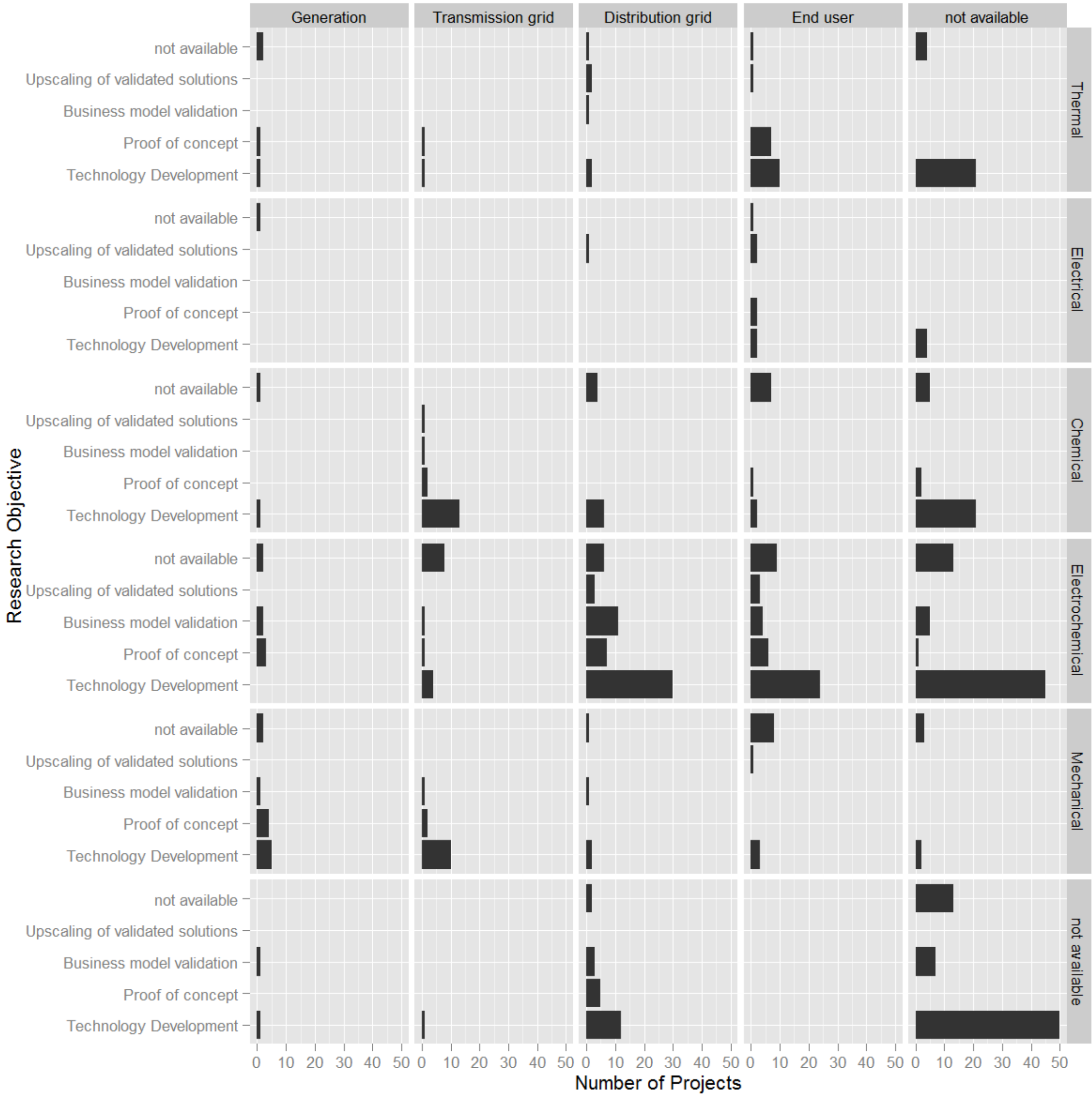

Figure 12: The number of projects and the project objectives

A second interesting insight concerns a clarification on a comment made before. We had noted that seventy projects were generic in terms of both the level and the technology. Here it is clear that the vast majority on them are on technology development. The same holds for projects that are generic in one of the two dimensions (either undefined level or undefined technology). Most often this concerns fundamental development of optimized storage solutions with generic applications. Figure 15 will show that it is indeed most often pure research projects that make up this category.

4.5.2. Project objectives: budgets

Figure 13 Depicts the same categorization but in terms of budgets. There is still a very considerable investment in all types of projects on electrochemical storage, but this graph is heavily influenced by the very large outliers.

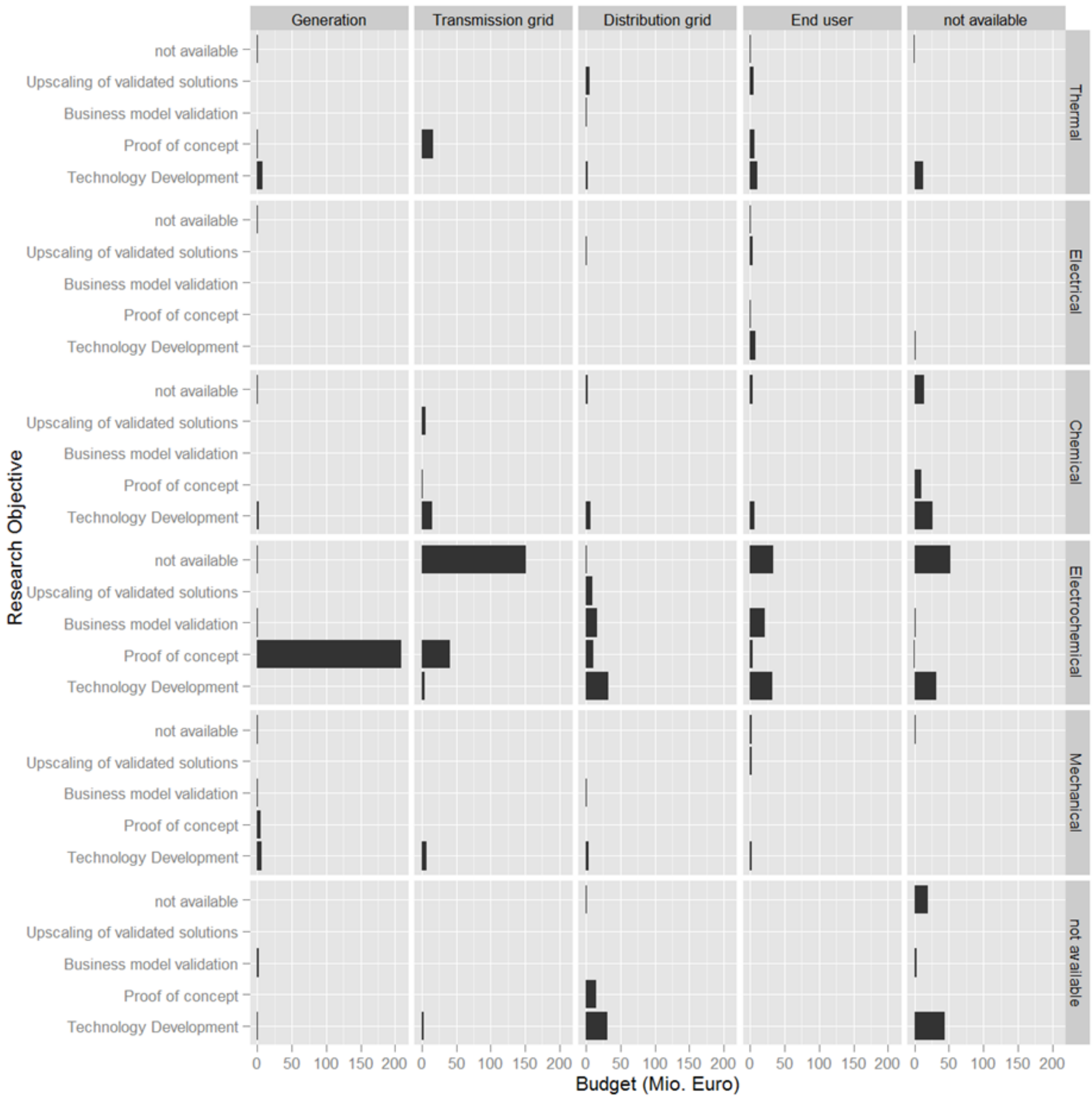

Figure 13: Total project budgets and the project objectives

The picture is made more accurate still by retaining only the portion of project budgets that are devoted strictly to storage. This is shown in Figure 14.

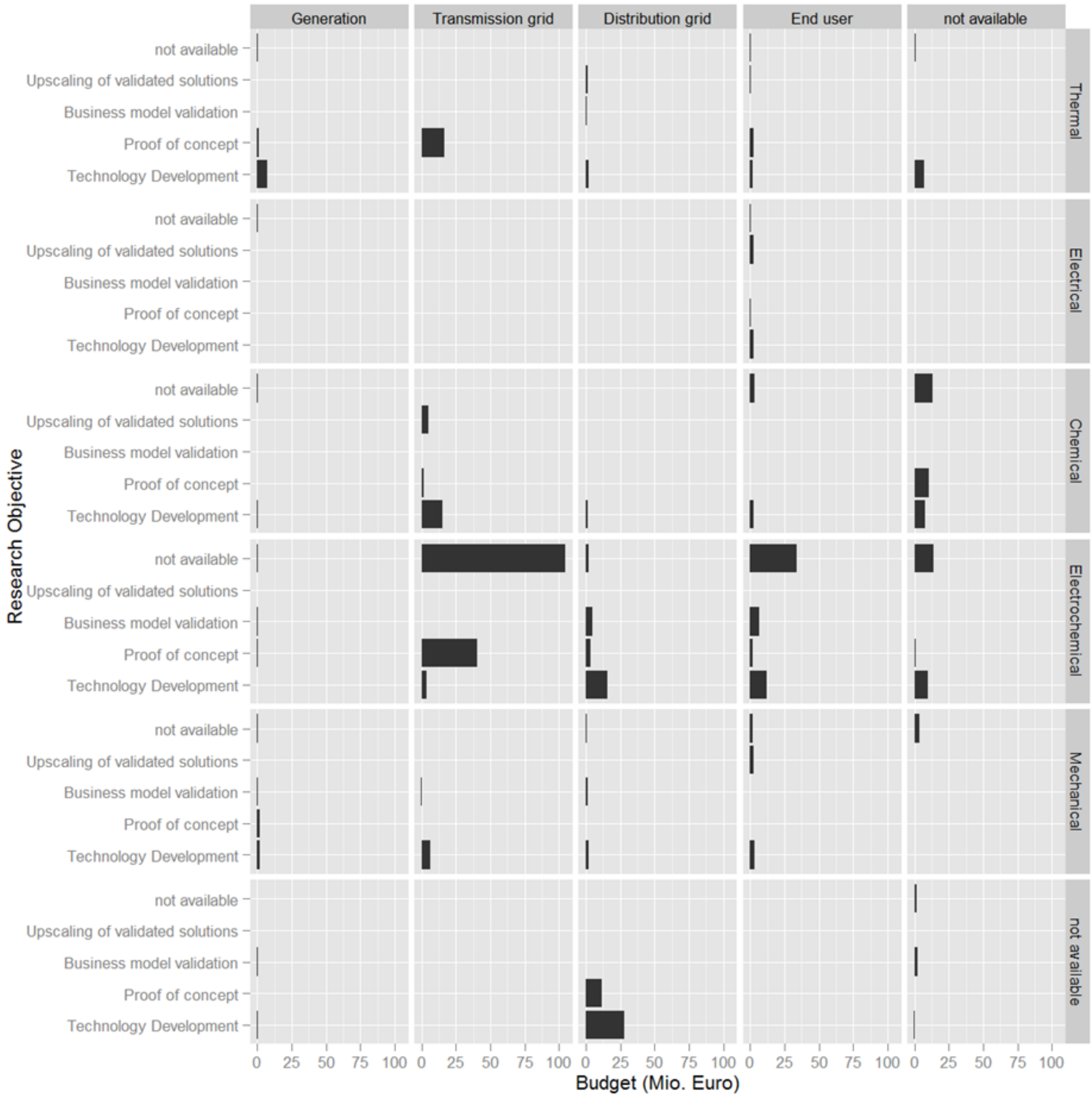

Figure 14: Budgets specifically for storage and project objectives

Overall the picture is more or less comparable to the situation with the complete project budgets that was shown in Figure 13. It is clear that projects that include electrochemical storage are most often the ones where a major portion of the budget is also dedicated to the storage as such. This may once again confirm that batteries – and some related technologies, like ultra caps – are considered to be crucial and thus deserve major attention.

4.5.3. Project development stage

A final bit of extra information is an insight into the stage of development each project is at. It is sometimes dubbed the 'readiness level' here, as it captures the idea of a progression from a basic idea over R&D to pilots and finally commercial deployment. It is based, however, on a judgement by experts in each country involved and does not necessarily comply with the formal definitions often used for Technology Readiness Levels. Moreover the readiness here refers to the project and how it positions itself, not necessarily to the products or services being developed as such.

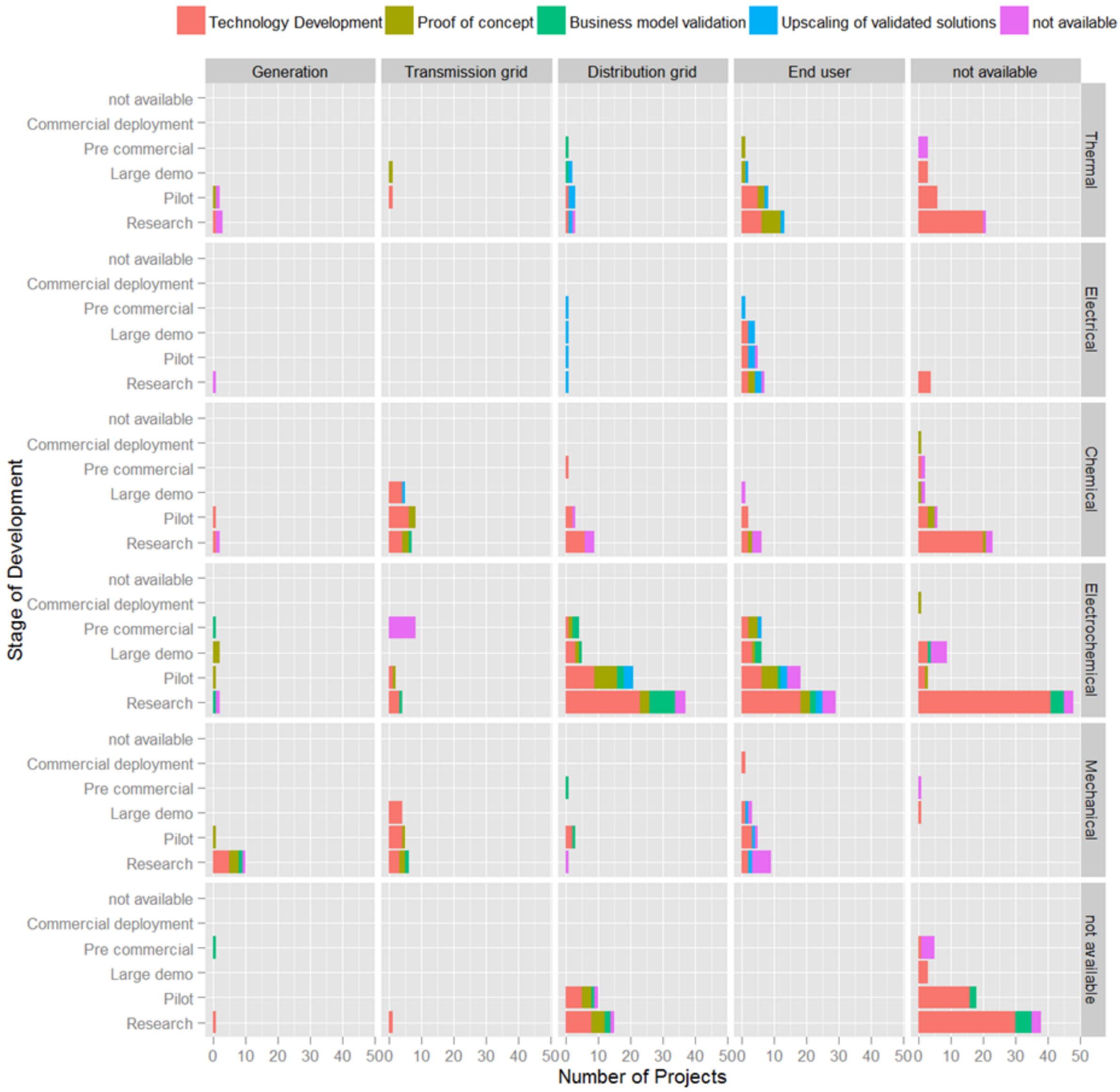

Figure 15: Stage of development and the number of projects

Figure 15 depicts the number of projects, clearly showing the continuum from research (at the bottom of each box) over pilots, large demos, pre-commercial and finally commercial deployment (at the top). Moreover, the different colouring of the bars adds information on the project objectives (as seen in Figure 12). Three main remarks have to be made.

There are hardly any projects at a commercial stage (although they are often the ones with the big budgets, as seen in the other graphs) . This need not be surprising as this survey was focused at storage research, development and demonstration projects. Commercially available solutions or running plants were not taken into account. All pumped hydro plants, which currently account for some 99% of installed storage capacity in Europe, are for example not part of this overview. The few projects that have reached a commercial or even a pre-commercial stage in this overview are therefore indicative of real progress that has been made.

Secondly, and this is one of the main conclusions from this entire mapping exercise, the vast majority of storage projects are still in a research stage. Especially the high number of efforts on electrochemical storage turns out to be at a very early stage. This also explains to some extent the number of generic efforts, where neither the technology nor the level of storage are defined: exploratory studies into the nature and the best choice of storage abound.

Based on these insights we should expect a high number of demos and pilots over the next few years in three fields: electrochemical storage (obviously) and chemical storage, but also in thermal storage. There seems to be considerable R&D activity in thermal storage technology development for end users and for generic applications.

4.6. Conclusions

We can summarize the main observations of the thematic mapping

- Europe as a whole is betting heavily on batteries and is seriously investing in Power-to-gas and thermal storage. Most of these developments concern other than centralized storage.
- Most efforts on storage are clearly research efforts (which explains the smaller shares of investment). We are, in other words, sowing for 2020 and beyond.
- Although many more projects cover the distribution and the end-user level, large and concentrated investments can be seen in transmission (and to some extent) generation based storage. This reflects the fact that large and centralized storage solutions have been mature for a longer period of time now.
- For the years to come we may expect many demo and pilot projects on distributed/local electrochemical, chemical and thermal storage as the current generation of research matures.
- National governments are the main source of funding, although the EC's share is relatively high in comparison to general R&D spending in the EU. The EC seems to be a bit more selective in the areas it is funding in a way that is complementary (i.e. it may be somewhat longer term work) to national funding.

5. Country mapping

This mapping covers 14 EU countries, as shown in Figure 16.

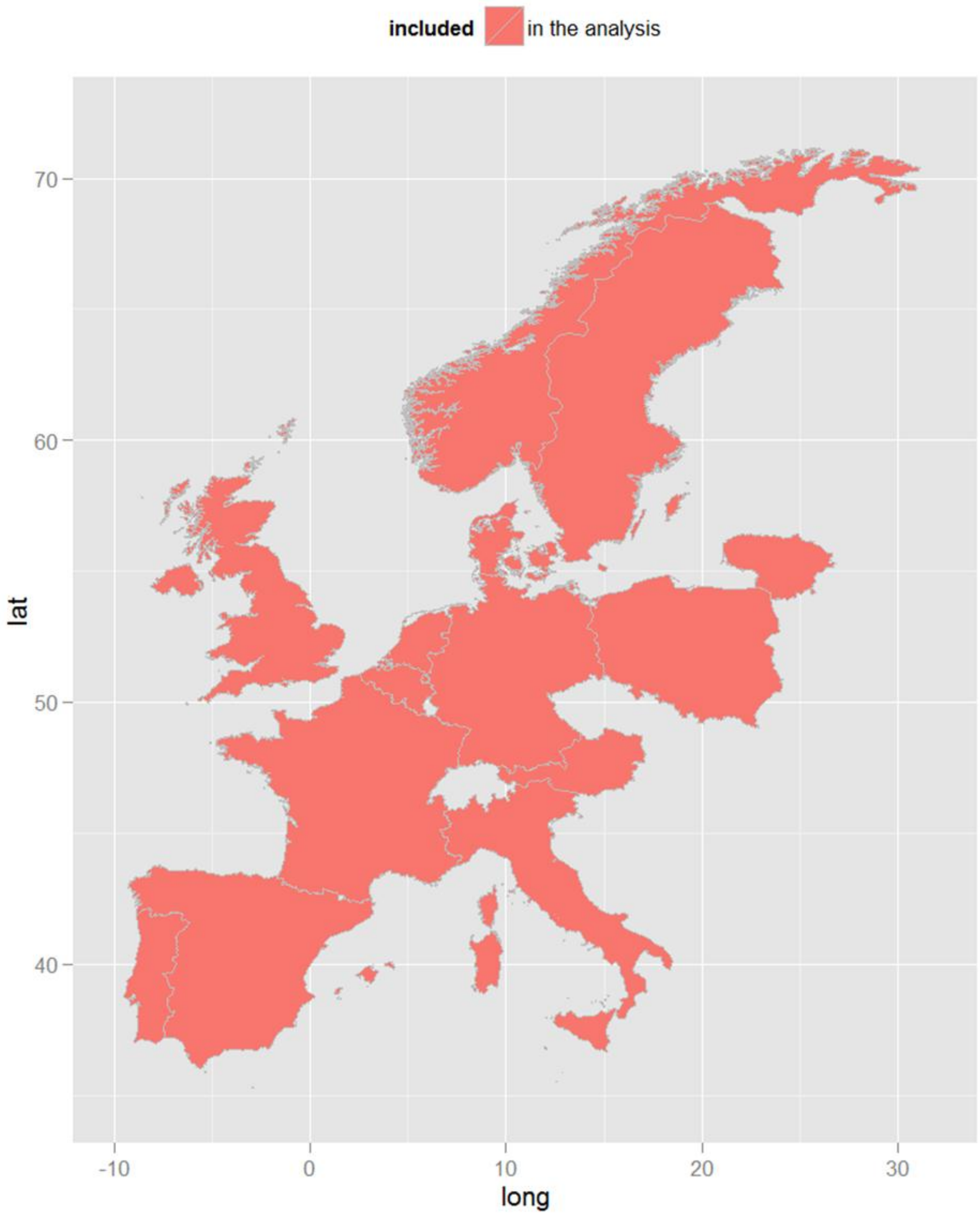

Figure 16: The countries involved in the analysis

Western and Northern Europe are almost entirely covered. Only Ireland (which is not actively involved in the EEGI) and Finland (where all project data are confidential and not available for analysis) are missing. Switzerland, the final blind spot in the region, was not yet able to provide overviews but may do so in future revisions of the database.

The picture is far less complete in Central and Eastern Europe. Poland and Lithuania are included, but the remaining countries are missing. This is a reflection of a general trend in many European innovation-oriented constellations, warranting attention.

The main missing country in Southern Europe is Greece, which is also explained by its absence from the EEGI.

Figure 17 provides an overview of how the projects are distributed among the countries in this mapping. The colours refer to the funding schemes involved (blue: private; rest: public).

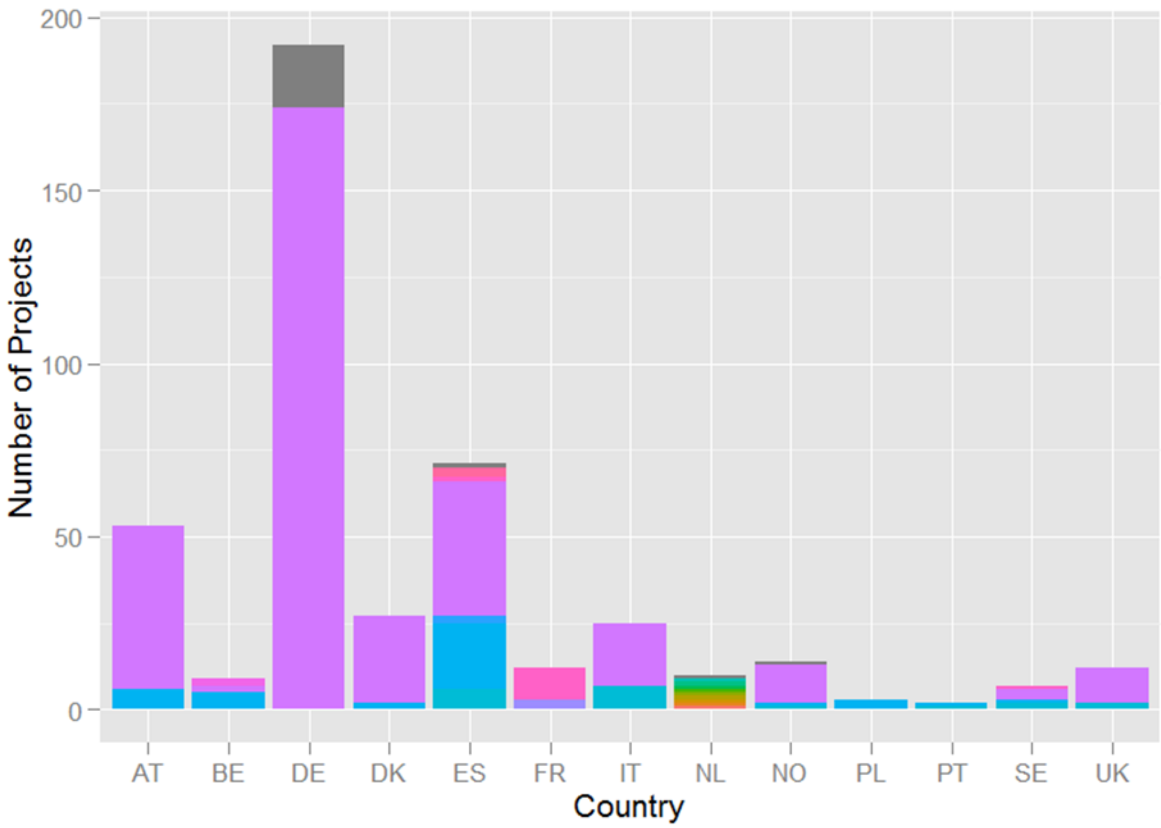

Figure 17: Distribution of projects over the countries

Because projects can vary wildly in their scope and budget, Figure 18 sketches the situation again in terms of total sums invested.

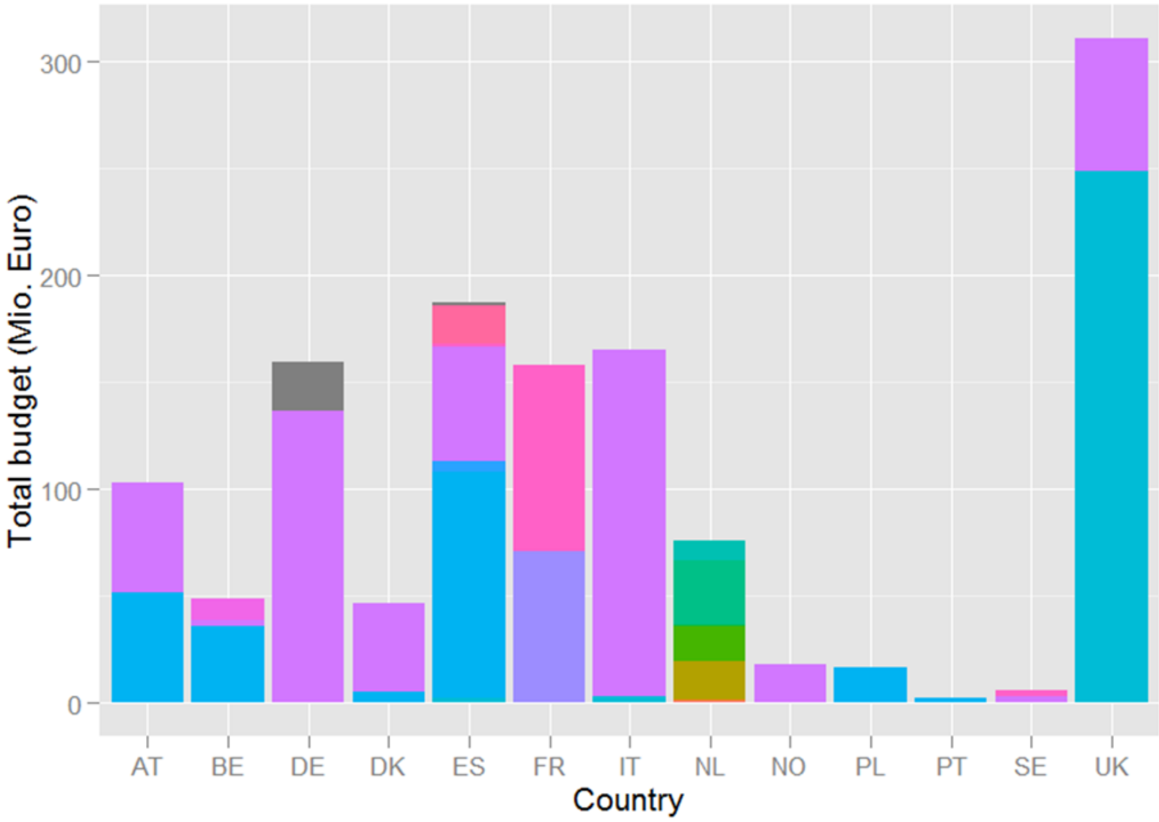

Figure 18: The distribution of budgets over countries

5.1. Country fact sheet: Austria

5.1.1. Overall situation

The analysis of the EEGI storage mapping questionnaires shows that in Austria totally 47 projects deal with storage systems. The total budget of these projects amounts to 51.26 Mio. Euro, less than 10% of the total budget of the countries covered by the EEGI storage mapping activity. However, these projects are not solely and exclusively dedicated to storage solutions, but they also tackle higher level concepts such as electric vehicles and smart grids or they include projects researching in advanced materials (especially Li-Ion). Congruently, the storage related budget amounts to 46.15 Mio. Euro (about 89% of the total budget).

5.1.1.1. Number of projects

Figure 19 shows the number of projects according to the type of technology, the project's connection level and the projects readiness level. One project covers 2 and one project 5 types of technology groups. This is also indicated with different colourings. For example, it can be seen that 13 projects deal with electrochemical storage solutions connected at the End user level at different stages of development. Those projects also cover pure technology development without addressing a certain application.

In general, it can be inferred that most projects belong to the End user and distribution level or they have not specified the project's connection level. Further, most projects deal with mechanical or chemical storage technologies.

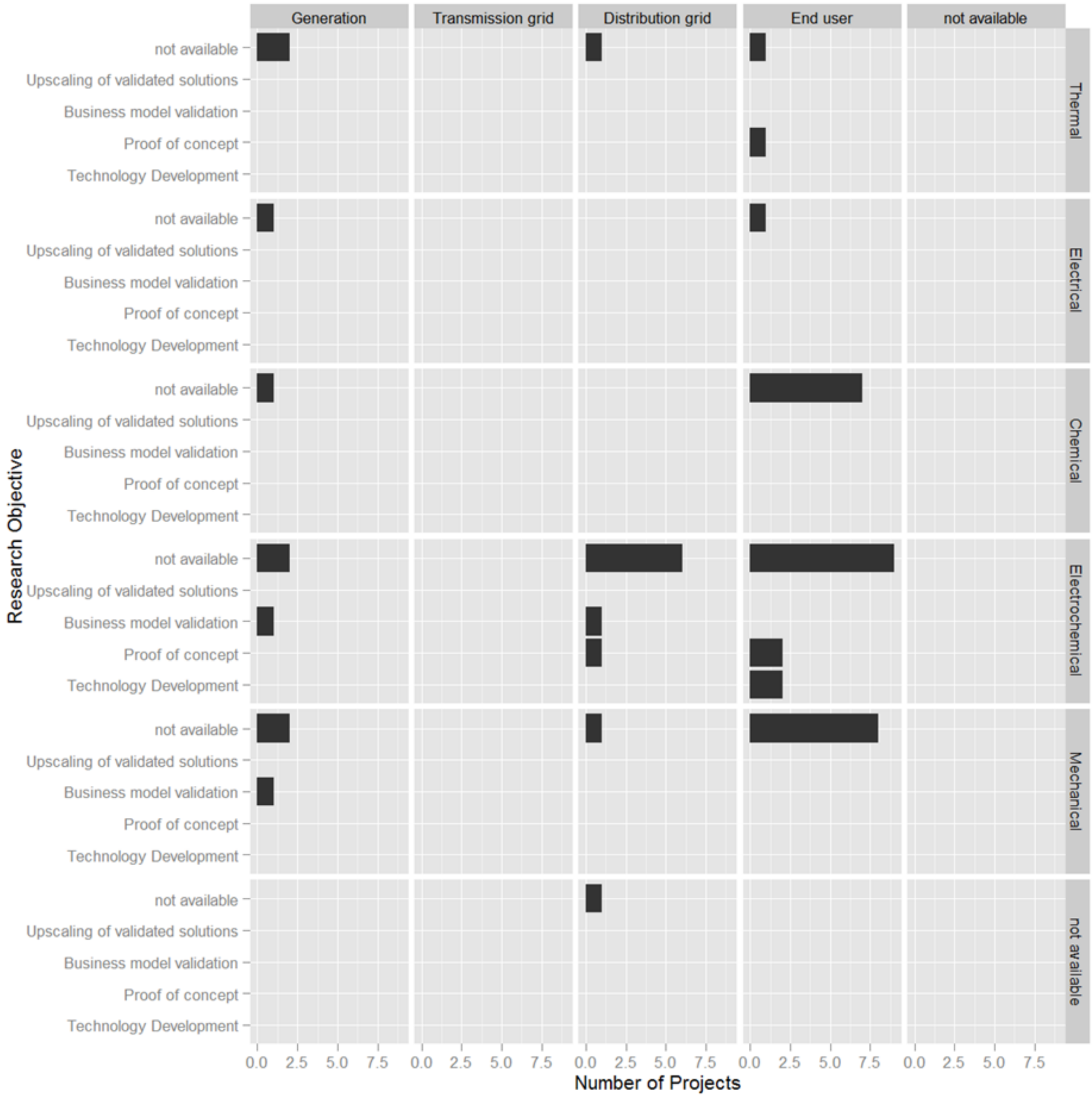

Figure 19: Number of projects according to the type of technology, the project's connection level and the projects readiness level.

5.1.1.2. Total budget

Figure 20 shows the total budget of projects according to the type of technology, the project's connection level and the projects readiness level. Again, some projects cover up to five types of technologies.

In general, it can be seen that the majority of the total budget of the projects is dedicated to technology development. A major part of the total budget of projects is partially or fully used for (see Figure 21) electrochemical storage technologies.

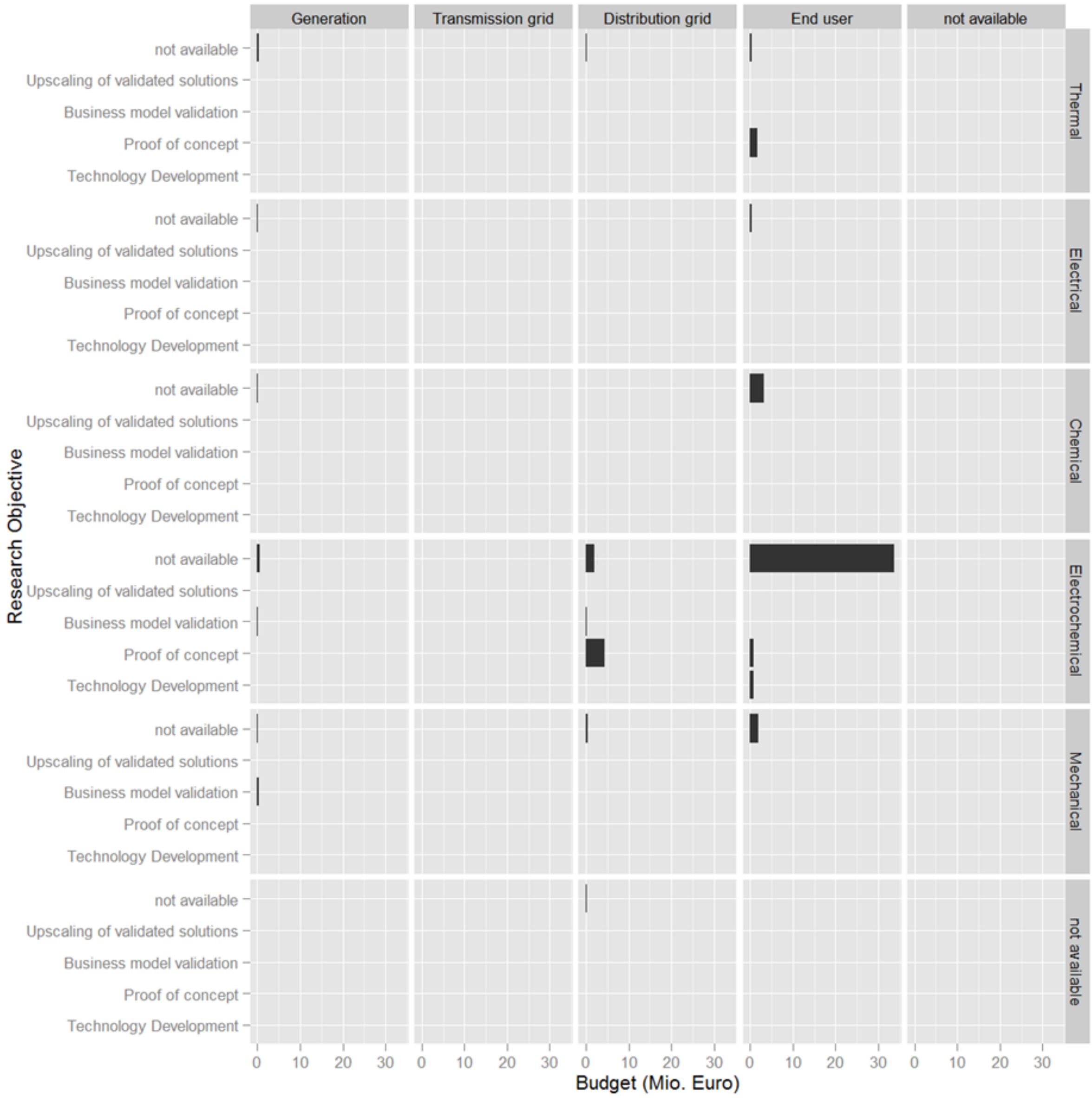

Figure 20: Project budget according to the type of technology, the project's connection level and the projects readiness level.

5.1.2. Specific storage related budget

Figure 21 shows the storage related budget of projects according to the type of technology, the project's connection level and the projects readiness level. Again, some projects cover up to five types of technologies.

Basically the budget is nearly exactly the same distributed as the total project budget (Figure 20). Most relevant are here some large projects addressing electric vehicles and technology development of Li-Ion batteries.

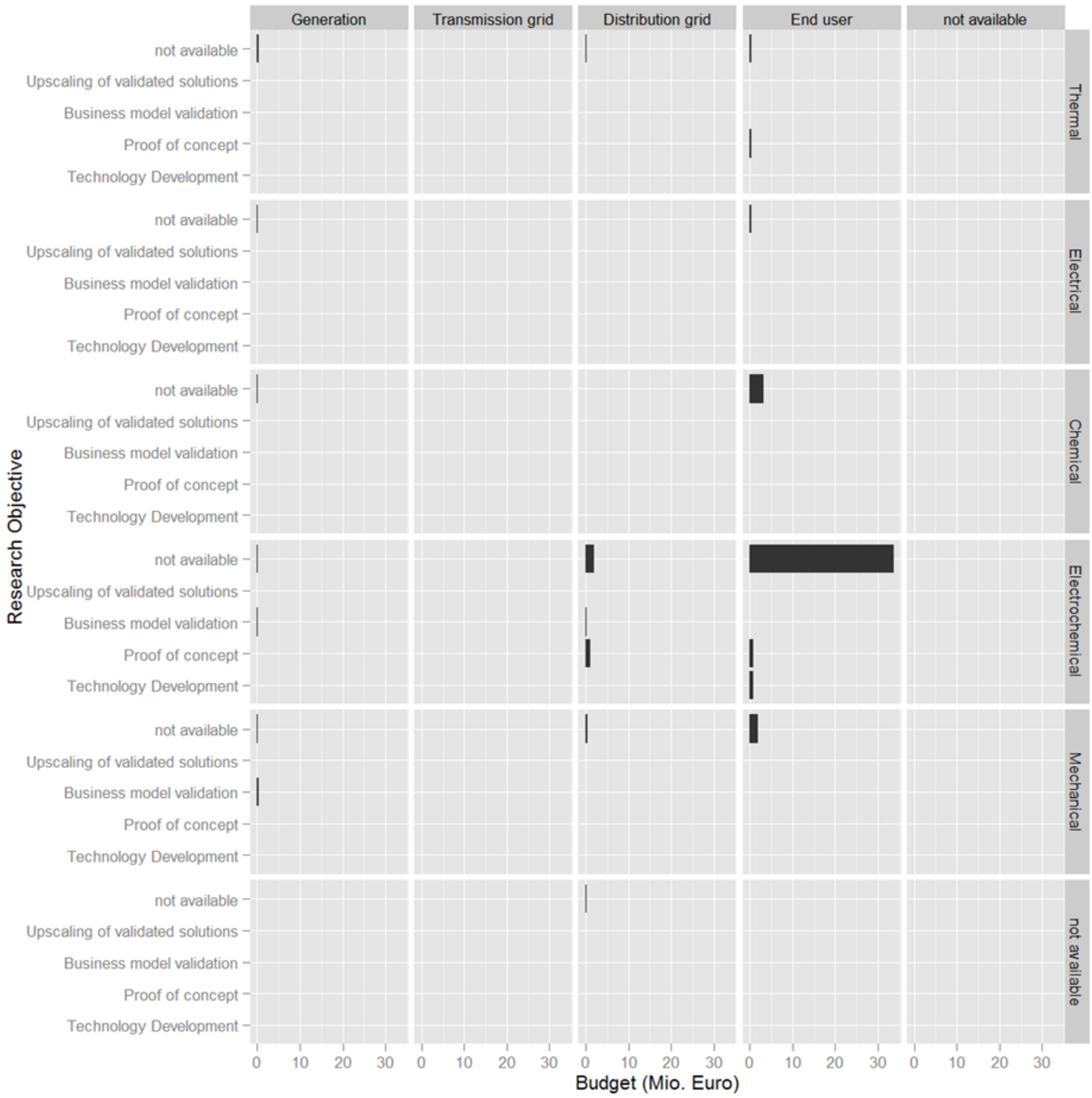

Figure 21: Specific storage related budget according to the type of technology, the project's connection level and the projects readiness level.

5.1.3. Project readiness level

Figure 22 shows the number of projects belonging to a specific technology readiness level according to the type of technology, the project's connection level and the project's nature.

There are no projects in Austria targeting a commercial deployment of storage systems and only one project addressing a pre commercial phase. This project however is only at the state of proof of concept. Two projects are large demo projects. The rest of the 47 projects are either research or first pilots whereas there are more research projects.

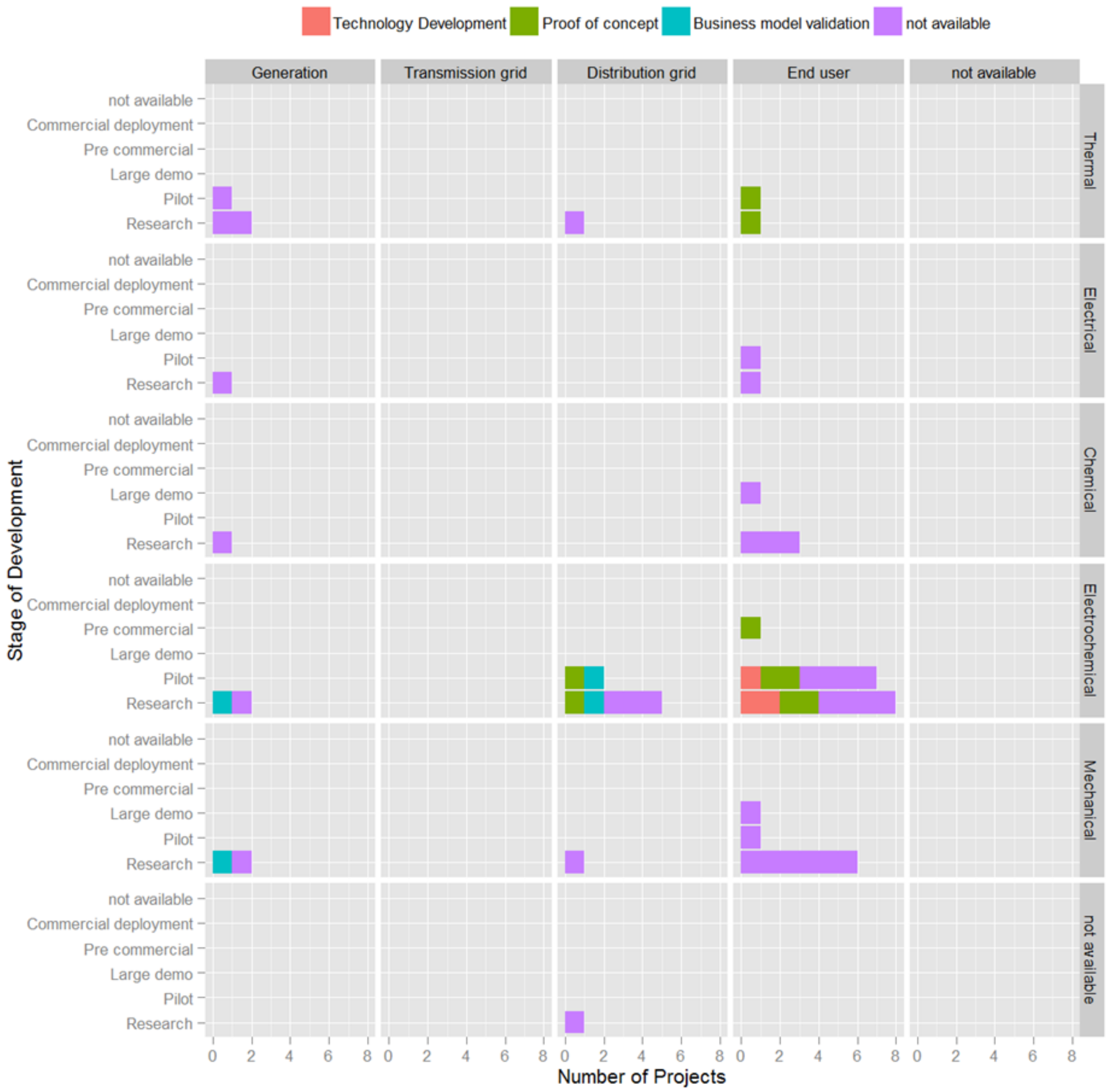

Figure 22: Storage readiness level according to the type of technology and the project's connection level.

5.2. Country fact sheet: Belgium

5.2.1. Overall situation

The analysis of the EEGI storage mapping questionnaires shows that in Belgium totally 9 projects deal with storage solutions. The total budget of these projects amounts to 12,33 Mio. Euro, representing about 1,4% of the total budget of the countries covered by the EEGI storage mapping activity. These projects are not solely and exclusively dedicated to storage solutions, but they also consider storage application in the context of concepts such as smart grids, smart cities, building integration, data centres. Attention is given to both thermal and electrical/electrochemical technologies. The storage related budget within these projects is estimated at around 3,07 Mio. Euro (about 25% of the total budget).

5.2.1.1. Number of projects

Figure 23 shows the number of projects according to the type of technology, the project's connection level and the projects readiness level. Some projects cover several types of technologies. This is also indicated.

There are no projects documented with a strong market push (pre-commercial or commercial). Nevertheless, it can be seen that about half of the projects combine either research and pilots or pilots and large demonstrations. The other half of the projects is research, typically focussed on technology development. Projects with focus on mechanical storage were not found, but this could be explained partly by the absence of fully privately organized research projects in the project matrix.

In general, most projects belong to the end user level and the distribution grid. Projects deal primarily with thermal and electrochemical storage technologies. No projects were found with a primary focus on mechanical or chemical storage. Finally, the majority of the total project budgets fall within the technology development or the proof of concept readiness levels. None of the projects specifically target business model validation or at up scaling of validated solution readiness level.

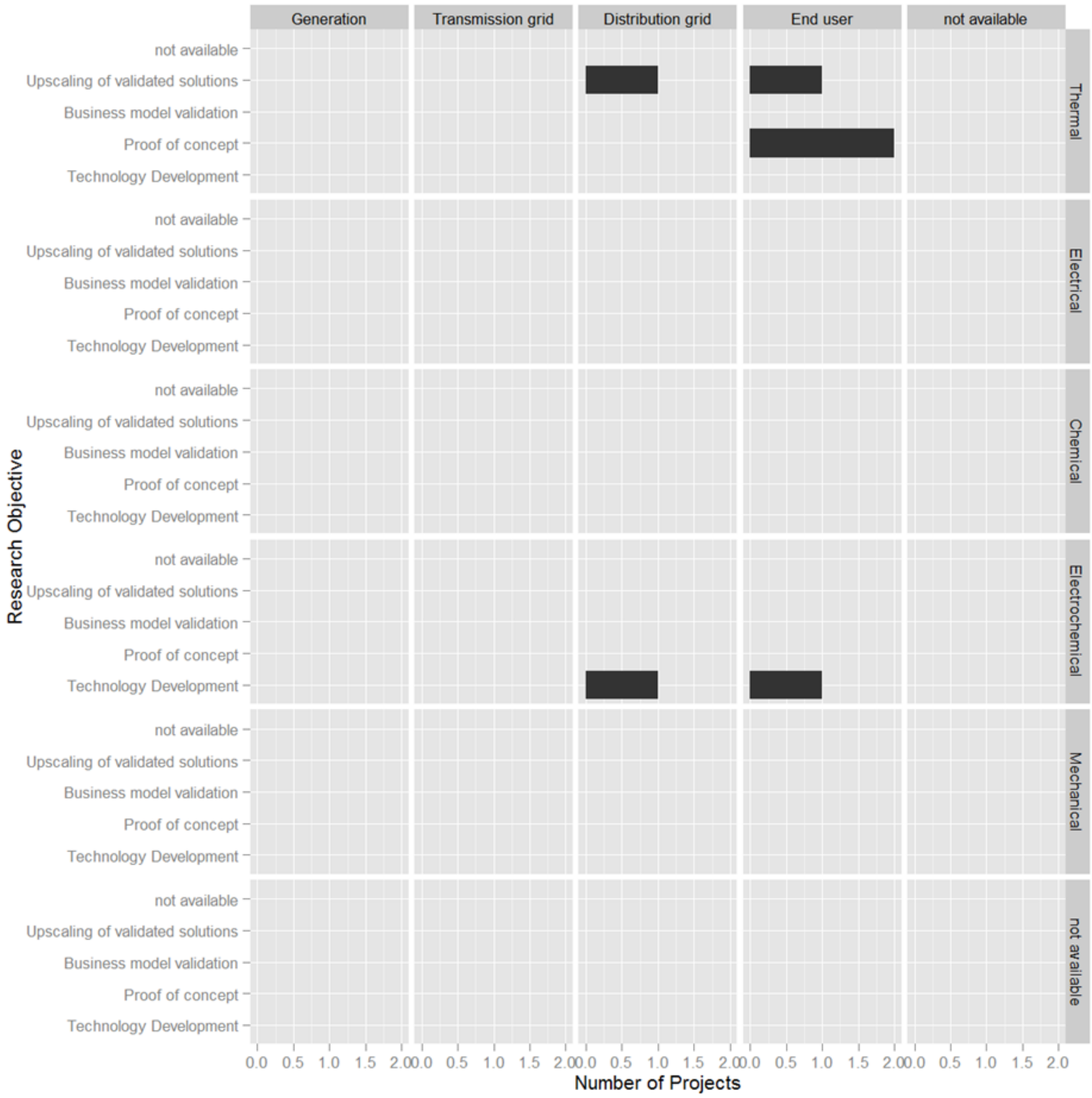

Figure 23: Number of projects according to the type of technology, the project's connection level and the projects readiness level.

5.2.1.2. Total budget

Figure 24 shows the total budget of projects according to the type of technology, the project's connection level and the projects readiness level. Again, some projects combine multiple technologies. Electrochemical technology development represents the largest part of the budget.

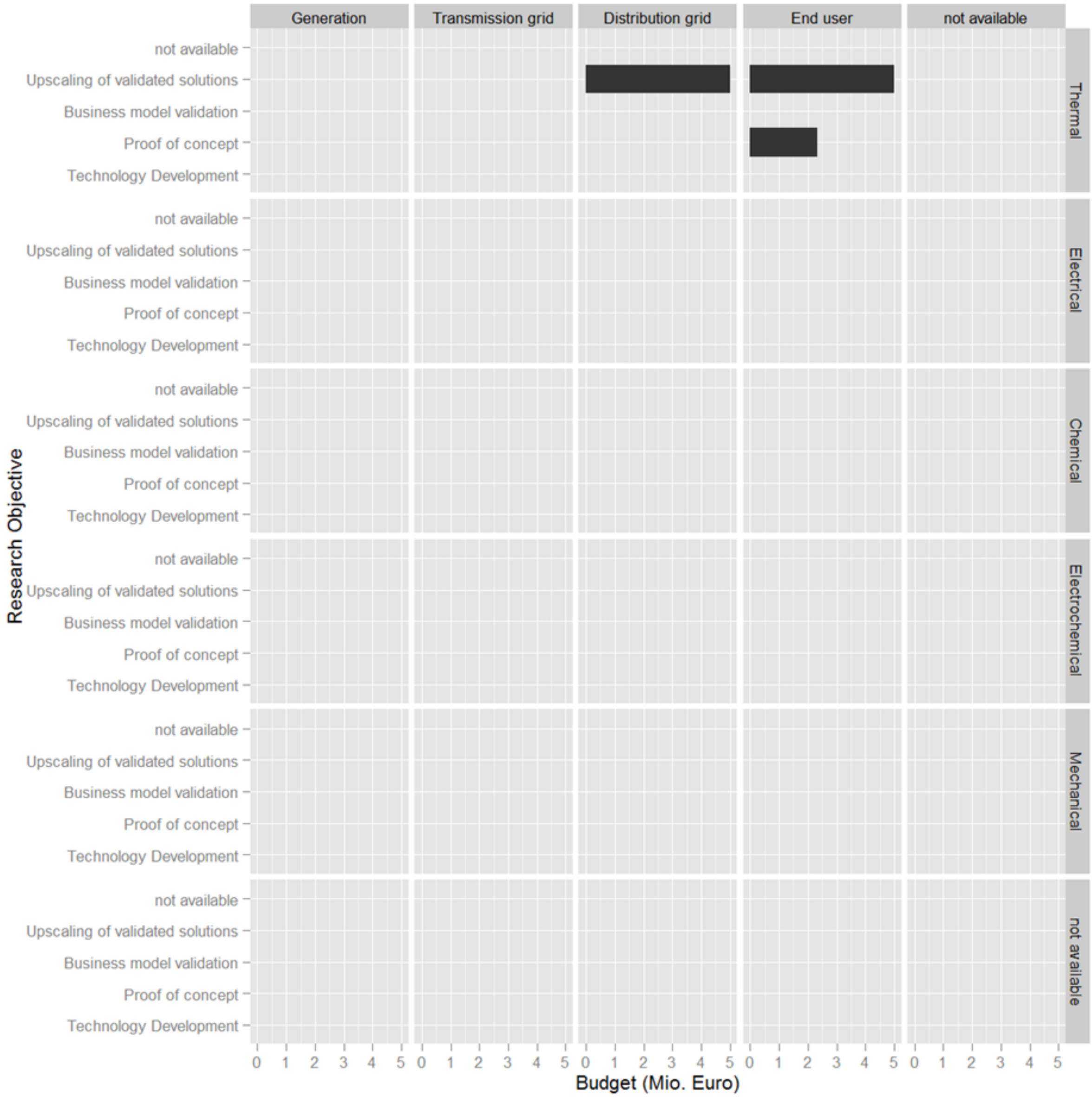

Figure 24: Project budget according to the type of technology, the project's connection level and the projects readiness level.

5.2.2. Specific storage related budget

Figure 25 shows the storage related budget of projects according to the type of technology, the project's connection level and the projects readiness level.

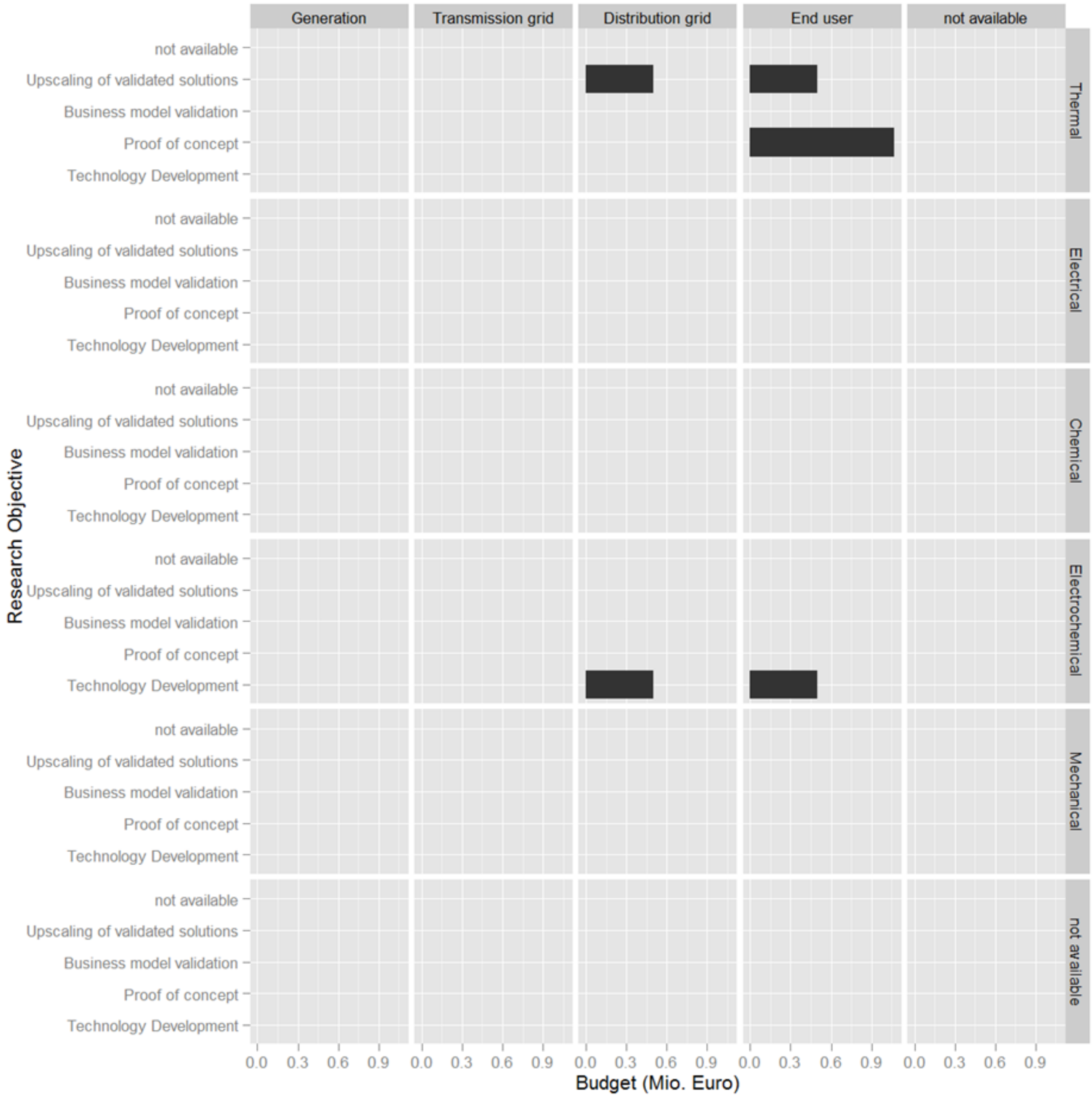

Figure 25: Specific storage related budget according to the type of technology, the project's connection level and the projects readiness level.

5.2.3. Project readiness level

Figure 26 shows the number of projects belonging to a specific technology readiness level according to the type of technology, the project's connection level and the project's nature.

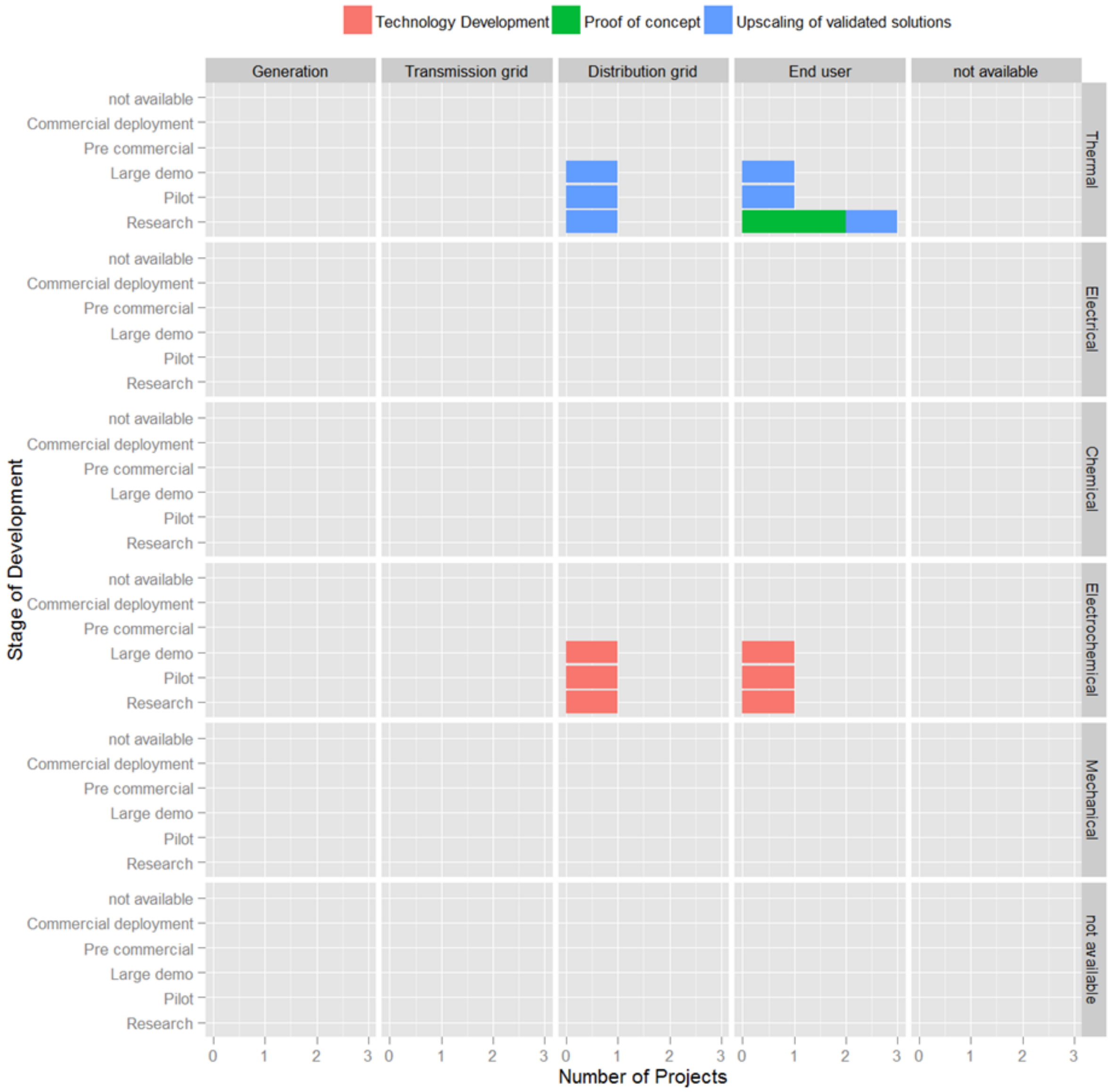

Figure 26: Storage readiness level according to the type of technology and the project's connection level.

5.3. Country fact sheet: Germany

5.3.1. Overall situation

The analysis of the EEGI storage mapping questionnaires shows that in Germany totally 41 projects deal with storage solutions. No other country has this many projects. Nevertheless, the project data quality varies, primarily in the axes of technology and power system integration level. Budget information is considered to be accurate. The total budget of these projects amounts to 159,29 Mio. Euro, representing about 15% of the total budget of the countries covered by the EEGI storage mapping activity. These projects are not solely and exclusively dedicated to the technology development of storage components and systems, but they also consider storage application in the context of concepts such as smart grids and smart regions. Projects are document along all technology axes. The storage related budget within these projects is estimated at around 41 Mio. Euro (about 23% of the total budget).

5.3.1.1. Number of projects

Figure 27 shows the number of projects according to the type of technology, the project's connection level and the projects readiness level. Some projects cover several types of technologies. Some of the projects cover a multiple technologies. Technology development is considered the primary objective.

Few projects are found with a strong market push (pre-commercial or commercial). Nevertheless, it can be seen that a lot of the projects focus on research. Pilots and large demonstrations are next.

In general, most projects belong to the end user level and the distribution grid. Projects deal primarily with electrochemical, thermal and chemical storage technologies. Few projects consider electrical and mechanical concepts. Finally, the majority of the total project budgets fall within the technology development. Secondly, some projects specifically target business model validation.

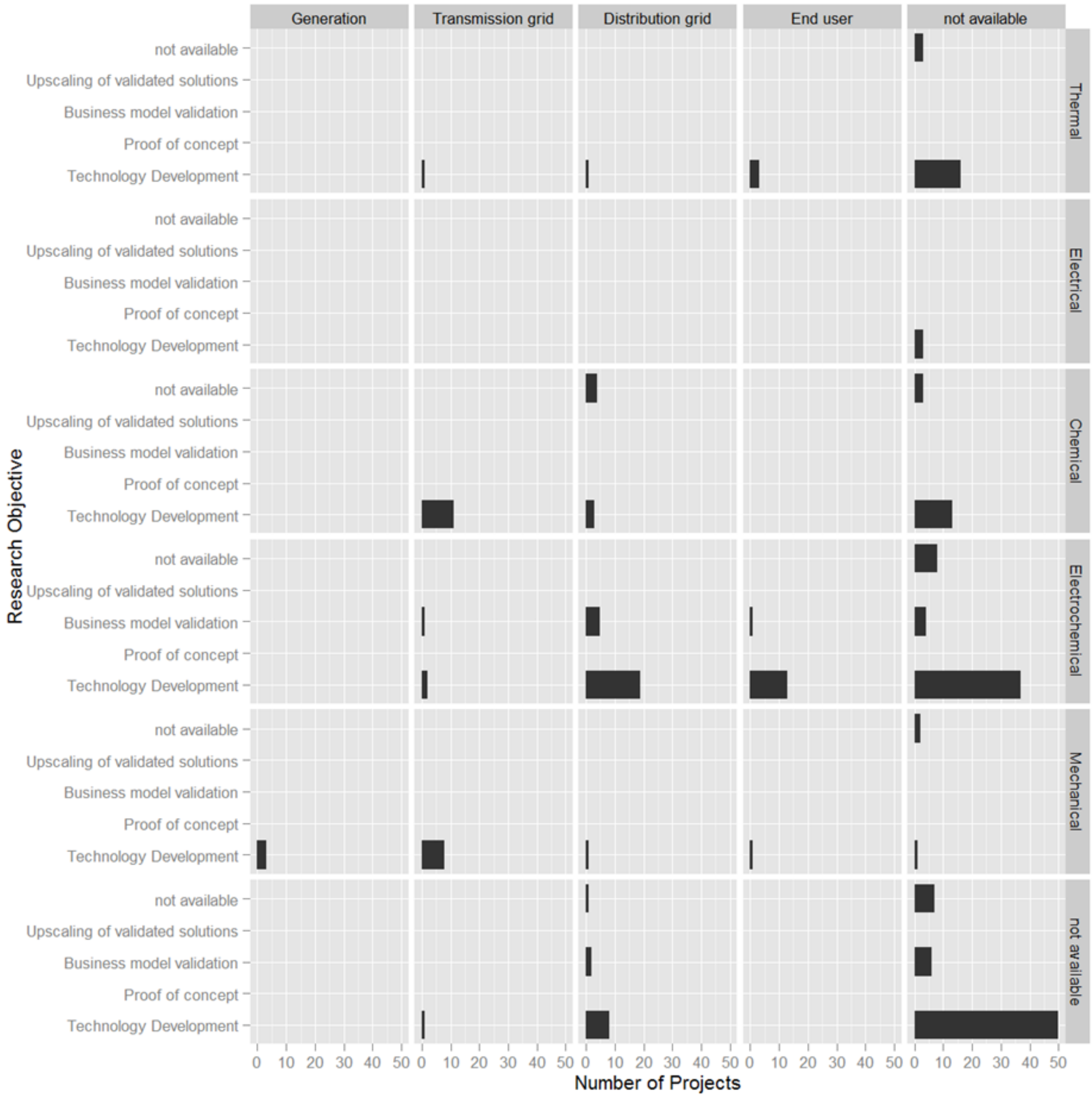

Figure 27: Number of projects according to the type of technology, the project's connection level and the projects readiness level.

5.3.1.2. Total budget

Figure 28 shows the total budget of projects according to the type of technology, the project's connection level and the projects readiness level. Again, some projects combine multiple technologies. Electrochemical technology development represents the largest part of the budget.

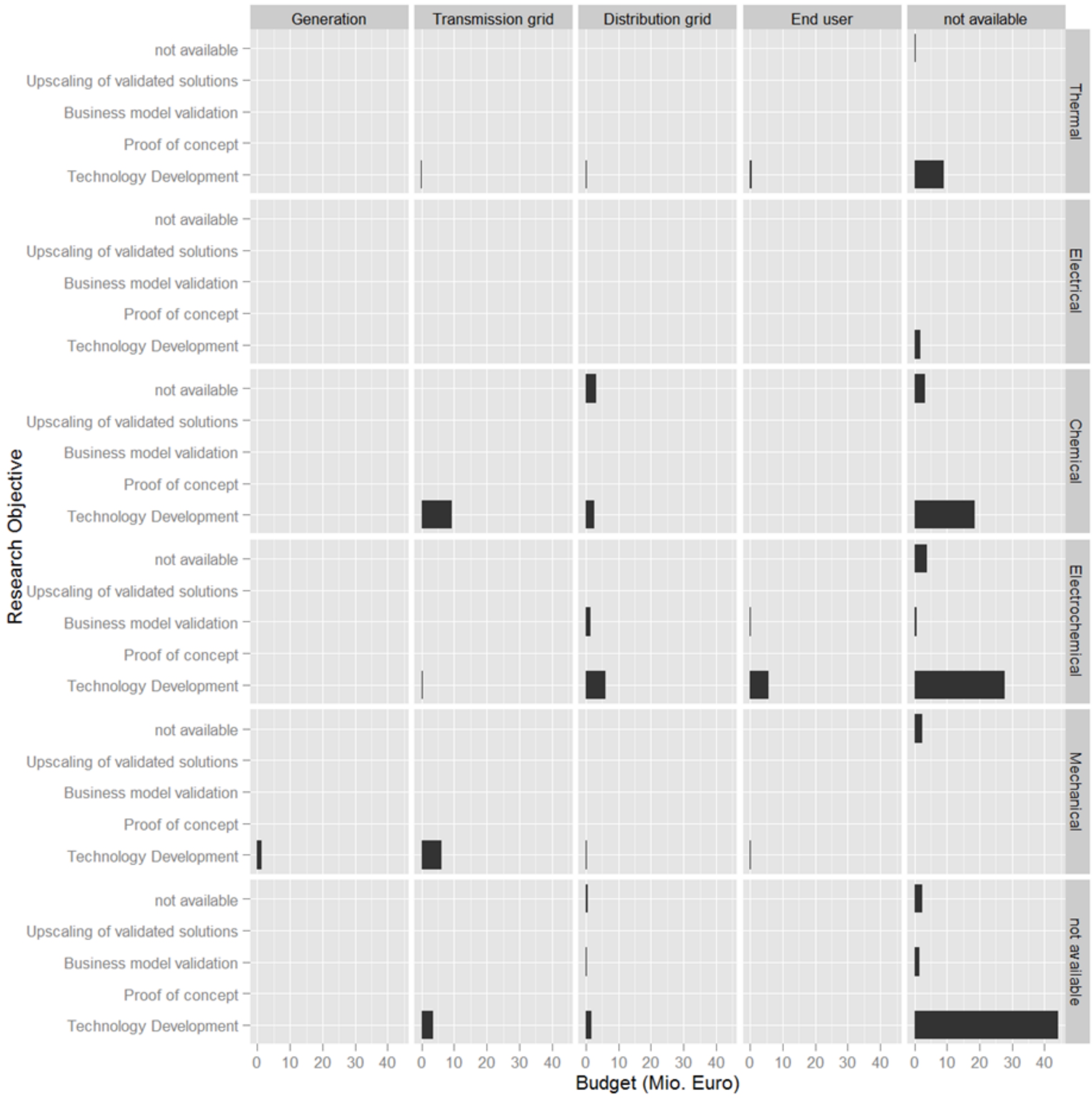

Figure 28: Project budget according to the type of technology, the project's connection level and the projects readiness level.

5.3.2. Specific storage related budget

Figure 29 shows the storage related budget of projects according to the type of technology, the project's connection level and the projects readiness level.

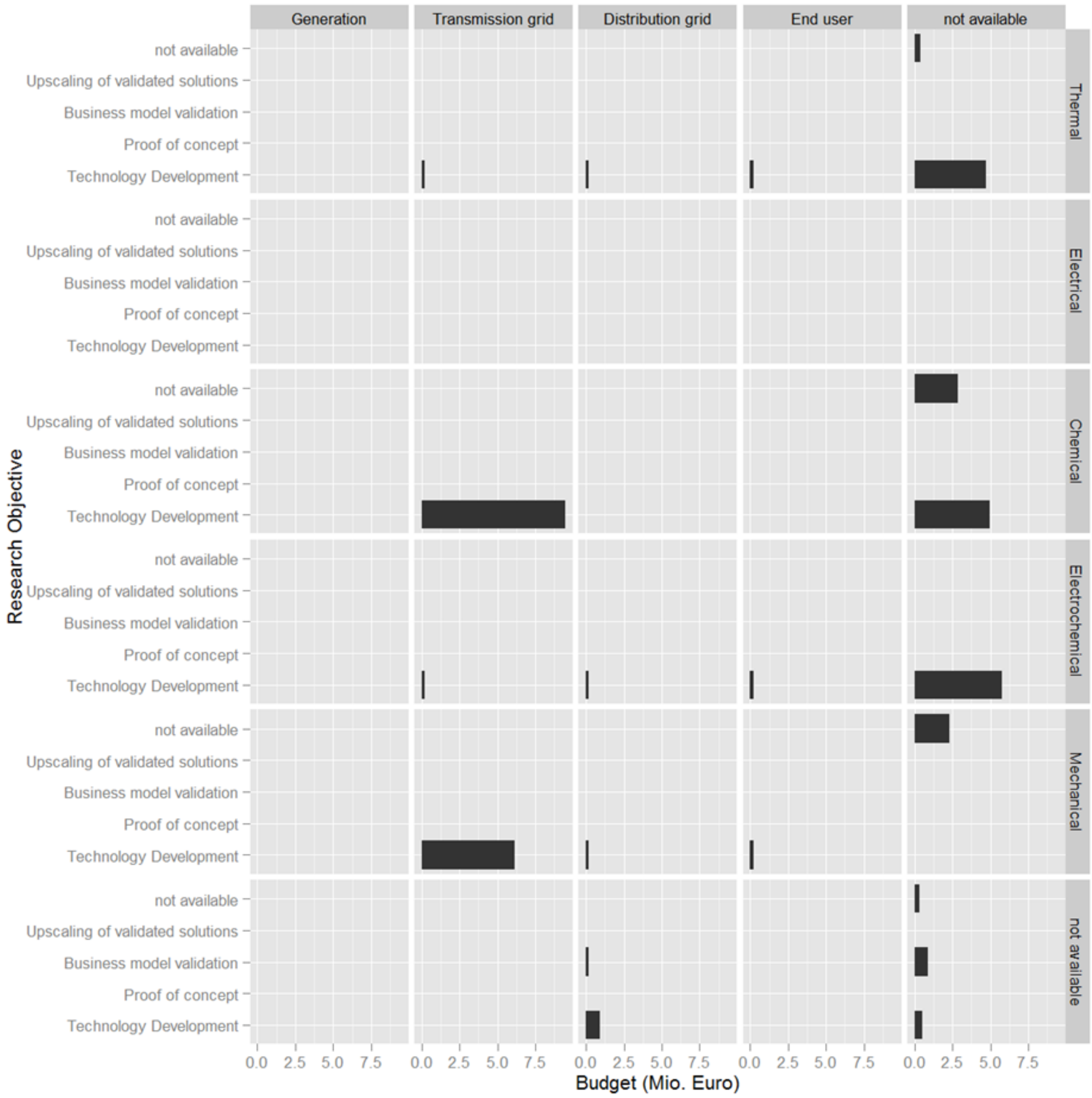

Figure 29: Specific storage related budget according to the type of technology, the project's connection level and the projects readiness level.

5.3.3. Project readiness level

Figure 30 shows the number of projects belonging to a specific technology readiness level according to the type of technology, the project's connection level and the project's nature.

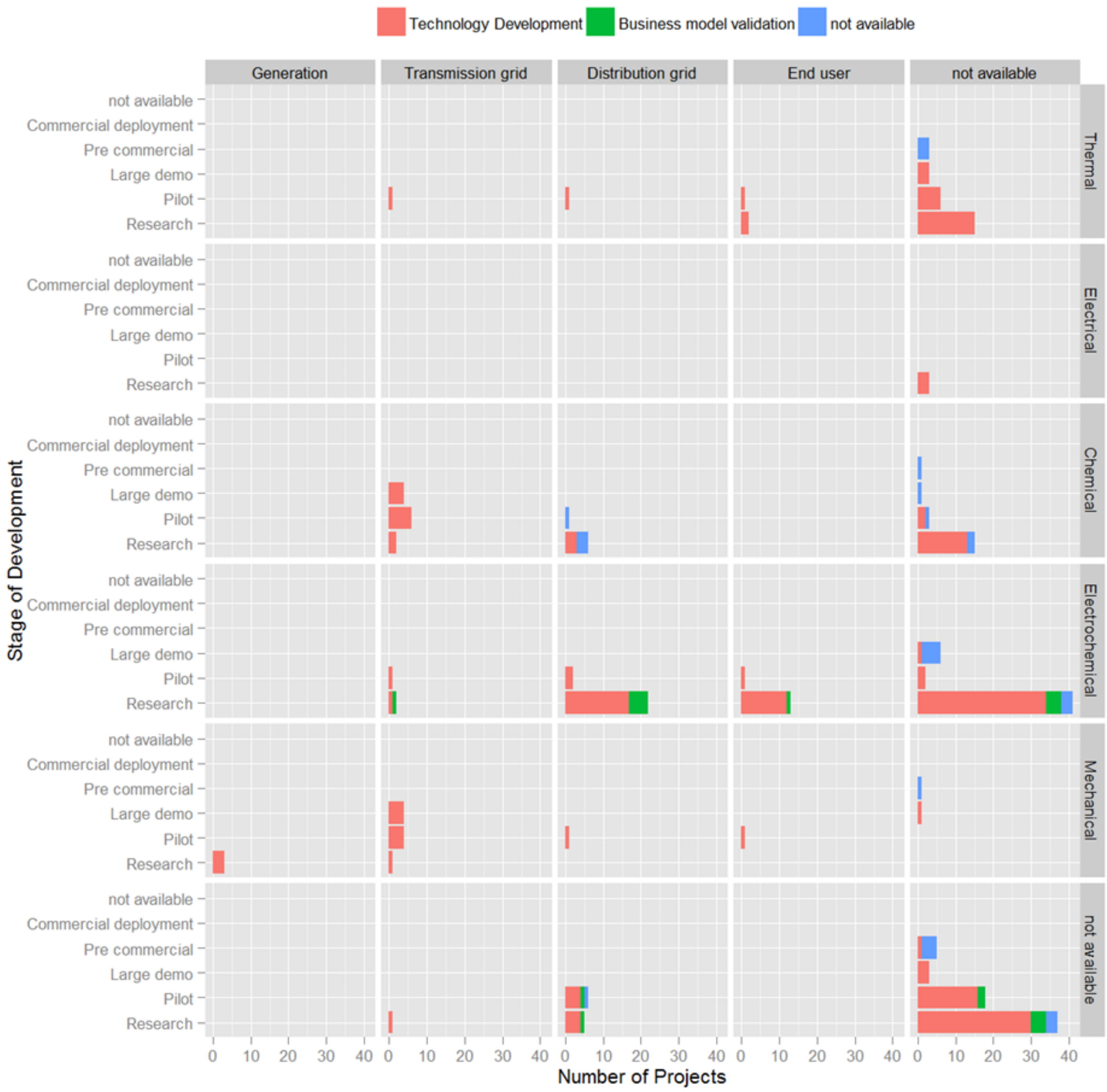

Figure 30: Storage readiness level according to the type of technology and the project's connection level.

5.4. Country fact sheet: Denmark

5.4.1. Overall situation

The analysis of the EEGI storage mapping questionnaires shows that in Denmark totally 25 projects deal with storage solutions. The total budget of these projects amounts to 40.86 Mio. Euro, less than 10% of the total budget of the countries covered by the EEGI storage mapping activity. However, these projects are not solely and exclusively dedicated to storage solutions. Congruently, the storage related budget amounts to 32.12 Mio. Euro (about 80% of the total budget).

5.4.1.1. Number of projects

Figure 31shows the number of projects according to the type of technology, the project's connection level and the projects readiness level and the number of technology types covered. Except electrical storage systems all types of technologies (mechanical, chemical, electrochemical and thermal) are covered. Significant to mention is the number of thermal storage projects on both the end user and distribution level. Chemical storage system projects are mostly allocated in the transmission grid. All in all most projects are allocated in the distribution and transmission grid. End user and generation located storage systems are only addressed in 6 projects.

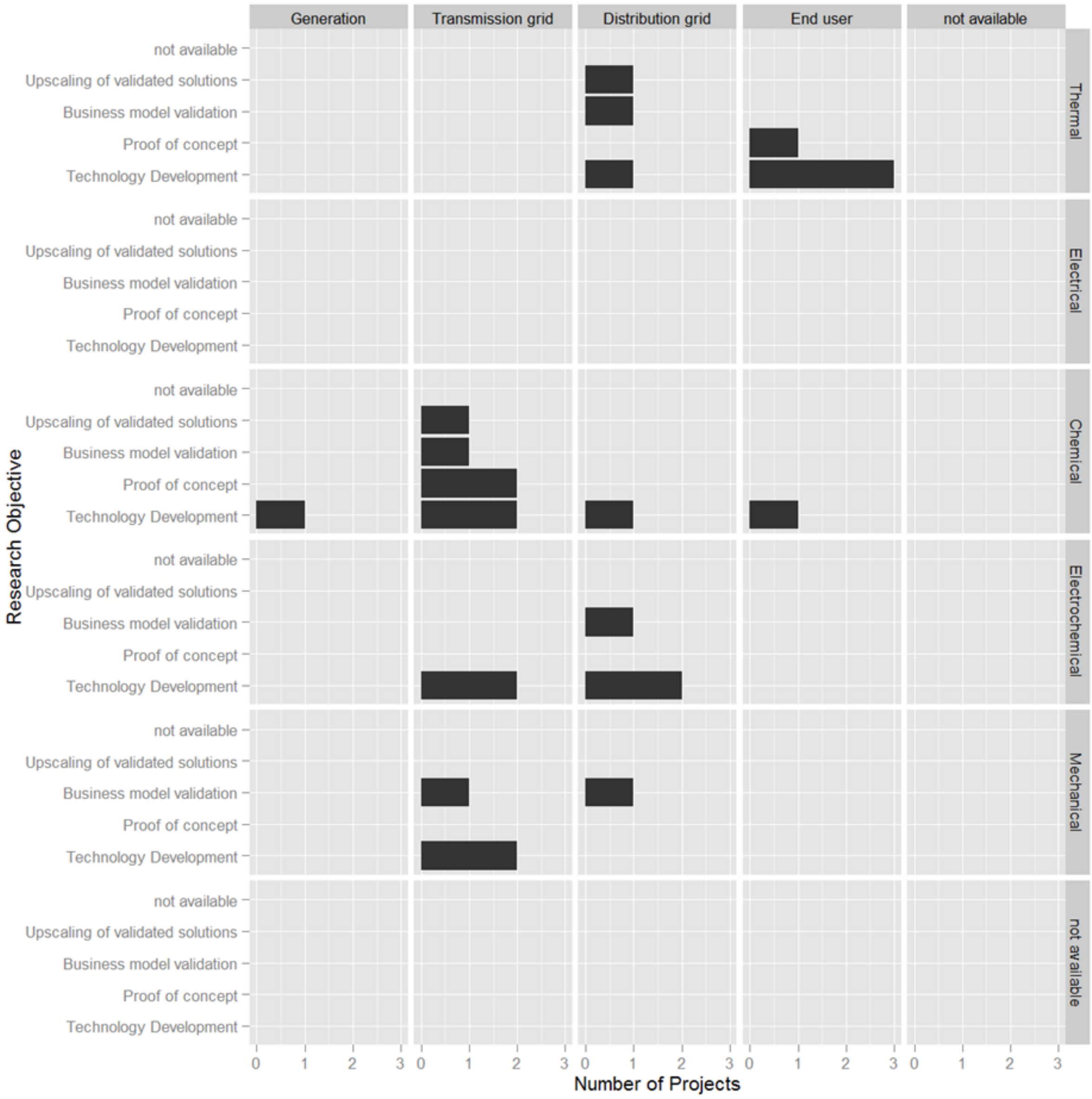

Figure 31: Number of projects according to the type of technology, the project's connection level and the projects readiness level.

5.4.1.2. Total budget

Figure 32 shows the total budget of projects according to the type of technology, the project's connection level and the projects readiness level.

The total budget of the project analysed is mainly distributed between transmission grid projects and distribution grid projects. Along the technologies most money is spend on chemical and electrochemical storage systems. This indicates that the projects addressing thermal storage are a larger number of small projects. A majority of the projects address the technology development of storage systems for all types of technologies.

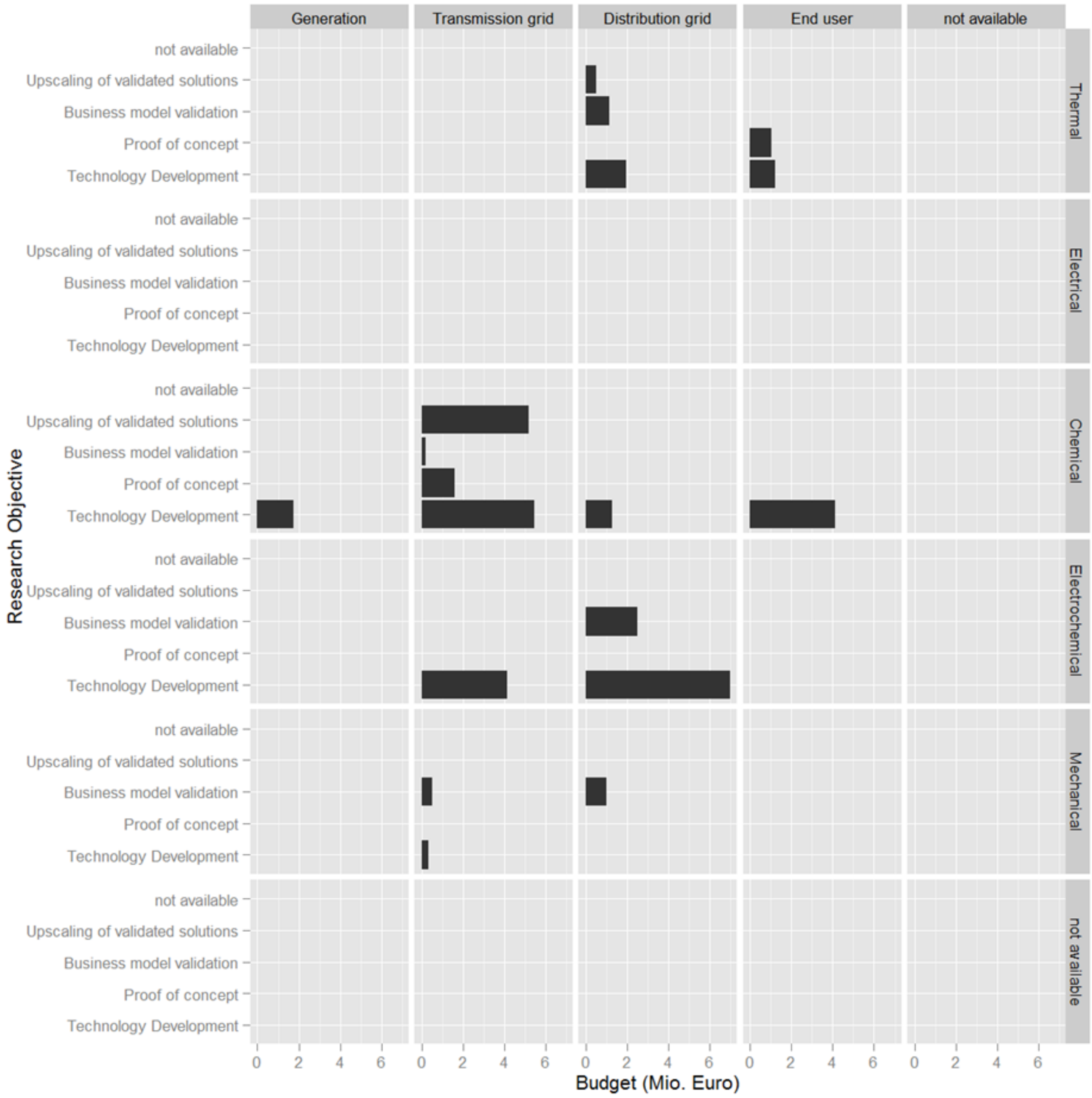

Figure 32: Project budget according to the type of technology, the project's connection level and the projects readiness level.

5.4.2. Specific storage related budget

Figure 33 shows the storage related budget of projects according to the type of technology, the project's connection level and the projects readiness level.

Basically the same picture is in Figure 32 can be seen except one project addressing chemical storage on the end user level. Here only a part of the project addresses storage.

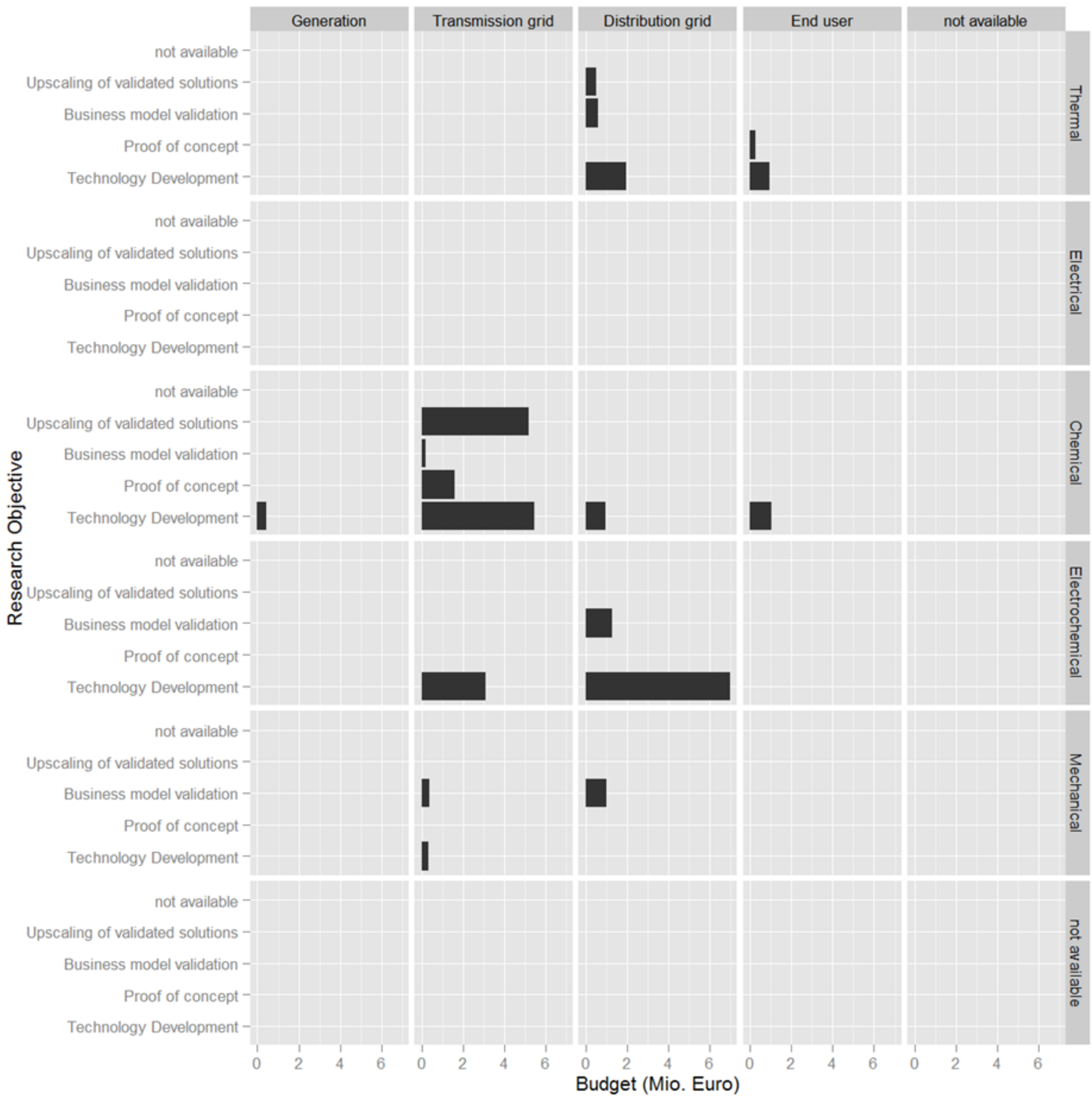

Figure 33: Specific storage related budget according to the type of technology, the project's connection level and the projects readiness level.

5.4.3. Project readiness level

Figure 34 shows the number of projects belonging to a specific technology readiness level according to the type of technology, the project's connection level and the project's nature.

The basic picture relates to the overall picture: The majority of the projects address research and some pilot projects. Outstanding is that there are two projects in the pre commercial phase implementing thermal storage and one addressing a large demo. There is as well one large demo project on-going for chemical storage in the transmission grid.

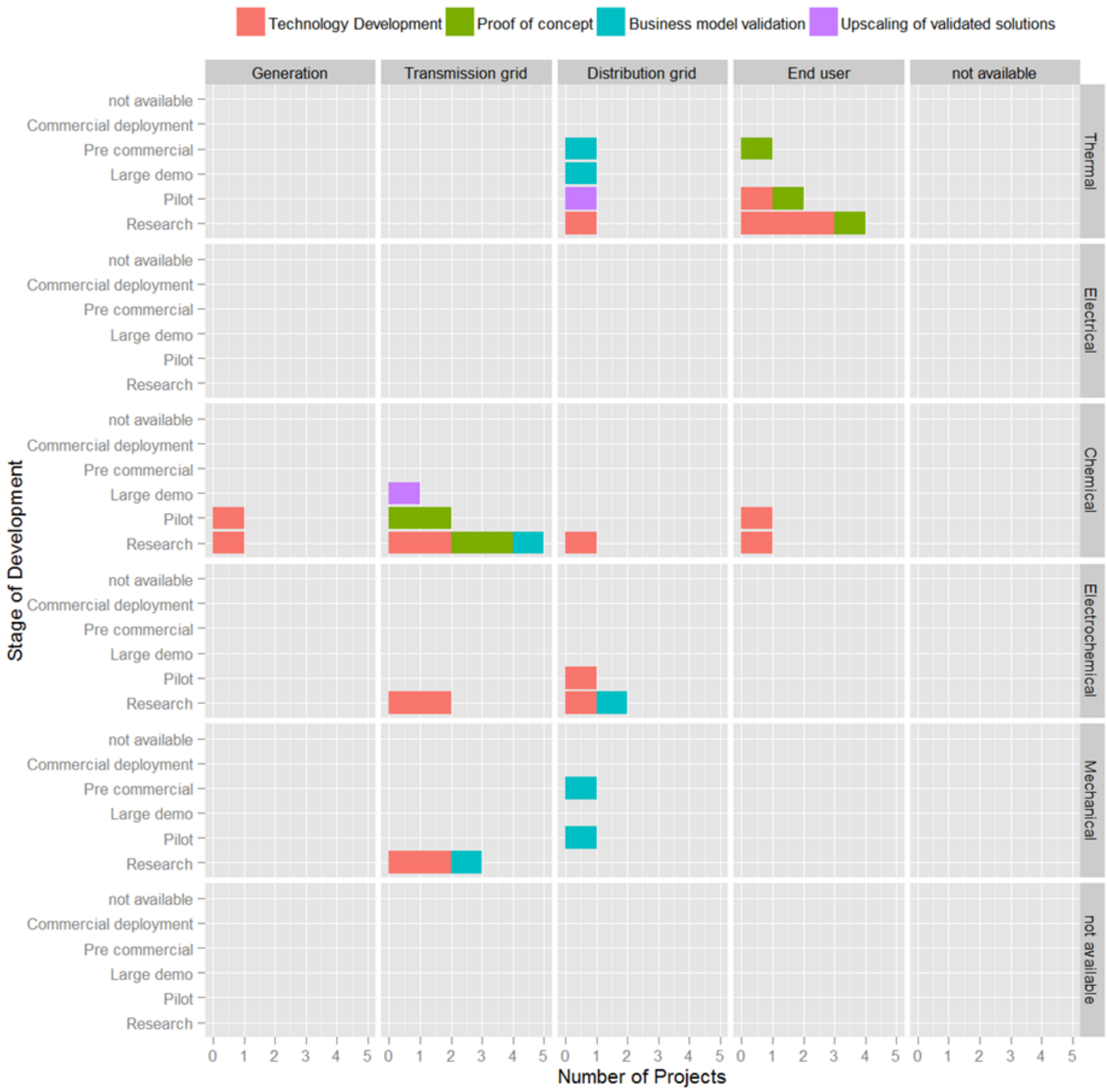

Figure 34: Storage readiness level according to type of technology and project's connection level.

5.5. Country fact sheet: Spain

5.5.1. Overall situation

The analysis of the EEGI storage mapping questionnaires shows that in Spain totally 47 projects deal with storage solutions (another 27 projects are classified as European projects). The total budget of these projects amounts to 58.8 Mio. Euro, slightly less than 6% of the total budget of the countries covered by the EEGI storage mapping activity. However, these projects are not solely and exclusively dedicated to storage solutions, but they also tackle higher level concepts such as microgrids and smart grids or they include projects researching in advanced materials. Congruently, the storage related budget amounts to 40.09 Mio. Euro (about 70% of the total budget).

5.5.1.1. Number of projects

Figure 35shows the number of projects according to the type of technology, the project’s connection level and the projects readiness level. Some projects cover several types of technologies. This is also indicated. For example, it can be seen that three projects deal with thermal storage solutions connected at the End user level and currently Proof of concept readiness level. Among these three projects, two cover one technology only, whereas one covers two technologies.

In general, it can be inferred that most projects belong to the End user level or they have not specified the project’s connection level. Further, most projects deal with chemical or electrochemical storage technologies, followed by thermal and electrical storage technologies and by cases without specified technologies. Only few are designated to mechanical storage. Finally, the majority of the total project budgets fall within the technology development or the proof of concept readiness levels. Very few are at the business model validation or at up-scaling of validated solution readiness level.

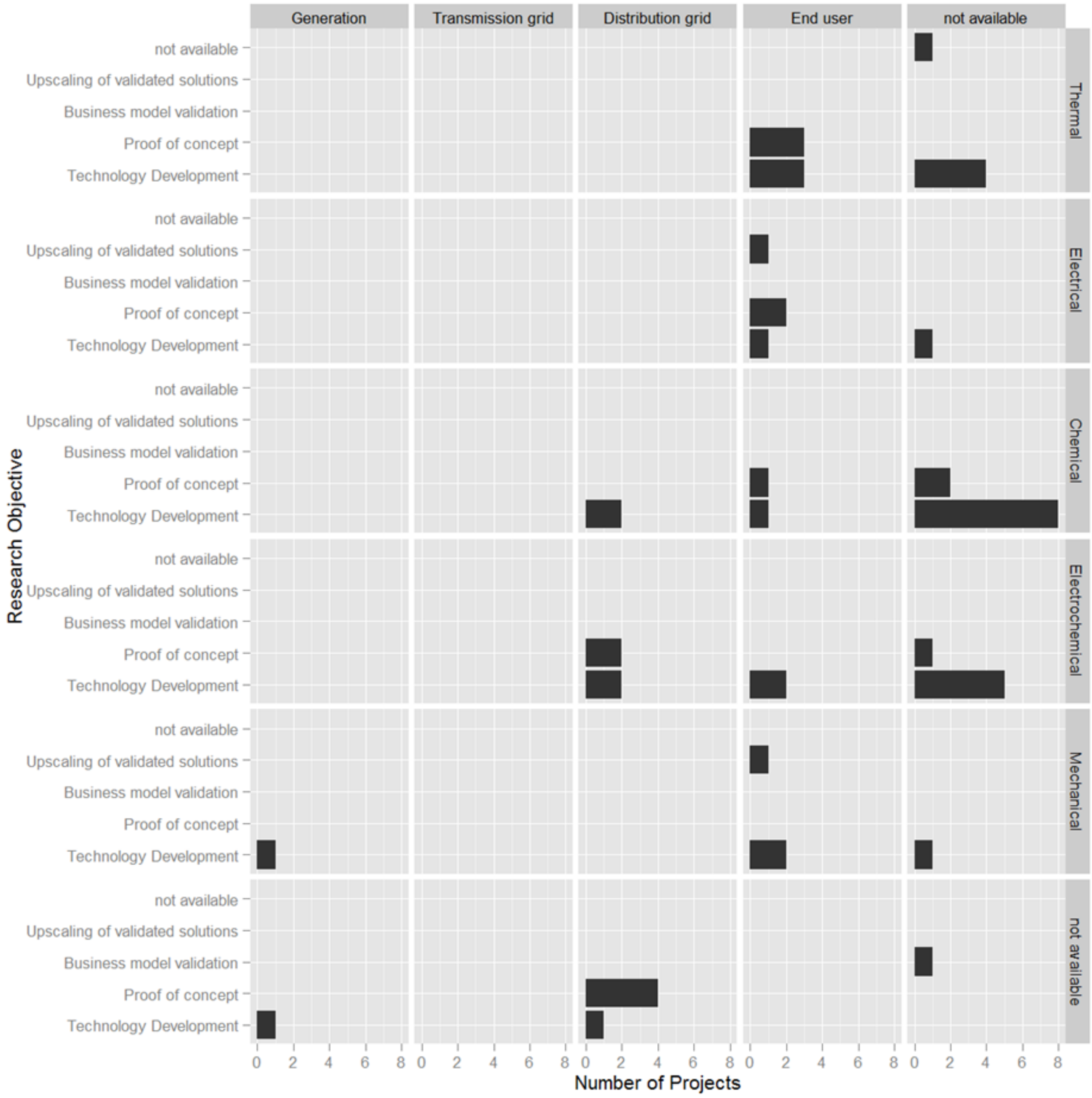

Figure 35: Number of projects according to the type of technology, the project's connection level and the projects readiness level.

5.5.1.2. Total budget

Figure 36 shows the total budget of projects according to the type of technology, the project's connection level and the projects readiness level. Again, some projects cover up to three types of technologies.

In general, it can be inferred that unlike suggested in Figure 35, the majority of the total budget of the projects is dedicated to solutions connected at the

Local/distribution grid level or they have not specified the project's connection level. A major part of the total budget of projects is partially or fully used for (see Figure 37) chemical or electrochemical storage technologies, followed by thermal and electrical storage technologies. Finally, the majority of the total budget of projects is used for storage solutions falling within the technology development or the proof of concept readiness levels. A small amount of total budget is dedicated to solutions at the business model validation or at up-scaling of validated solution readiness level.

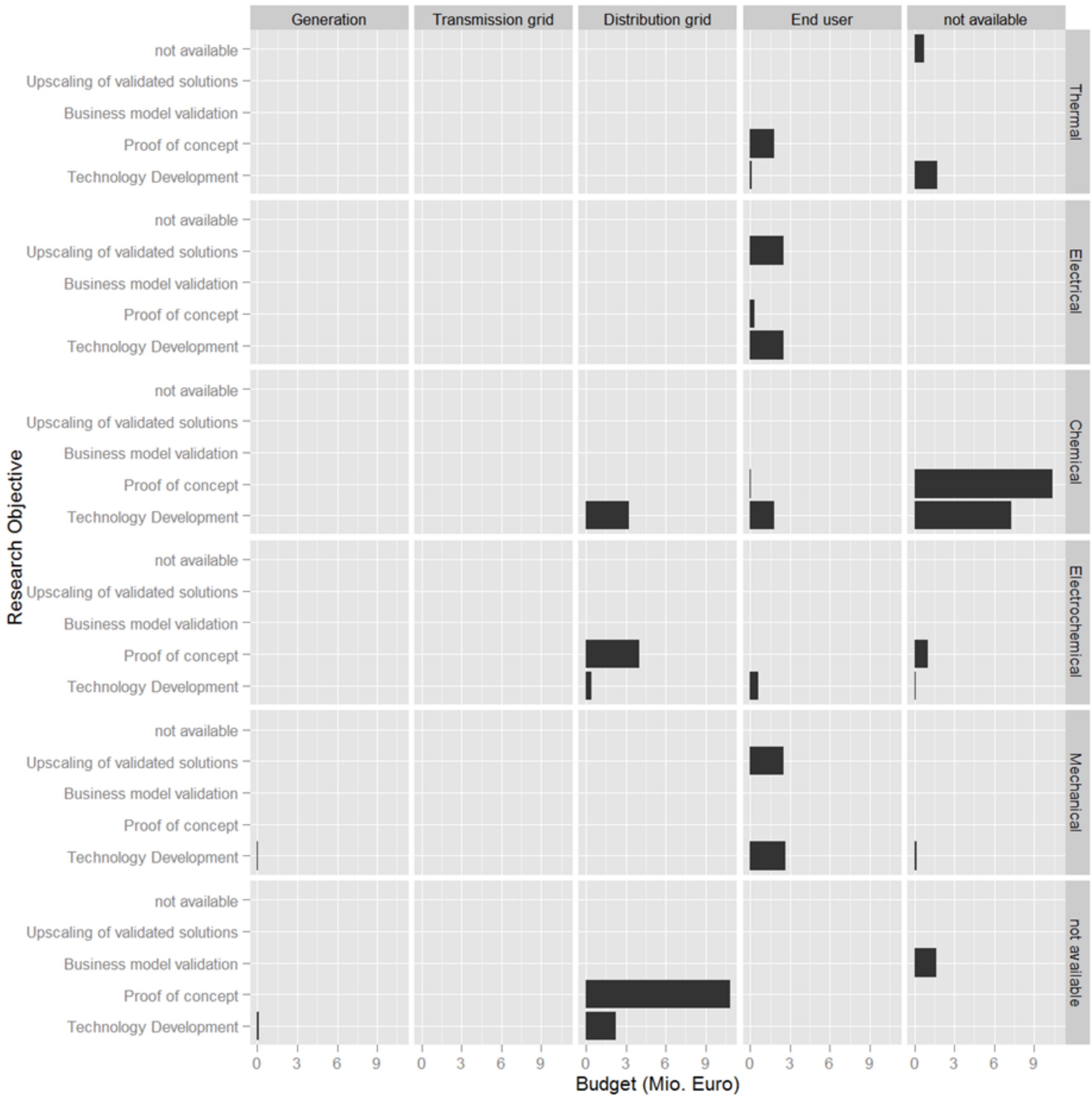

Figure 36: Project budget according to the type of technology, the project's connection level and the projects readiness level.

5.5.2. Specific storage related budget

Figure 37 shows the storage related budget of projects according to the type of technology, the project's connection level and the projects readiness level. Again, some projects cover up to three types of technologies.

In general, it can be inferred that similar to Figure 36, the majority of the storage related budget of the projects is dedicated to solutions connected at the Local/distribution grid level or they have not specified the project's connection level. A major part of the storage related budget of projects is designated to chemical or electrochemical storage technologies, followed by thermal and electrical storage technologies. The storage related budget of mechanical or non-specified technologies is readily smaller. Finally, the majority of storage related budget are used for storage solutions falling within the technology development or the proof of concept readiness levels. A smaller fraction of storage related budget can be found at the business model validation or at up-scaling of validated solution readiness level.

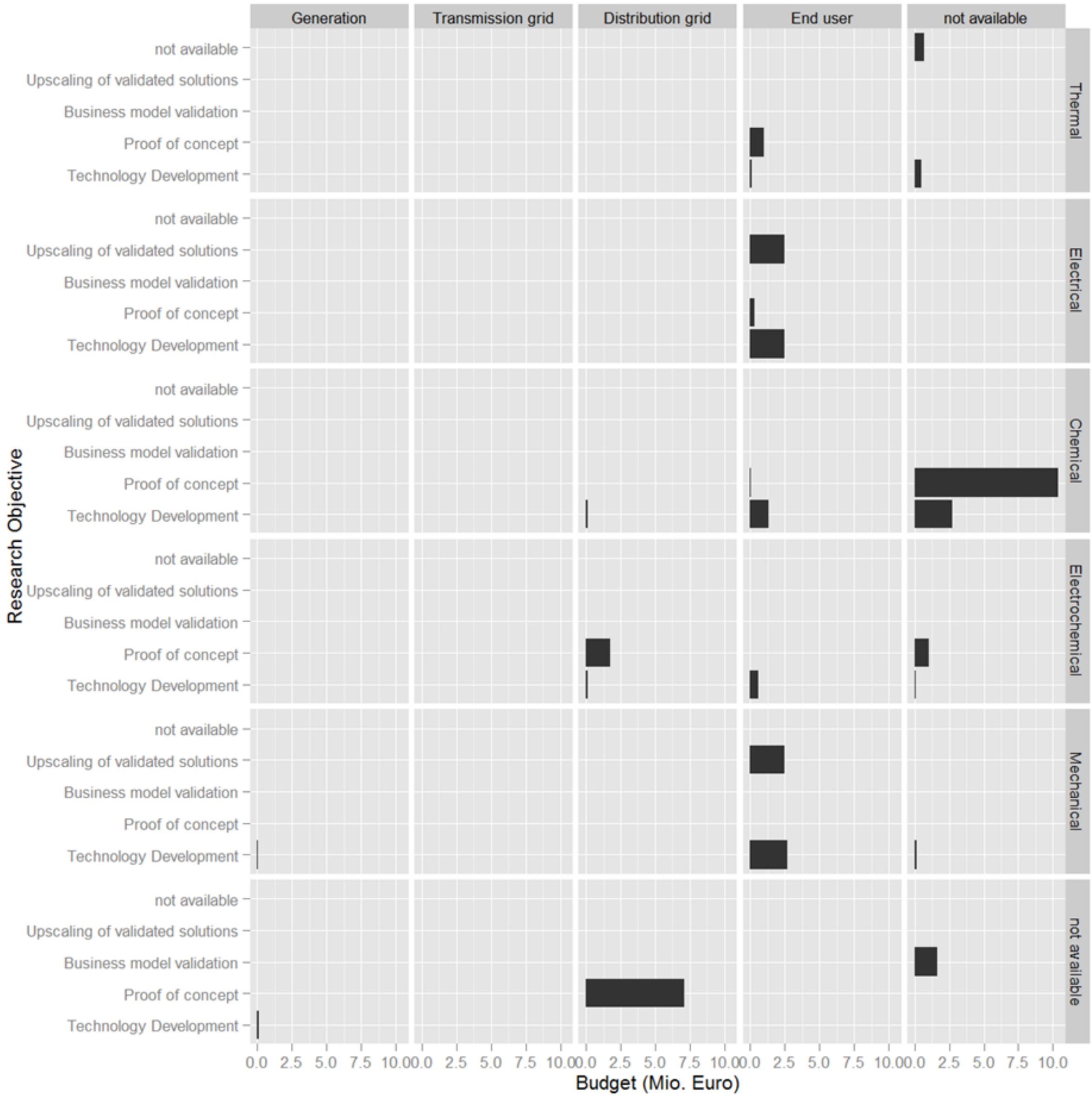

Figure 37: Specific storage related budget according to the type of technology, the project's connection level and the projects readiness level.

5.5.3. Project readiness level

Figure 38 shows the number of projects belonging to a specific technology readiness level according to the type of technology, the project's connection level and the project's nature.

In general, it can be inferred that a clear majority of the projects are technology development projects at the research or pilot stage. Some proof of concepts projects also exist. A much smaller amount of projects are at the large-scale demo or the pre-commercial stage. Only four projects are at the commercial deployment stage. Note the interesting occurrence of a technology development project at the commercial deployment stage. This is due to the fact that parts of the projects are also at the research and the pilot stage. Finally, note again the clear dominance of chemical or electrochemical storage technologies, followed by thermal and electrical storage technologies.

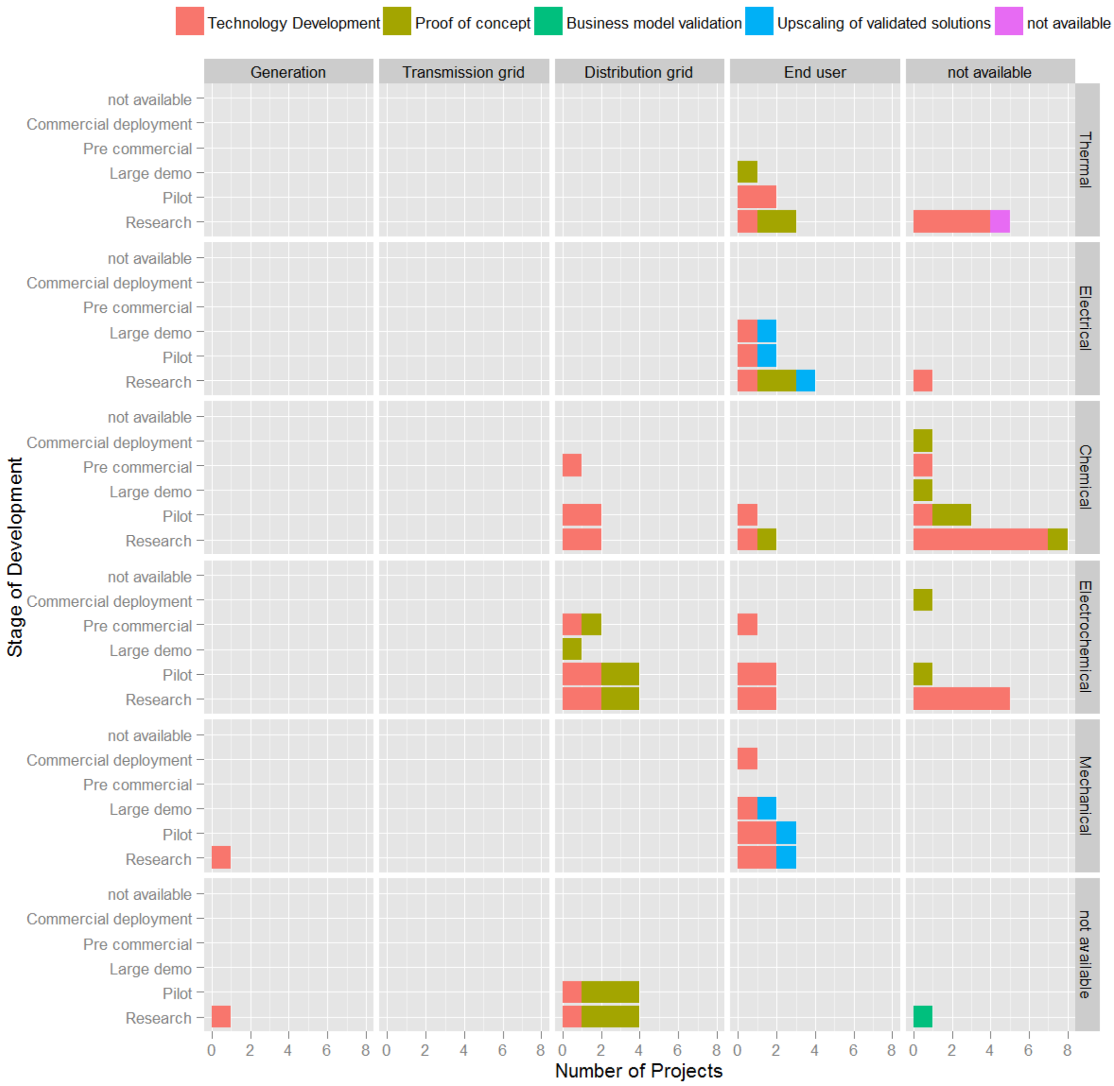

Figure 38: Storage readiness level according to the type of technology and the project's connection level.

5.6. Country fact sheet: France

5.6.1. Overall situation

The analysis of the EEGI storage mapping questionnaires shows that in France totally 9 projects deal with storage solutions. The total budget of these projects amounts to 86,7 Mio. Euro, representing about 9% of the total budget of the countries covered by the EEGI storage mapping activity. These projects are not solely and exclusively dedicated to storage solutions, but they also consider storage application in the context of concepts such as wind and PV integration and smart grids. Attention is given to both thermal and electrical/electrochemical technologies. The storage related budget within these projects is estimated at around 30,79 Mio. Euro (about 36% of the total budget).

5.6.1.1. Number of projects

Figure 39shows the number of projects according to the type of technology, the project's connection level and the projects readiness level. Some projects cover several types of technologies.

There are no projects documented with a strong market push (pre-commercial or commercial) or a pure research focus. About half of the projects are pilots, the other half is large demonstrations. Almost all of the projects target technology development. Furthermore, most aim to validate business models. Proof of concept is represented in a single project.

Projects consider mechanical, electrochemical and thermal storage technologies, with electrochemical technology being represented most often. Pure electrical storage or chemical storage technology projects were not found in the mapping. In the electrochemical technology efforts the focus is on batteries, with hydrogen in second place.

End user and local/distribution grid levels are the most common. Only a single project is looking at the generation/bulk system level.

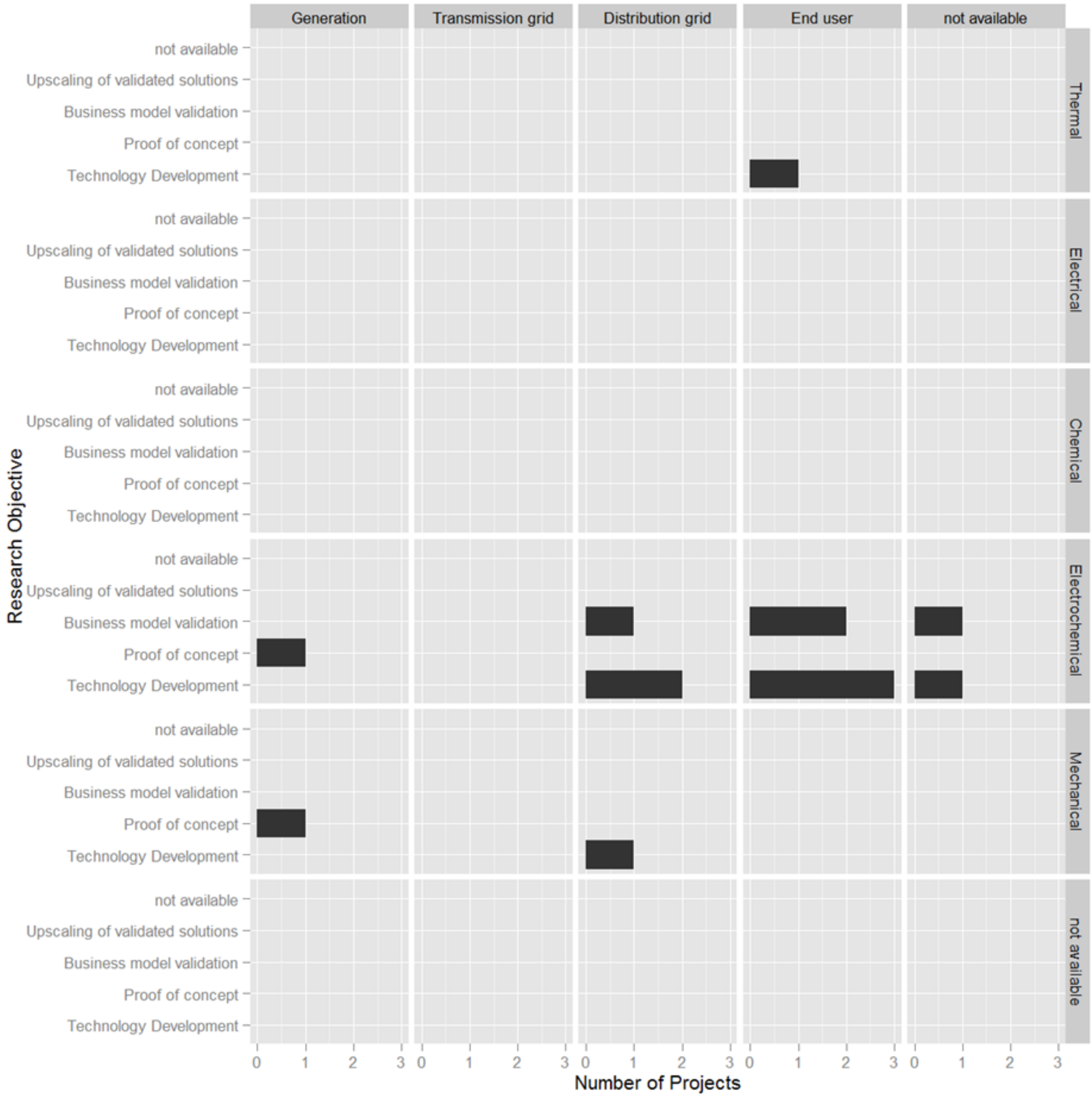

Figure 39: Number of projects according to the type of technology, the project's connection level and the projects readiness level.

5.6.1.2. *Total budget*

Figure 40 shows the total budget of projects according to the type of technology, the project's connection level and the projects readiness level. Again, some projects combine multiple technologies. Electrochemical technology development represents the largest part of the budget.

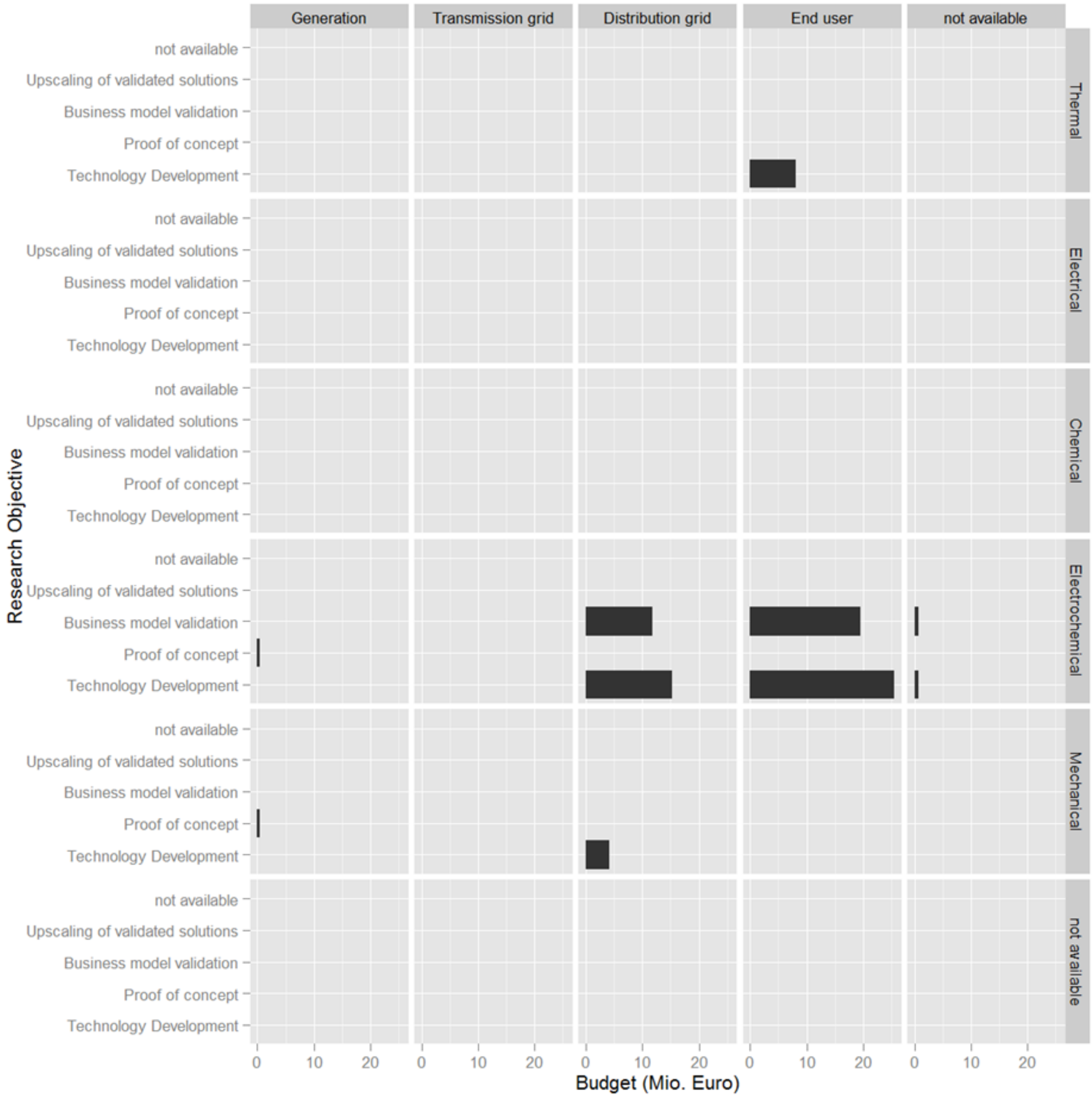

Figure 40: Project budget according to the type of technology, the project's connection level and the projects readiness level.

5.6.2. Specific storage related budget

Figure 41 shows the storage related budget of projects according to the type of technology, the project's connection level and the projects readiness level.

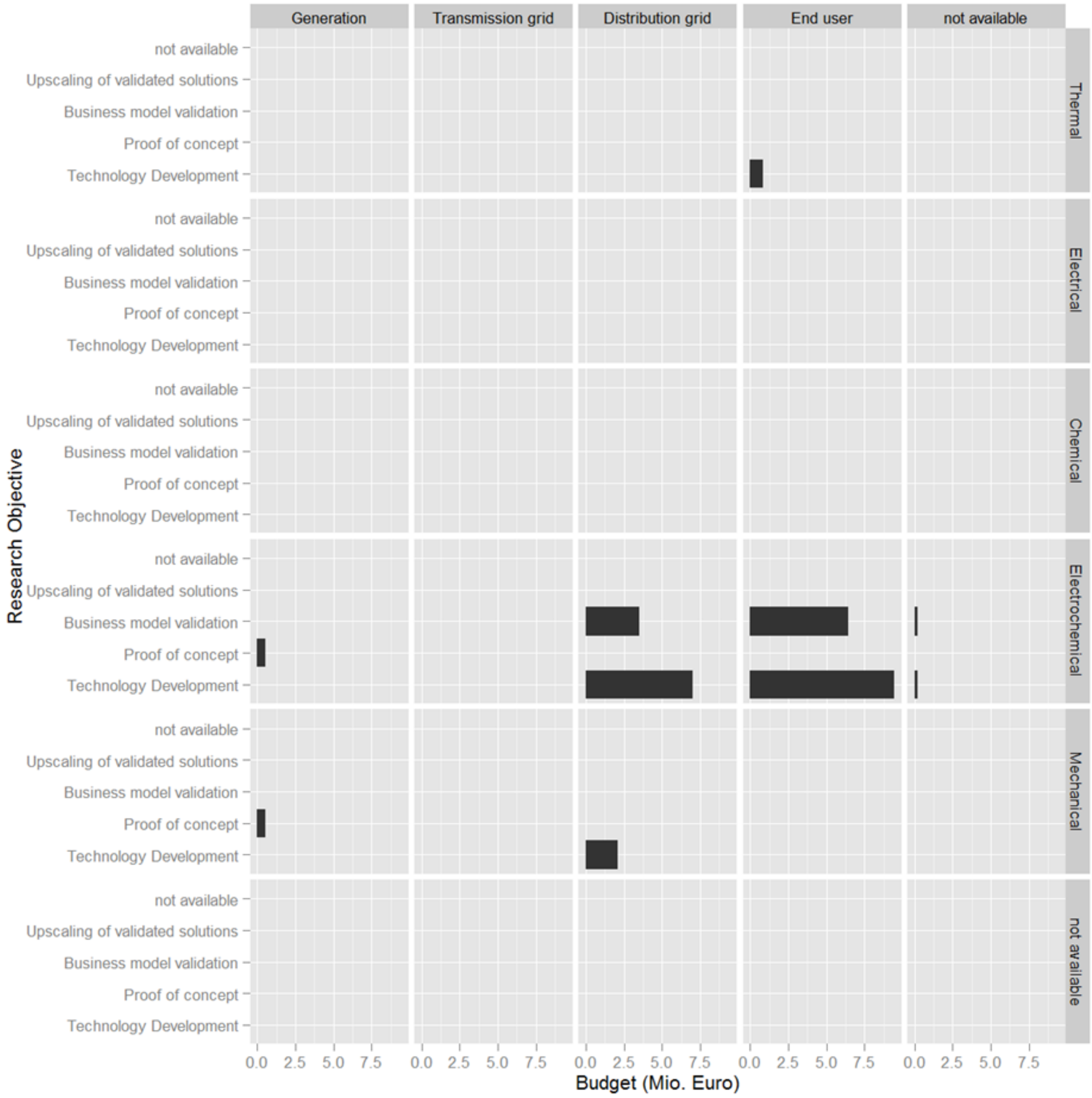

Figure 41: Specific storage related budget according to the type of technology, the project's connection level and the projects readiness level.

5.6.3. Project readiness level

Figure 42 shows the number of projects belonging to a specific technology readiness level according to the type of technology, the project's connection level and the project's nature.

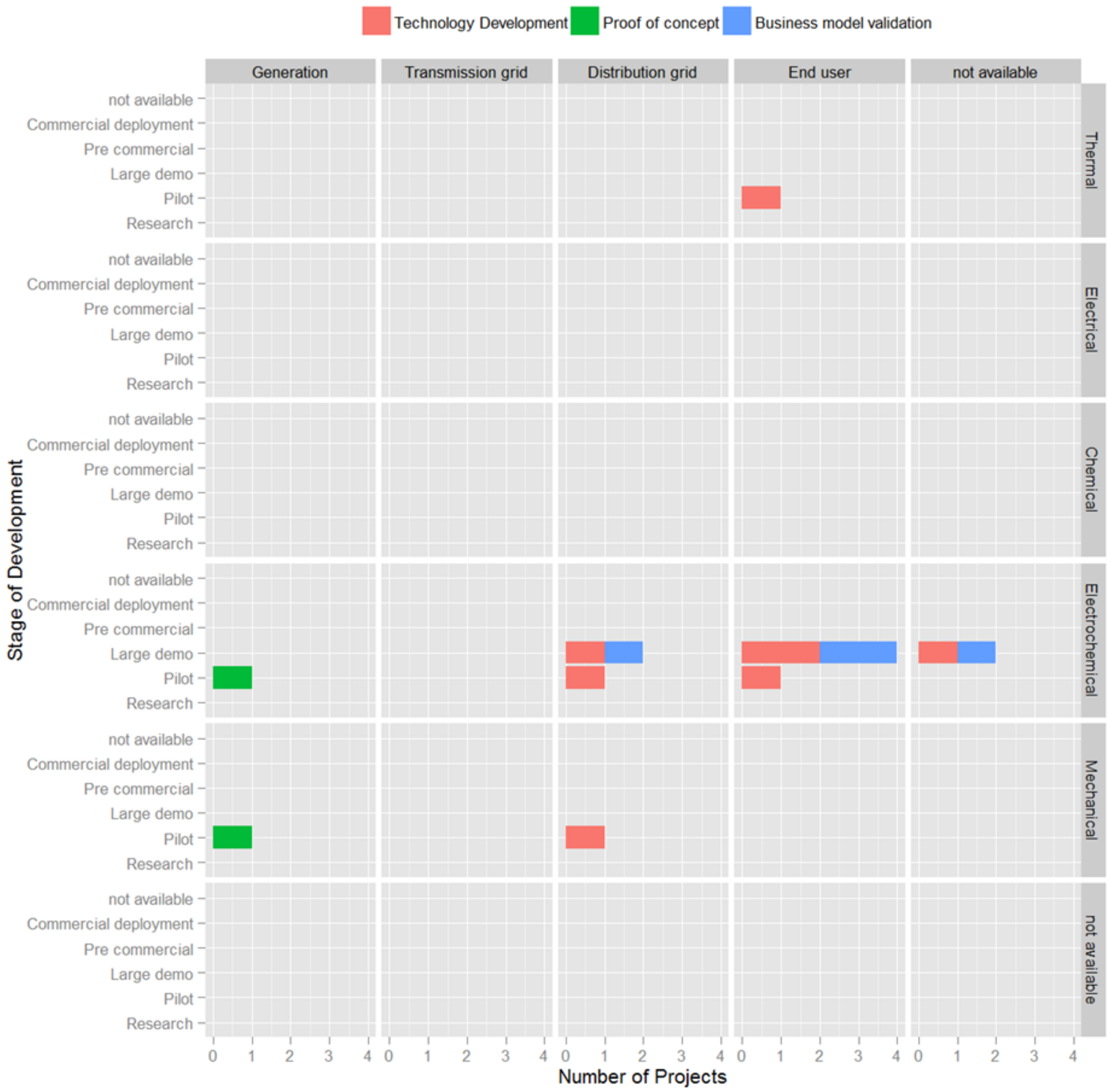

Figure 42: Storage readiness level according to the type of technology and the project's connection level.

5.7. Country fact sheet: Italy

5.7.1. Overall situation

The analysis of the EEGI storage mapping questionnaires shows that in Italy totally 25 projects deal with storage solutions whereas there are some projects which are divided sub projects of one larger project. The total budget of these projects amounts to 165.4 Mio. Euro, slightly less than 25% of the total budget of the countries covered by the EEGI storage mapping activity. However, these projects are not solely and exclusively dedicated to storage solutions, but they also tackle higher level concepts such as microgrids and smart grids. Congruently, the storage related budget amounts to 105.69 Mio. Euro (about 63% of the total budget. At this date (2013-09-27) some of the input data is still missing).

5.7.1.1. Number of projects

Figure 43 shows the number of projects according to the type of technology, the project's connection level and the projects readiness level as well as the number of covered types of technologies. Basically there are only projects addressing electrochemical storage systems on the transmission, distribution and end user level. The number of projects is roughly even distributed among those levels. Each project only covers one type of technology. Also the research objective is, as far as given, fairly even distributed among the single targets.

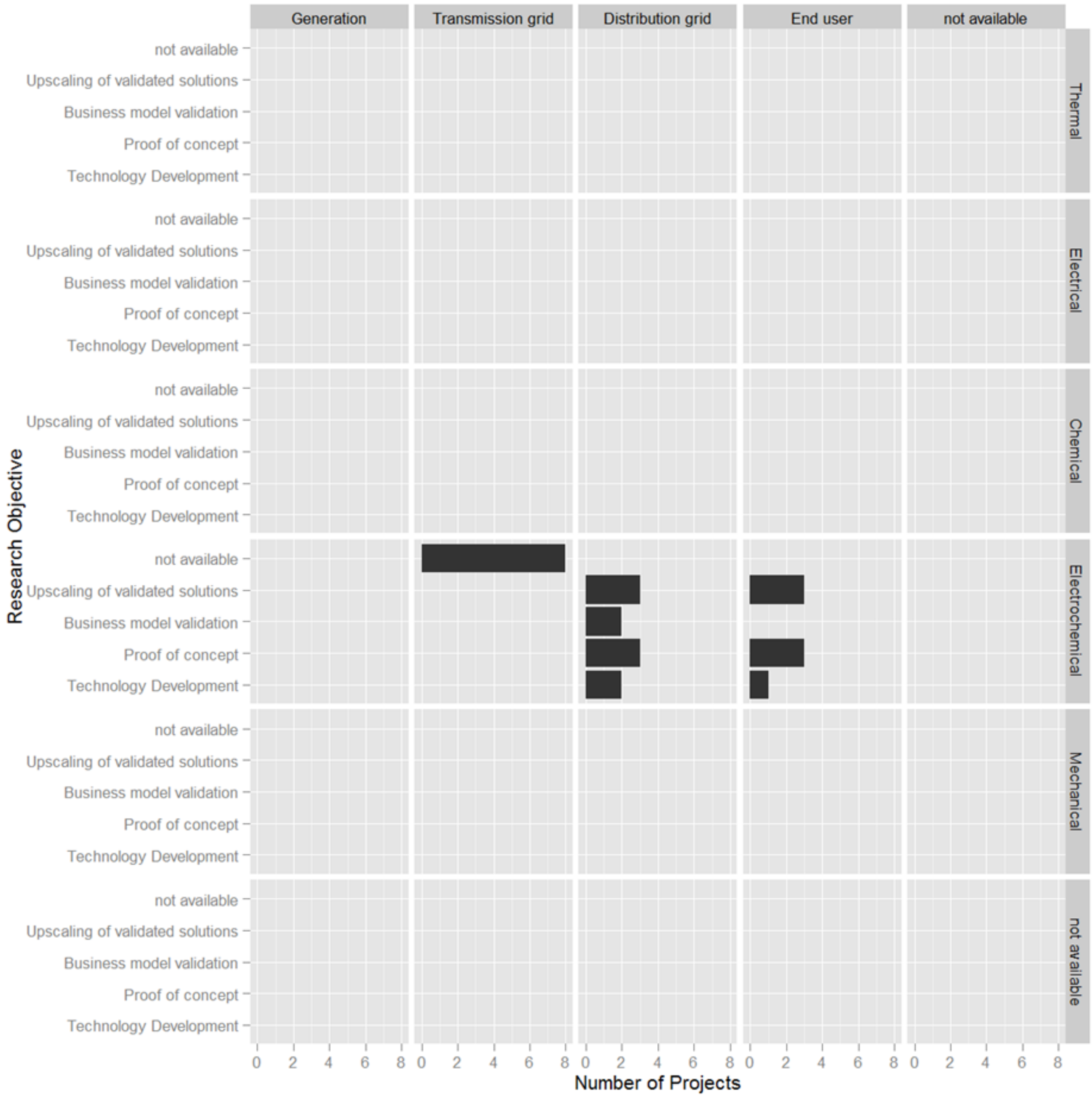

Figure 43: Number of projects according to the type of technology, the project's connection level and the projects readiness level.

5.7.1.2. *Total budget*

Figure 44 shows the total budget of projects according to the type of technology, the project's connection level and the projects readiness level. Again, some projects cover up to three types of technologies.

Where as the number of projects is distributed over more levels the major part of the money of about 150 Mio Euro is spent for projects on the transmission level (still project data missing).

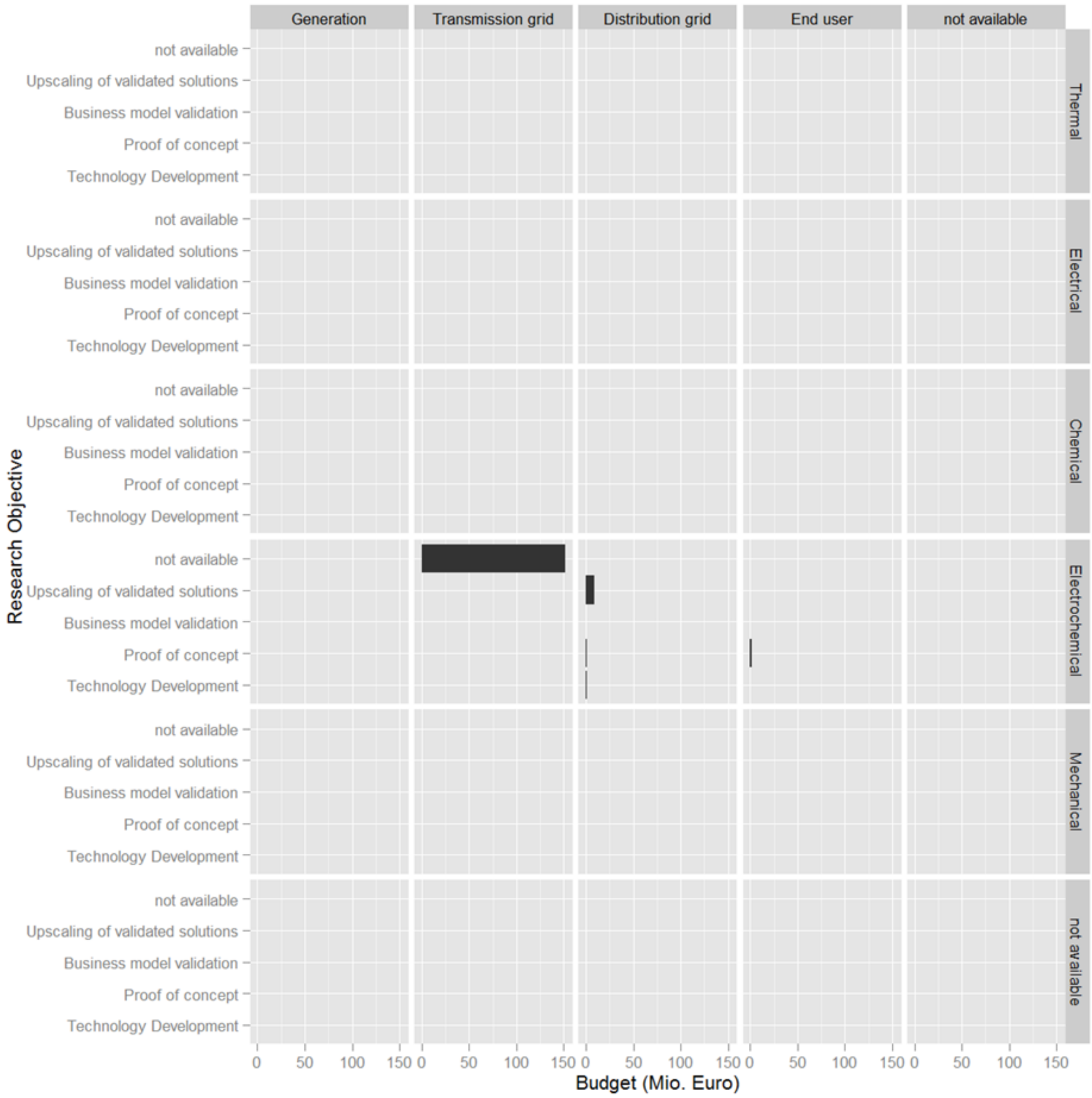

Figure 44: Project budget according to the type of technology, the project's connection level and the projects readiness level.

5.7.2. Specific storage related budget

Figure 45 shows the storage related budget of projects according to the type of technology, the project's connection level and the projects readiness level. It basically relates to Figure 44 but has a slightly smaller amount of input values.

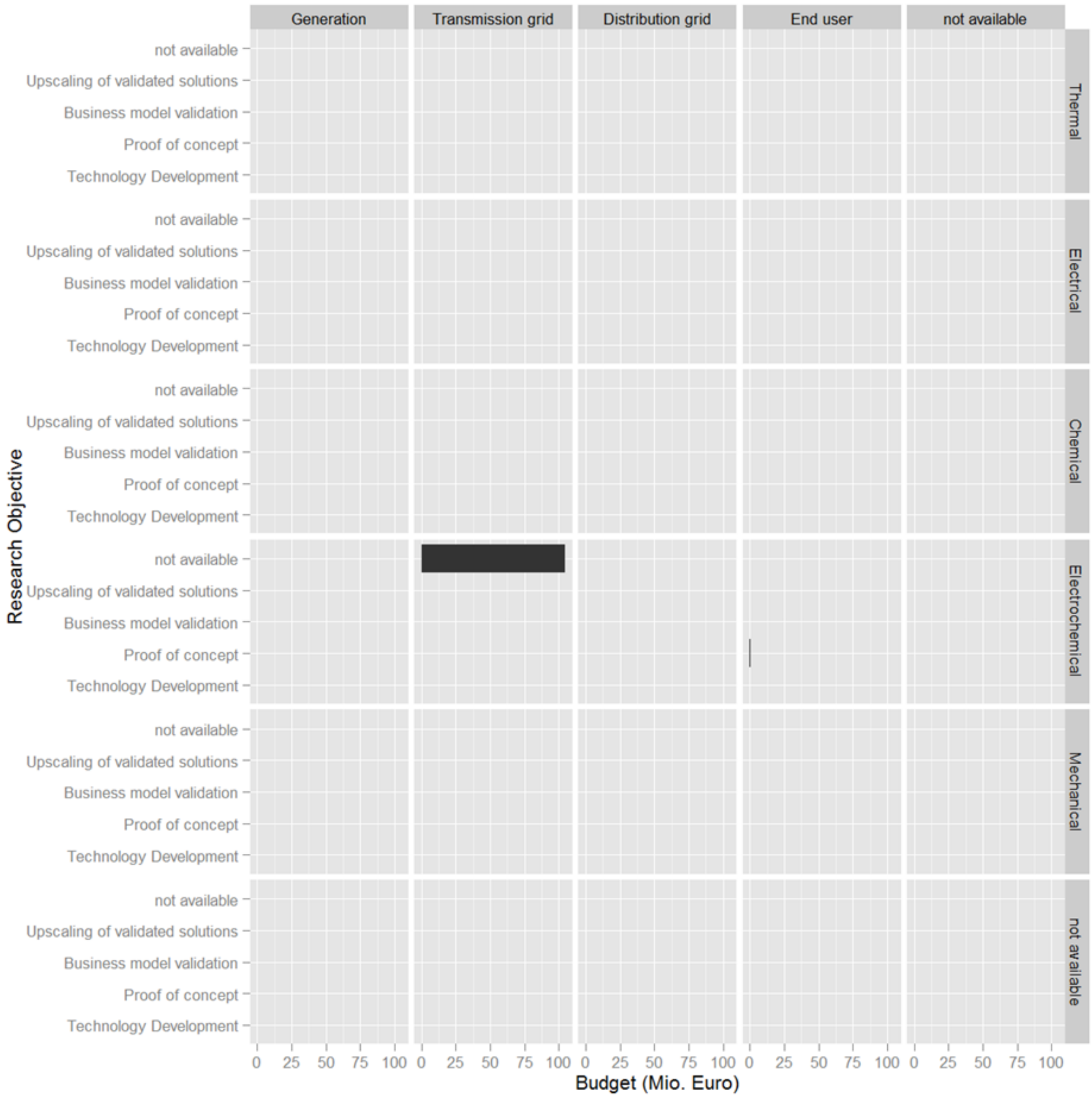

Figure 45: Specific storage related budget according to the type of technology, the project's connection level and the projects readiness level.

5.7.3. Project readiness level

Figure 46 shows the number of projects belonging to a specific technology readiness level according to the type of technology, the project's connection level and the project's nature.

Compared to other countries the Italian projects are commonly addressing a higher level. There are all in all 13 projects on a pre-commercial state which is compared to the total number of projects really high. There are also 14 pilot projects and one large demo projects on-going. The number of research projects is four. A reason for this special allocation of projects could lie within the funding scheme. A number of projects are financed from grid fees.

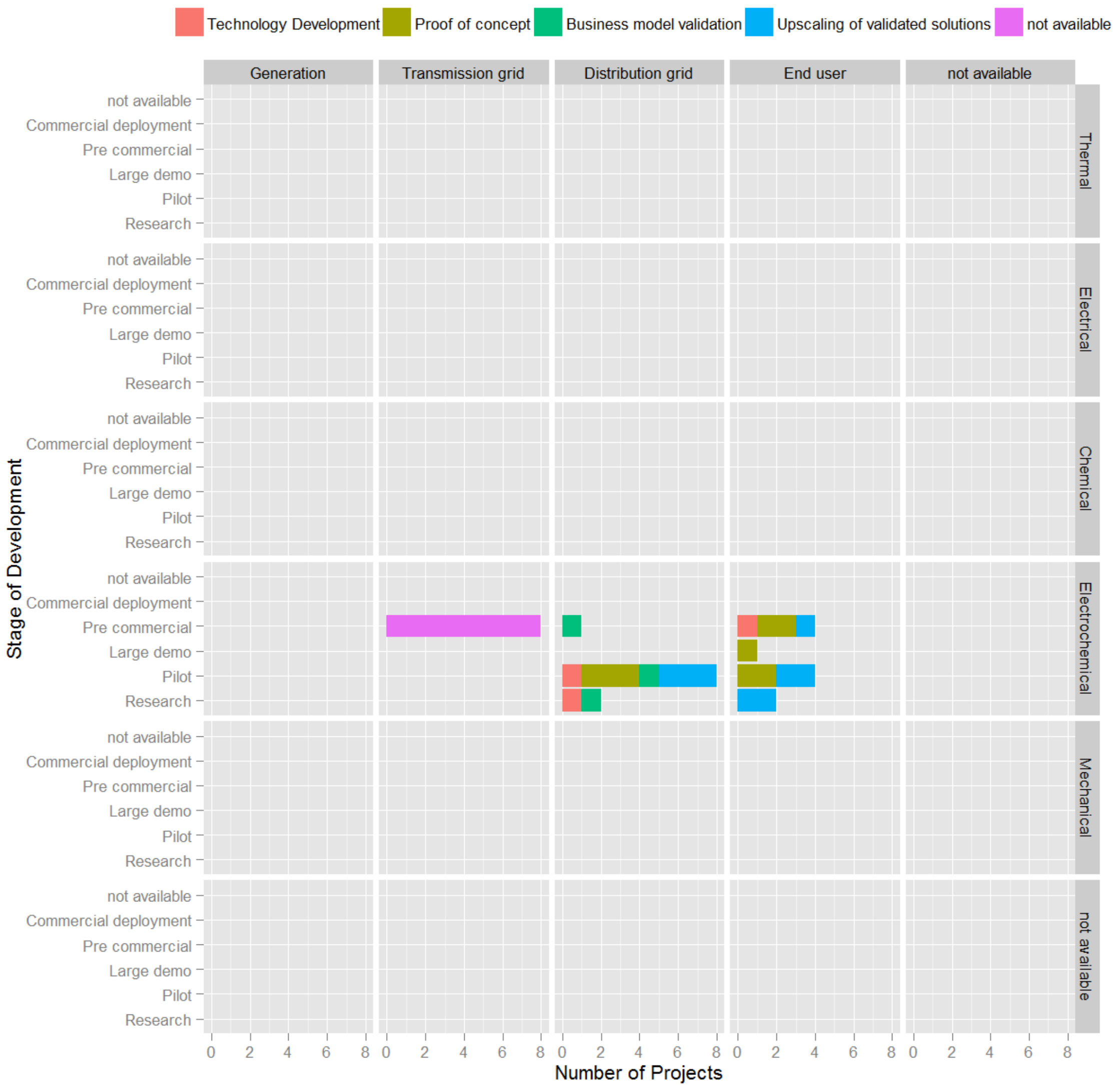

Figure 46: Storage readiness level according to the type of technology and the project's connection level.

5.8. Country fact sheet: Lithuania

Lithuania reported that it has no activities in the field of Energy storage.

5.9. Country fact sheet: Netherlands

5.9.1. Overall situation

The analysis of the EEGI storage mapping questionnaires shows that in Austria totally 10 projects deal with storage systems. The total budget of these projects amounts to 75,9 Mio. Euro, less than 10% of the total budget of the countries covered by the EEGI storage mapping activity. However, these projects are not solely and exclusively dedicated to storage solutions, but they also tackle higher level concepts such as projects researching advanced materials (especially Li-Ion). Congruently, the storage related budget amounts to 26,5 Mio. Euro (about 30% of the total budget).

Overall data for the Netherlands are at a rather aggregated level and would benefit from refinement during the next database update.

5.9.1.1. Number of projects

Figure 47 shows the number of projects according to the type of technology, the project's connection level and the projects readiness level. The most obvious message is that investment in electrochemical storage (batteries) is dominant.

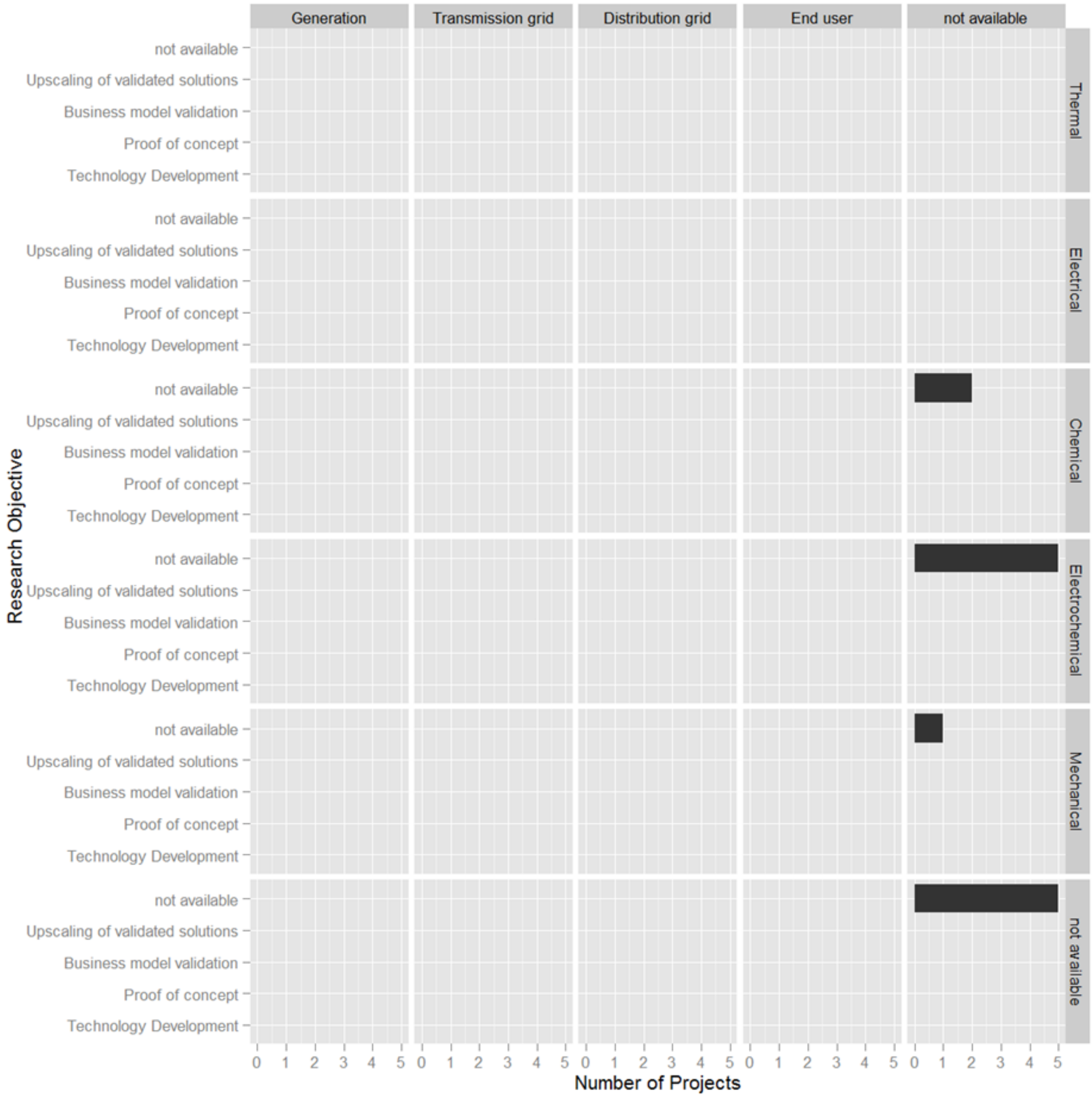

Figure 47: Number of projects according to the type of technology, the project's connection level and the projects readiness level.

5.9.1.2. Total budget

Figure 48 shows the total budget of projects according to the type of technology, the project's connection level and the projects readiness level. Because of the shortcomings of the data there are few inferences that can be made on the connection level or the project readiness. The graph confirms that electrochemical projects are dominant. In budgetary terms the dominance is even more outspoken, as EUR 50 million (or two thirds of the total) is spent on it.

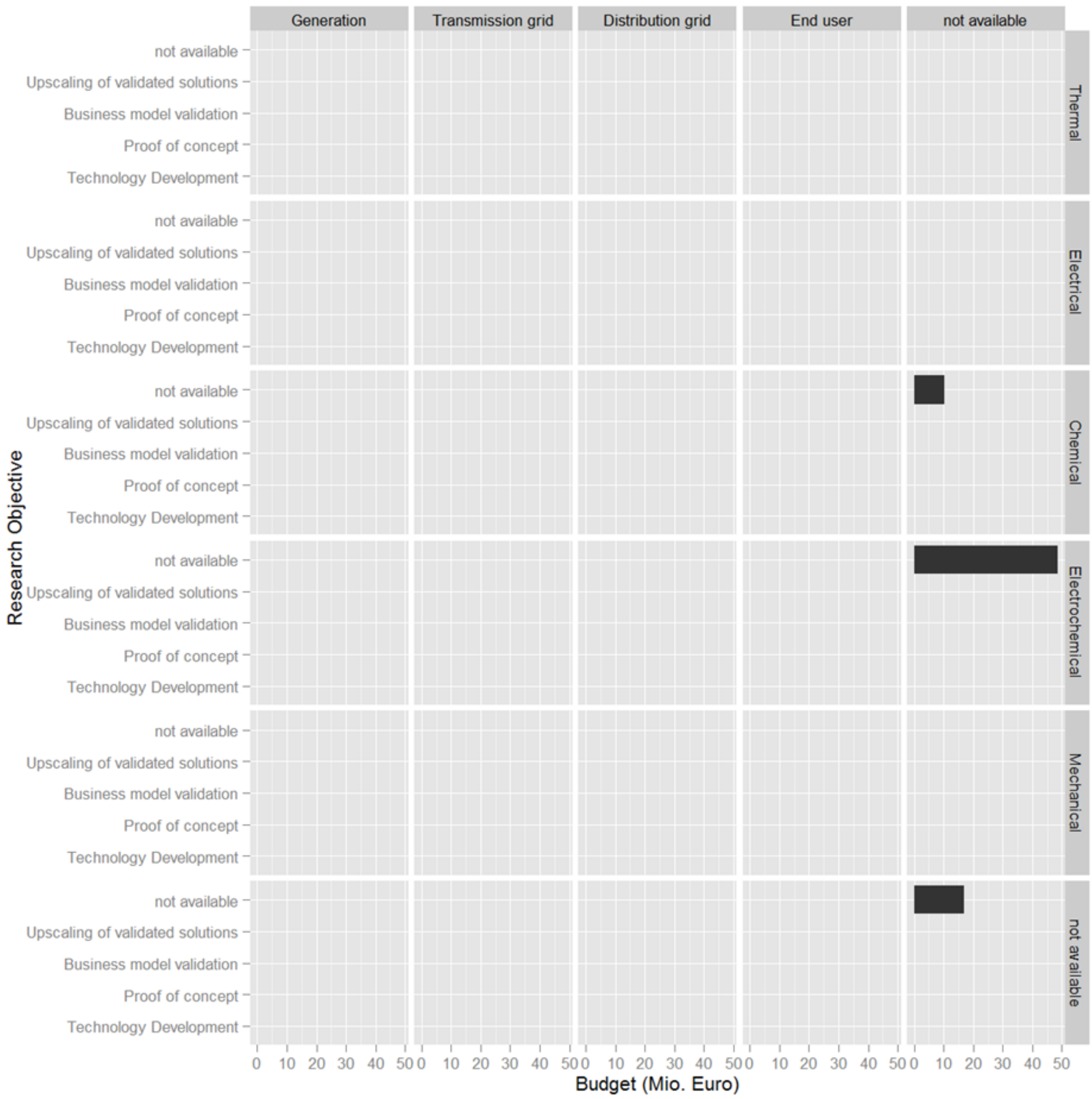

Figure 48: Project budget according to the type of technology, the project's connection level and the projects readiness level.

5.9.2. Specific storage related budget

Figure 49 shows the storage related budget of projects according to the type of technology, the project's connection level and the projects readiness level.

Although the overall image looks comparable, there is one subtle message hidden: electrochemical projects are for about 25% dedicated to storage, whereas chemical projects (mostly Power-to-gas, which is not unlogical in a gas country like the Netherlands) are almost entirely dedicated to storage. This means the actual storage investment in chemical and in electrochemical are not that far apart.

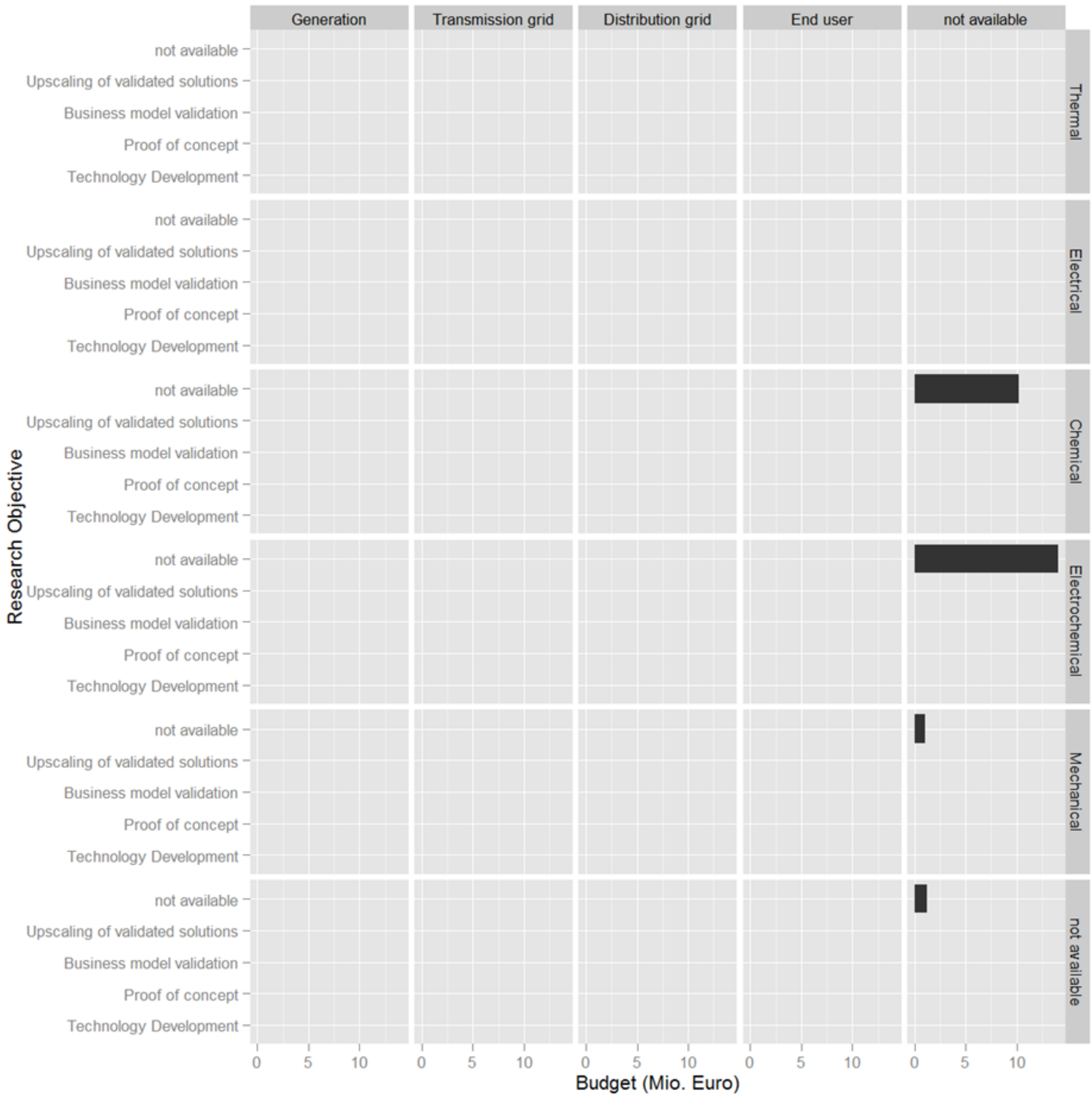

Figure 49: Specific storage related budget according to the type of technology, the project's connection level and the projects readiness level.

5.9.3. Project readiness level

Unfortunately the data provide no insight on the project readiness level.

5.10. Country fact sheet: Norway

5.10.1. Overall situation

The analysis of the EEGI storage mapping questionnaires shows that in Norway a total of 13 projects have been identified, amounting to EUR 18 million of investment. This is less than five per cent of the total amount spent by the EC and the countries in this survey all taken together.

Many of the projects highlighted here cover a broader range of topics than purely storage. The budget strictly dedicated to storage is a relatively modest 3,79 million, or 21% of the total.

5.10.1.1. Number of projects

Figure 50 shows the number of projects according to the type of technology, the project's connection level and the projects readiness level. All projects cover only a single technology (which, in Norway's case is often hydropower-related). This is indicated by the single colouring of the bars.

Overall Norway opts for developments at other levels than the distribution grid. There are, for example, three projects looking to develop a proof of concept of storage at the generation level and two that focus on technology development for use at the end user level. Two projects cover more than one connection level, one of which also covers more than one research objective.

Overall Norway is remarkable given its focus on mechanical storage (obviously pumped hydro, but also some CAES) and on connection levels other than the distribution grid.

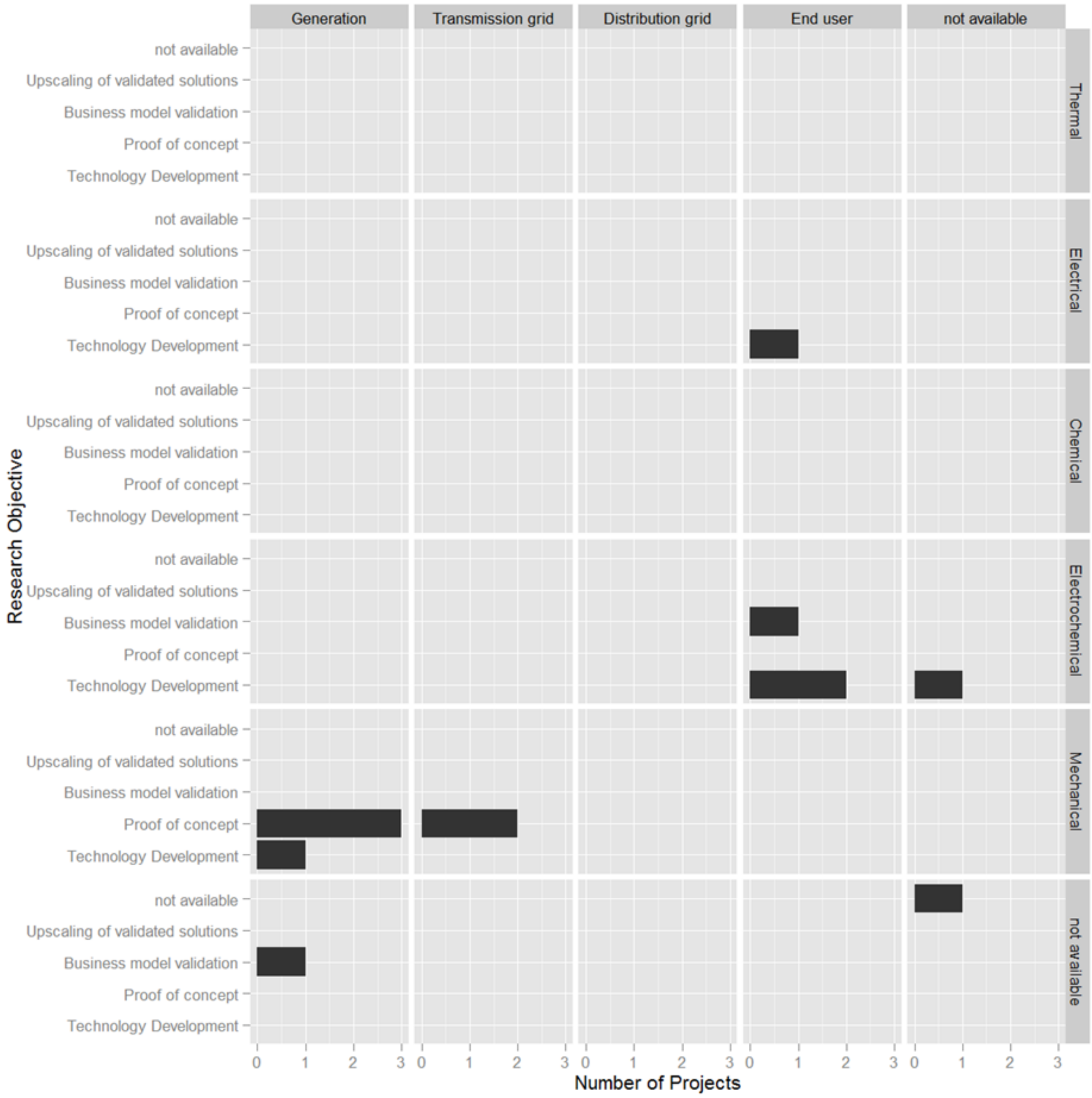

Figure 50: Number of projects according to the type of technology, the project's connection level and the projects readiness level.

5.10.1.2. Total budget

Figure 51 shows the total budget of projects according to the type of technology, the project's connection level and the projects readiness level. Figure 51 can be directly compared to Figure 50: all axes are the same, except for the number of projects. The latter has been replaced by the total budget (in EUR, after conversion from NOK).

In general, the graph confirms the dominance of mechanical storage. Investment in this area is more than half of the total (10 million or 55%), the rest being spread among electrical and electrochemical. In comparison to many other countries the investment in batteries (electrochemical) is modest.

It is also clear that investment in storage projects related to central generation units, dwarfs the rest. End user-level projects get about half of the central ones

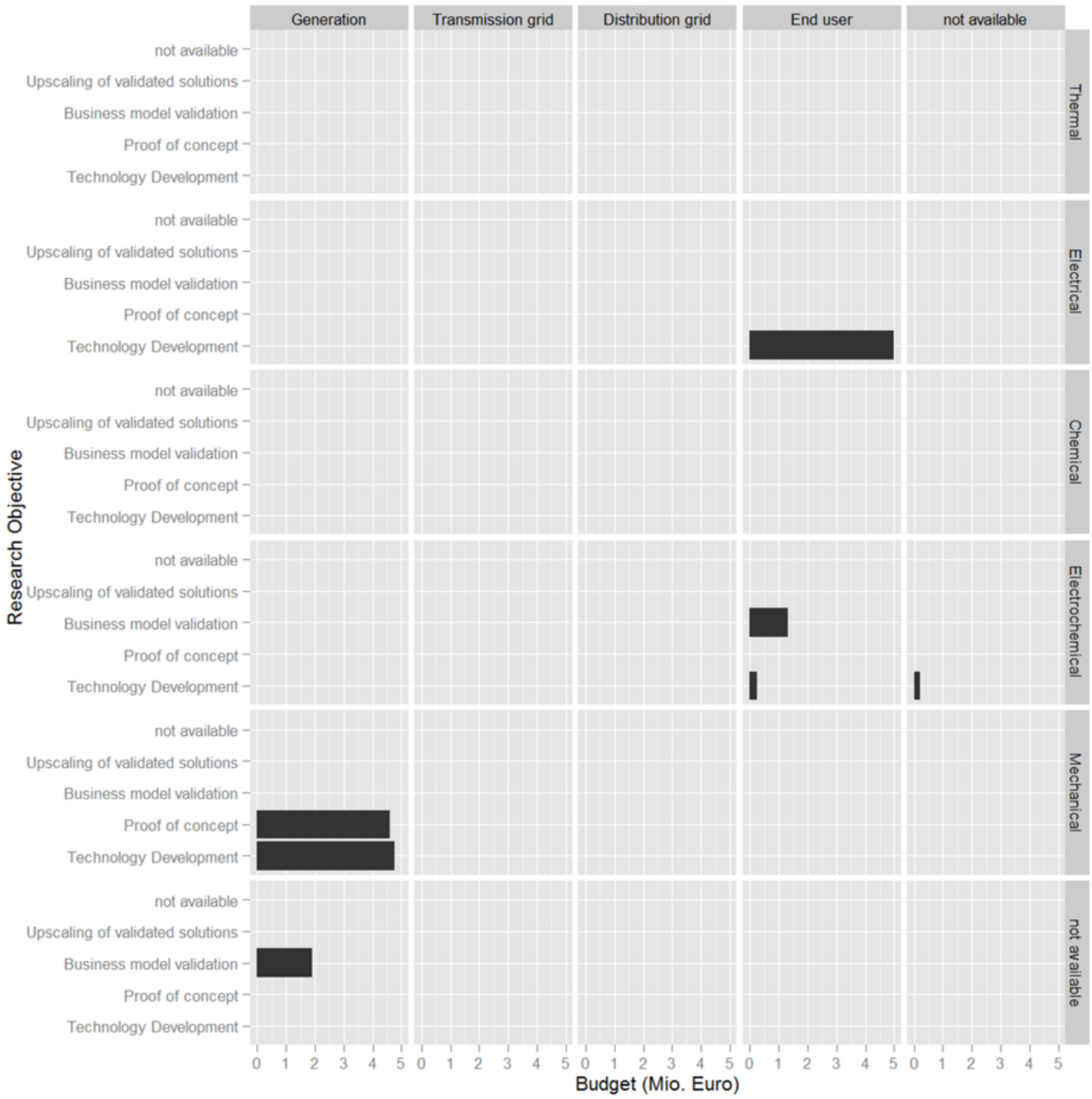

Figure 51: Project budget according to the type of technology, the project's connection level and the projects readiness level.

5.10.2. Specific storage related budget

Figure 52 shows the storage related budget of projects according to the type of technology, the project's connection level and the projects readiness level.

Here the preference for centralized mechanical storage is even more outspoken. The fractions of projects effectively spent on storage as such, are minimal to almost non-existent for all other options. Basically the budget is nearly exactly the same distributed as the total project budget (Figure 51). Most relevant are here some large projects addressing electric vehicles and technology development of Li-Ion batteries.

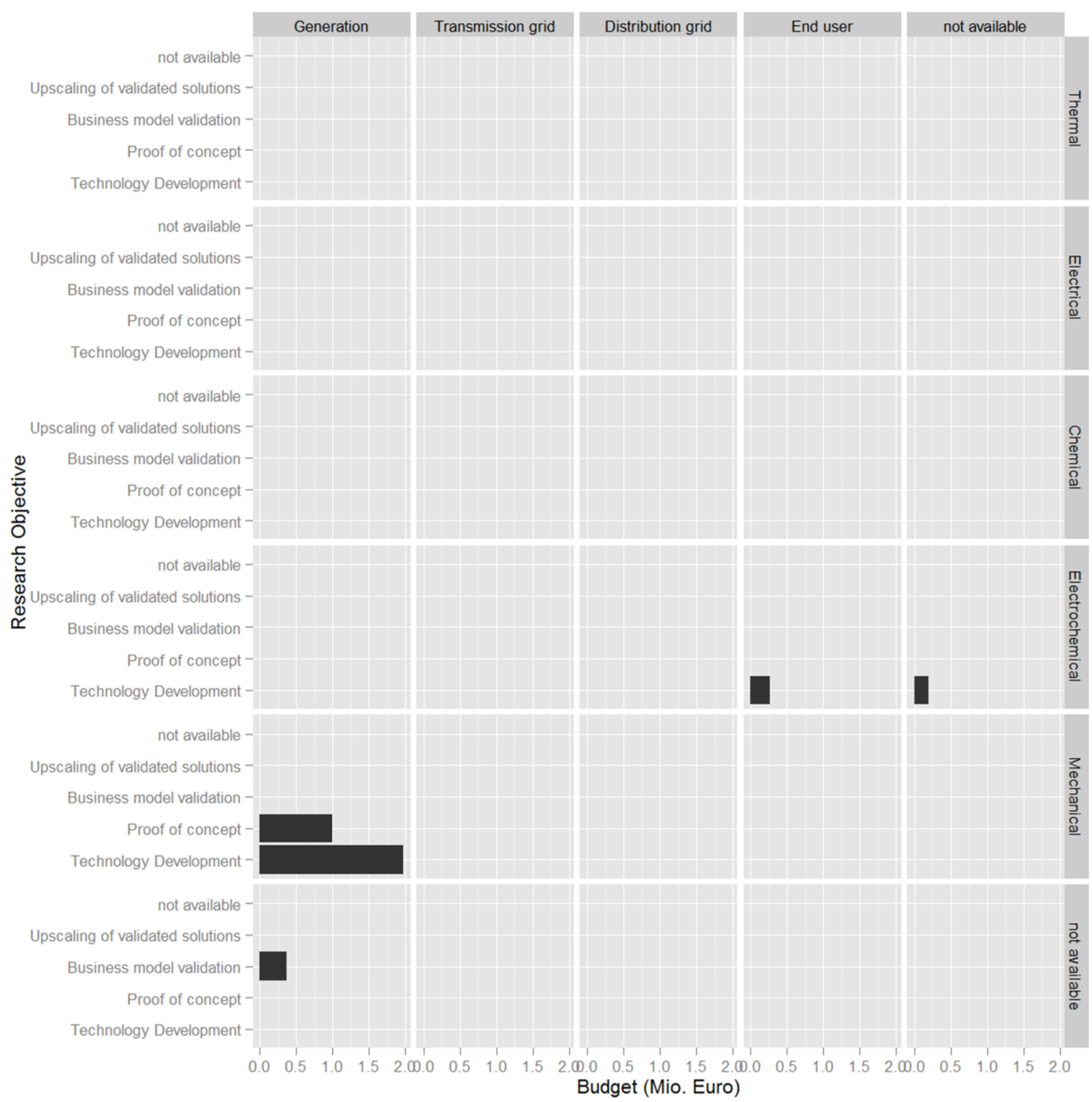

Figure 52: Specific storage related budget according to the type of technology, the project's connection level and the projects readiness level.

5.10.3. Project readiness level

Figure 53 shows the number of projects belonging to a specific readiness level according to the type of technology, the project's connection level and the project's nature.

Despite Norway's active use of standard pumped hydro facilities, no projects beyond the demo stage show up. Moreover, the most advanced projects are in areas that, judging from the previous graph, receive very minimal funding. As far as mechanical storage is involved, most projects are squarely within the Research phase mostly trying to come up with a proof concept.

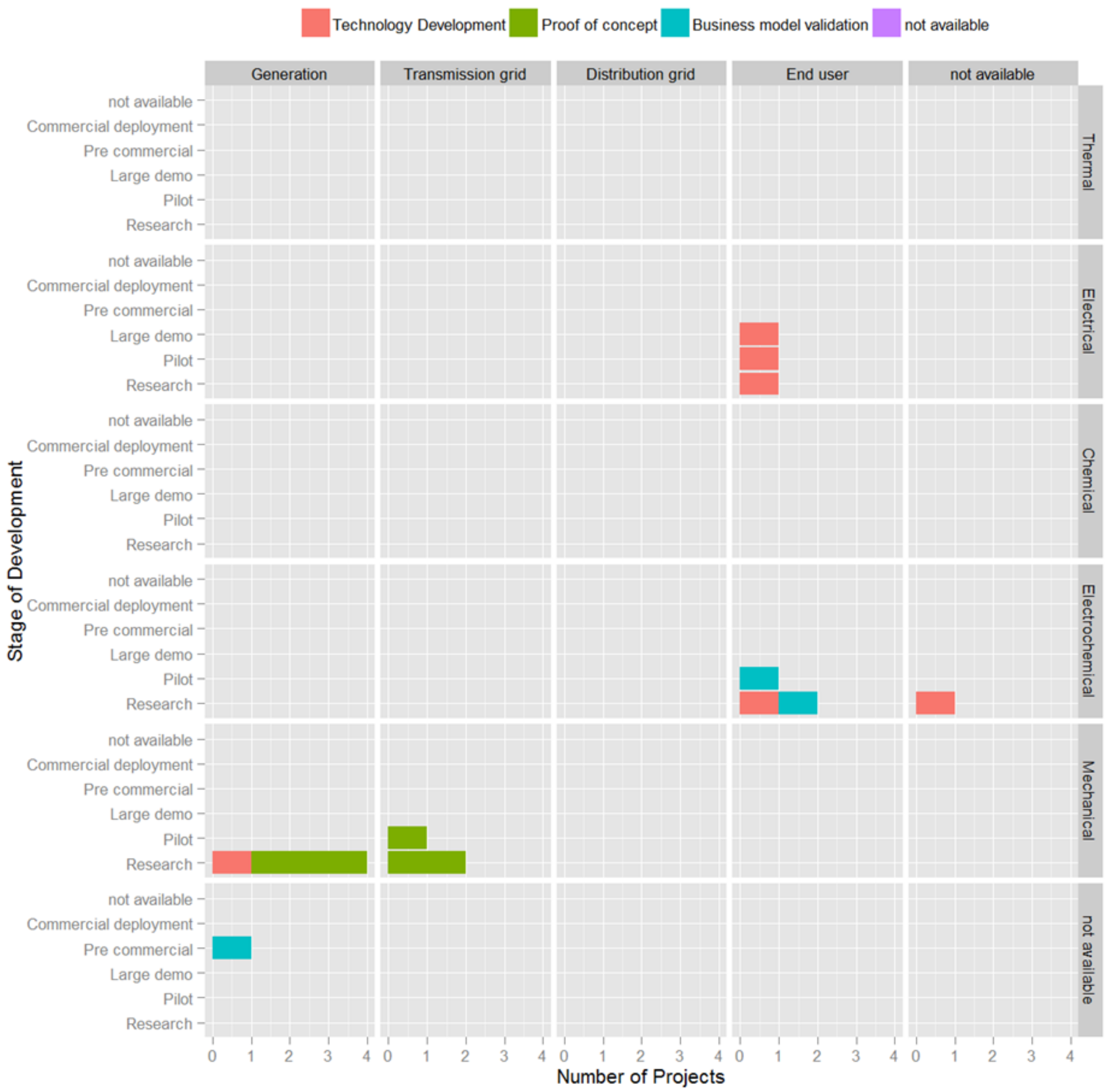

Figure 53: Storage readiness level according to the type of technology and the project's connection level.

5.11. Country fact sheet: Poland

Poland is one of the two Eastern European countries in the survey. Its activities on storage consist of participation in three European projects. Their total budget is about EUR 17 million and they together run from 2009 to 2015. They are large research oriented projects, encompassing storage technology development. The projects are

- Modern materials and innovative methods for processing and energy monitoring
- Effective INtegration of Seasonal Thermal Energy storage systems IN existing buildings
- Laboratory for Innovative Power Technologies and Integration of Renewable Energy Sources

This situation may suggest that Poland will, in the foreseeable future, become an active player in the field of storage development.

Because the clustering in this section is based on nationally funded projects, there are no graphs to show for Poland. The data on the projects have of course been incorporated into the treatment of European projects in the thematic section of this report.

5.12. Country fact sheet: Portugal

5.12.1. Overall situation

The analysis of the EEGI storage mapping questionnaires shows that in Portugal only one project deals with storage solutions (there is another one, but it is classified as European project). The total budget of the project amounts to 0.5 Mio. Euro, less than 0.1% of the total budget of the countries covered by the EEGI storage mapping activity. The storage related budget amounts to 0.5 Mio. Euro (100% of the total budget).

5.12.1.1. Number of projects

Figure 54 shows the number of projects according to the type of technology, the project's connection level and the projects readiness level. It can be seen that there is only one project and that it deals with electrochemical storage solutions connected at the Local/distribution grid level. Its readiness level is Proof of concept.

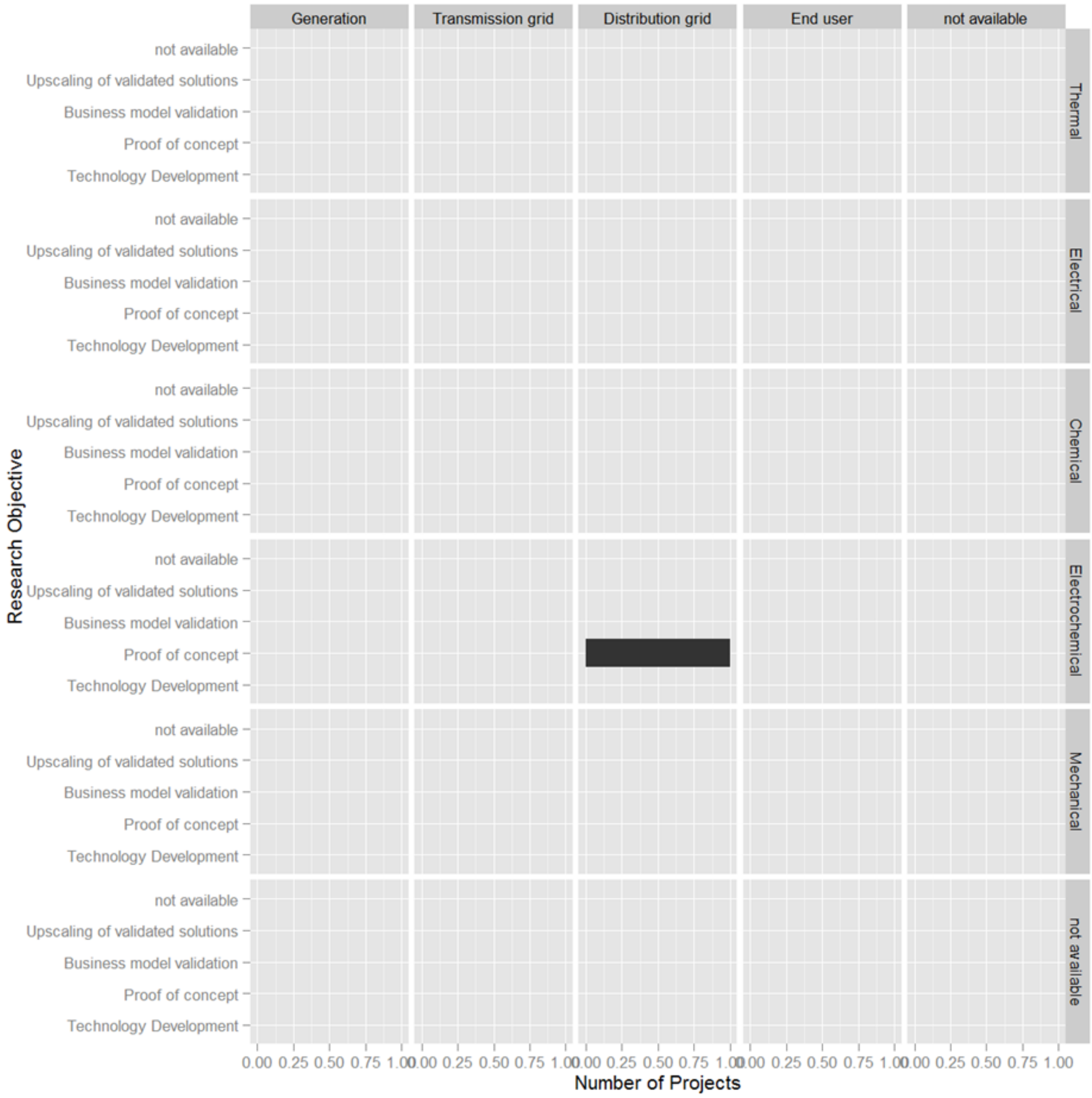

Figure 54: Number of projects according to the type of technology, the project's connection level and the projects readiness level.

5.12.1.2. Total budget

Figure 55 shows the total budget of the project according to the type of technology, the project's connection level and the projects readiness level.

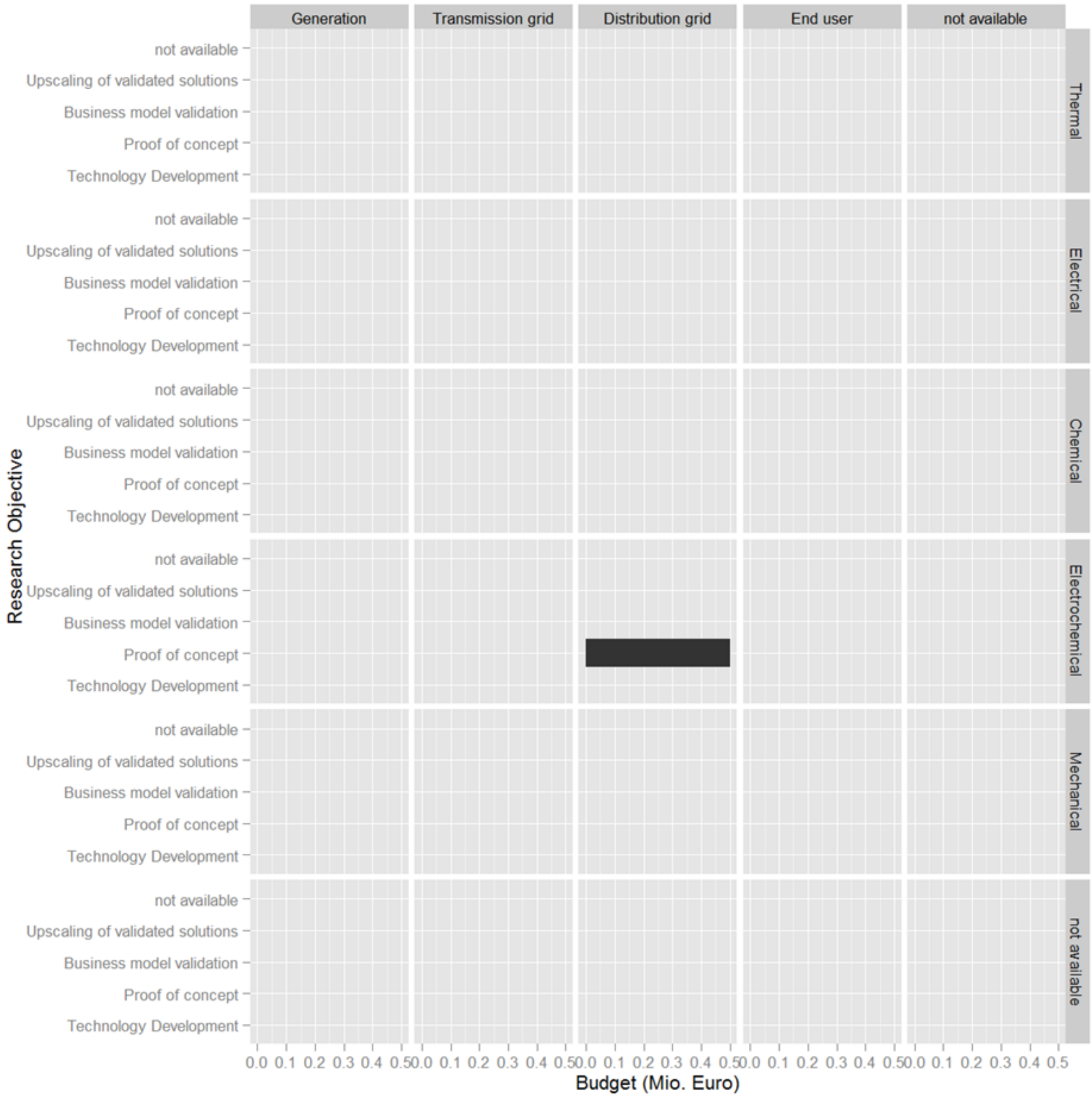

Figure 55: Project budget according to the type of technology, the project's connection level and the projects readiness level.

5.12.2. Specific storage related budget

Figure 56 shows the storage related budget of projects according to the type of technology, the project's connection level and the projects readiness level. It can be readily inferred that the project dedicates 100% of its total budget to the storage solution (see also Figure 55).

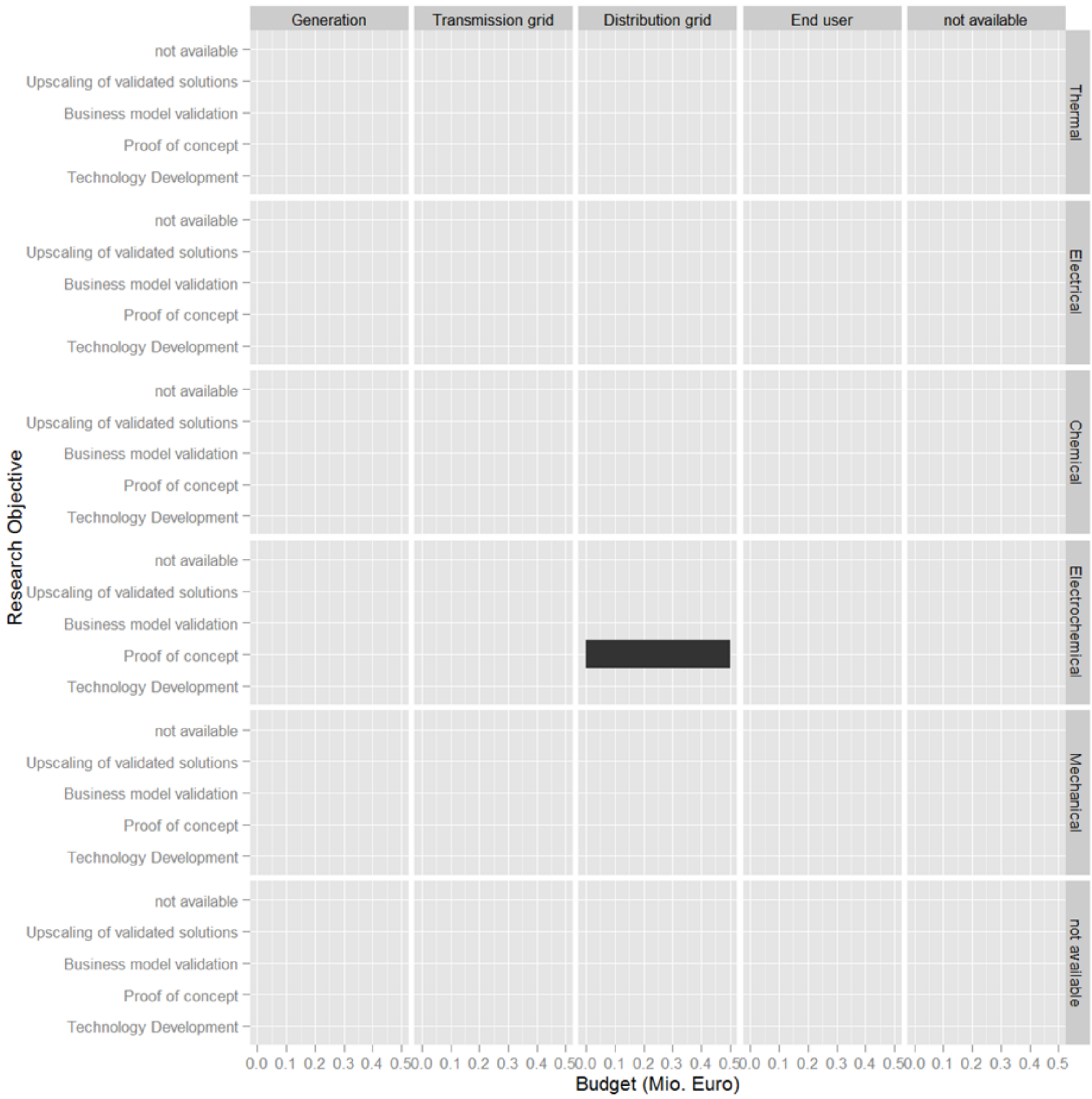

Figure 56: Specific storage related budget according to the type of technology, the project's connection level and the projects readiness level.

5.12.3. Project readiness level

Figure 57 shows the number of projects belonging to a specific technology readiness level according to the type of technology, the project's connection level and the project's nature. The project, which has been classified as a proof of concept project, is at the pilot stage.

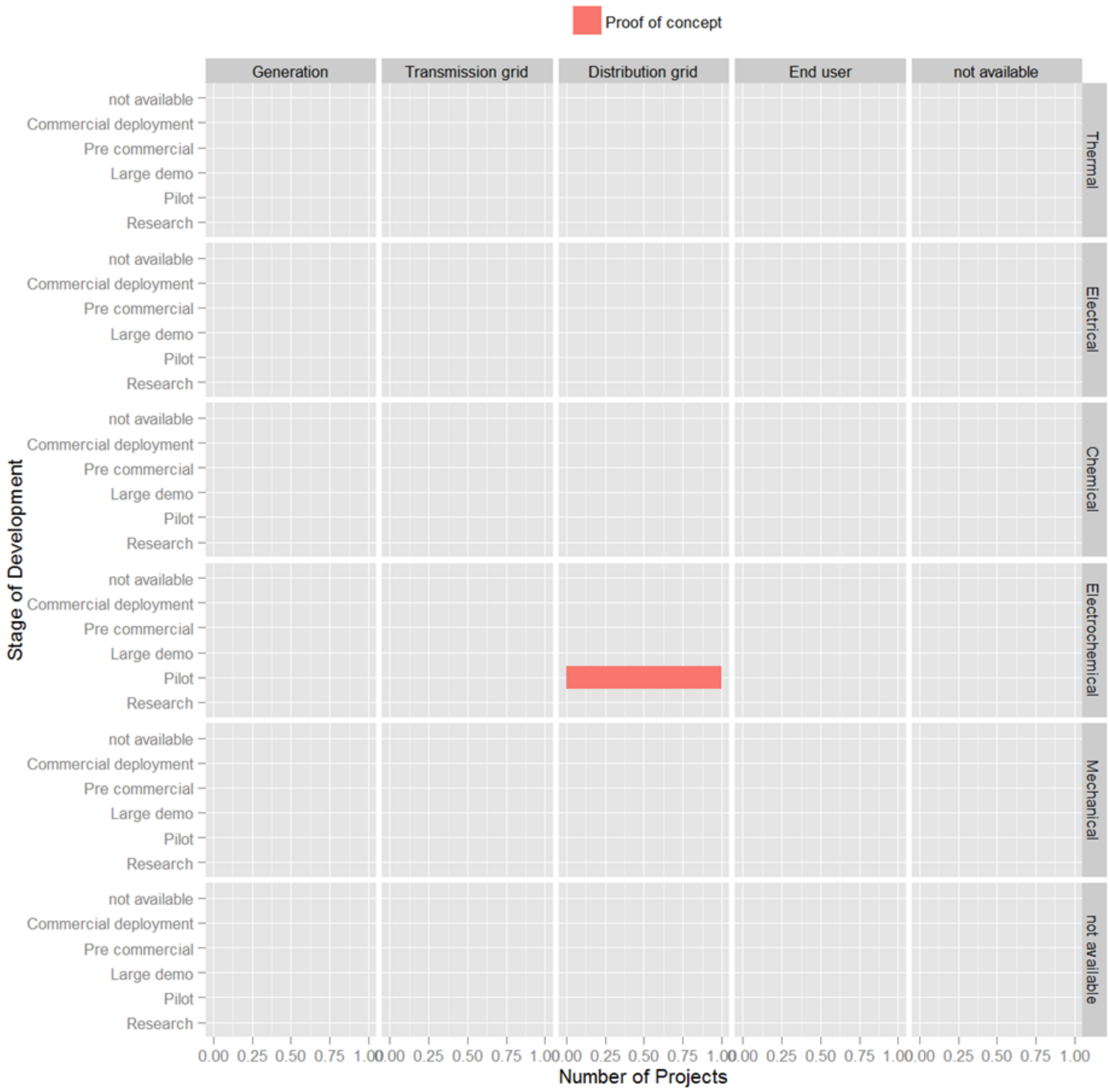

Figure 57: Storage readiness level according to the type of technology and the project's connection level.

5.13. Country fact sheet: Sweden

5.13.1. Overall situation

The analysis of the EEGI storage mapping questionnaires shows that in Sweden 6 projects deal with storage solutions. The total budget of these projects amounts to 5,98 Mio. Euro, representing about 0,05% of the total budget of the countries covered by the EEGI storage mapping activity. These projects are not solely and exclusively dedicated to storage solutions, but they also consider storage application in the context of concepts such as energy hubs, smart grids and Island grids. The budget information is rather incomplete. Based on the available information, the storage related budget within these projects is estimated at around 1,21 Mio. Euro (about 20% of the total budget).

5.13.1.1. Number of projects

Figure 58 shows the number of projects according to the type of technology, the project's connection level and the projects readiness level. Some projects cover several types of technologies.

There are no projects documented with a fully commercial focus. Nevertheless, it can be seen that the projects range from research to pilots to large demonstrations and pre-commercial. Two projects have only a single objective. Three projects combine research with either a pilot, a large demo or pre-commercial. A single project combines all the objectives from research to pre-commercial. Four projects develop electrochemical technology focusing on Li-ion battery chemistry. No projects were found with a primary focus on mechanical or chemical storage.

In general, most projects belong to local/distribution grid level. The combination with end-user and generation/bulk is also found.

Technology development and business model validation are represented by two projects each, whereas proof of concept and up-scaling of validated solutions are both only represented once.

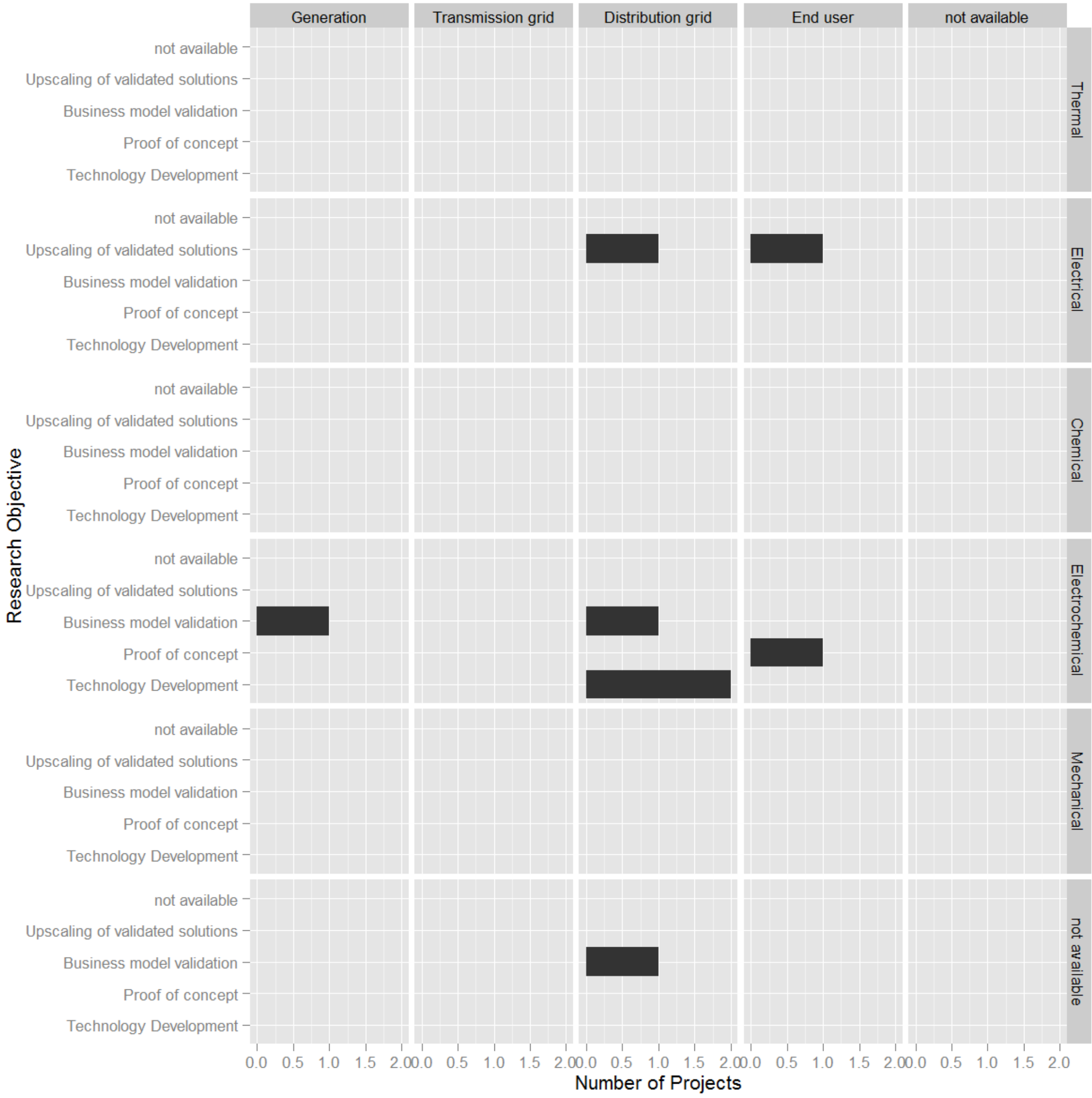

Figure 58: Number of projects according to the type of technology, the project's connection level and the projects readiness level.

5.13.1.2. Total budget

Figure 59 shows the total budget of projects according to the type of technology, the project's connection level and the projects readiness level. Projects consider one or two types of technologies.

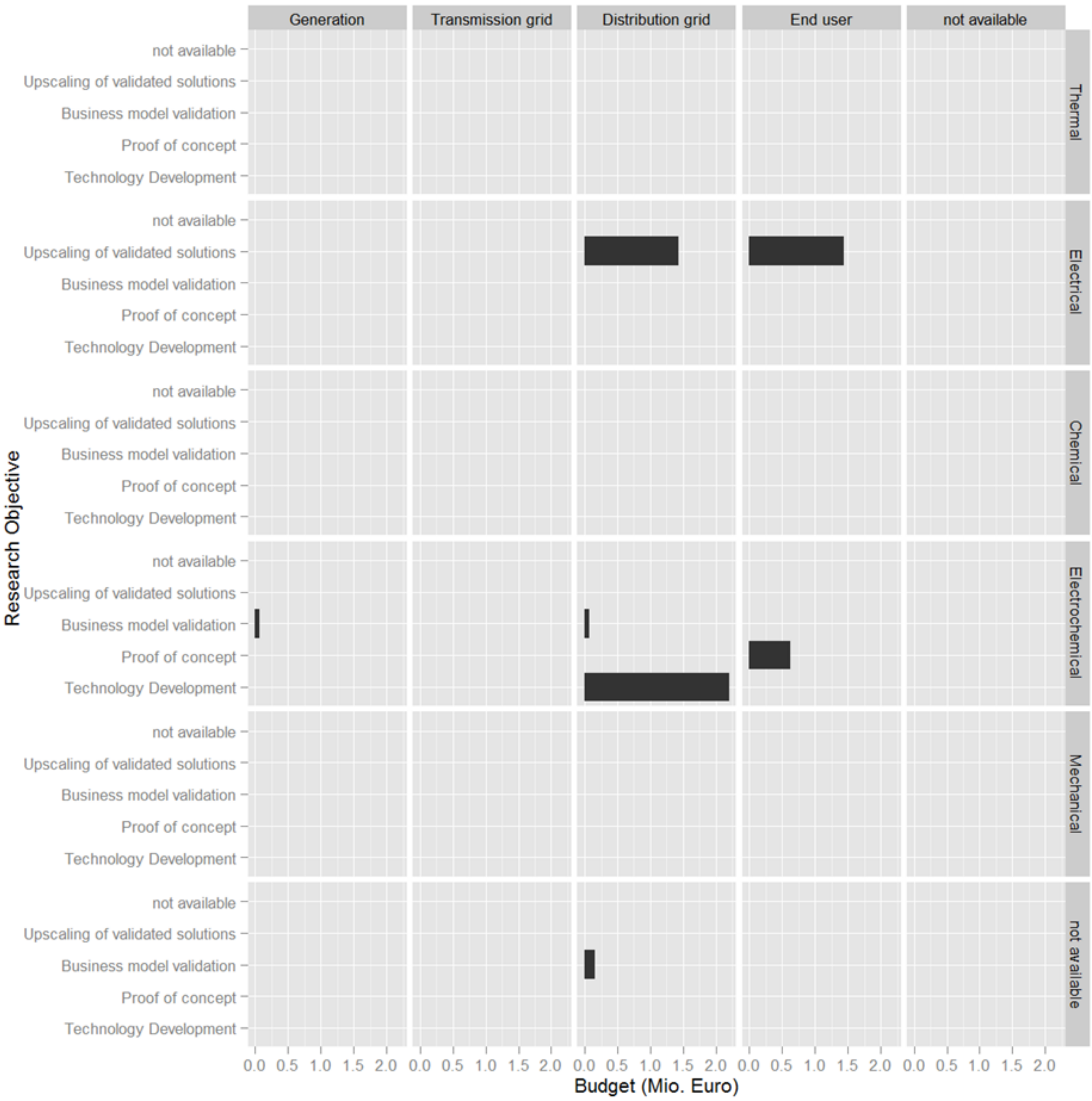

Figure 59: Project budget according to the type of technology, the project's connection level and the projects readiness level.

5.13.2. Specific storage related budget

Figure 60 shows the storage related budget of projects according to the type of technology, the project's connection level and the projects readiness level. Some projects cover two types of technologies.

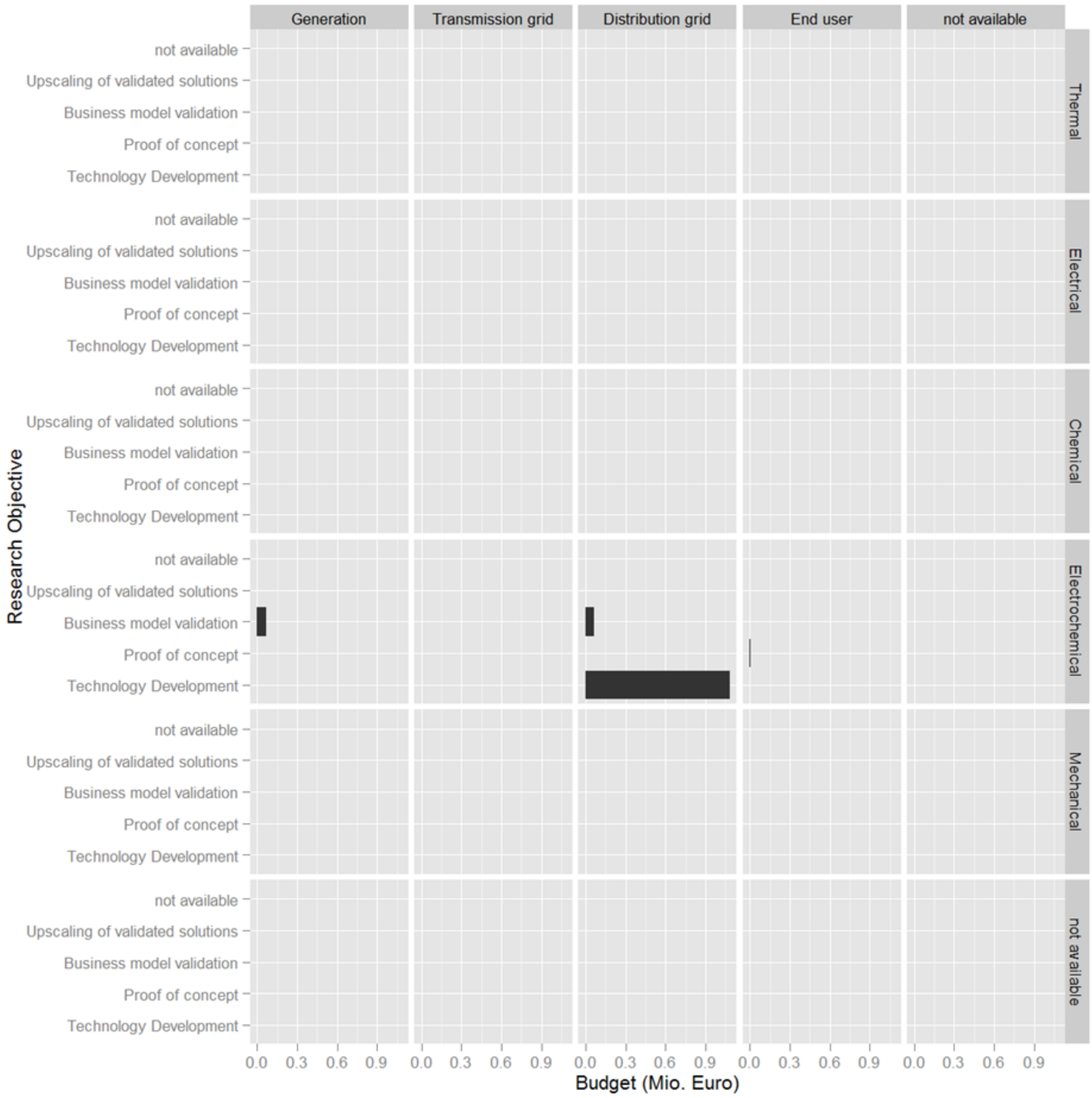

Figure 60: Specific storage related budget according to the type of technology, the project's connection level and the projects readiness level.

5.13.3. Project readiness level

Figure 61 shows the number of projects belonging to a specific technology readiness level according to the type of technology, the project's connection level and the project's nature. The budgetary focus here is clearly going further than research. Apart from one pre-commercial project on centralized storage, several relatively advanced pilots and demos are carried out on storage at the distribution and the end user level.

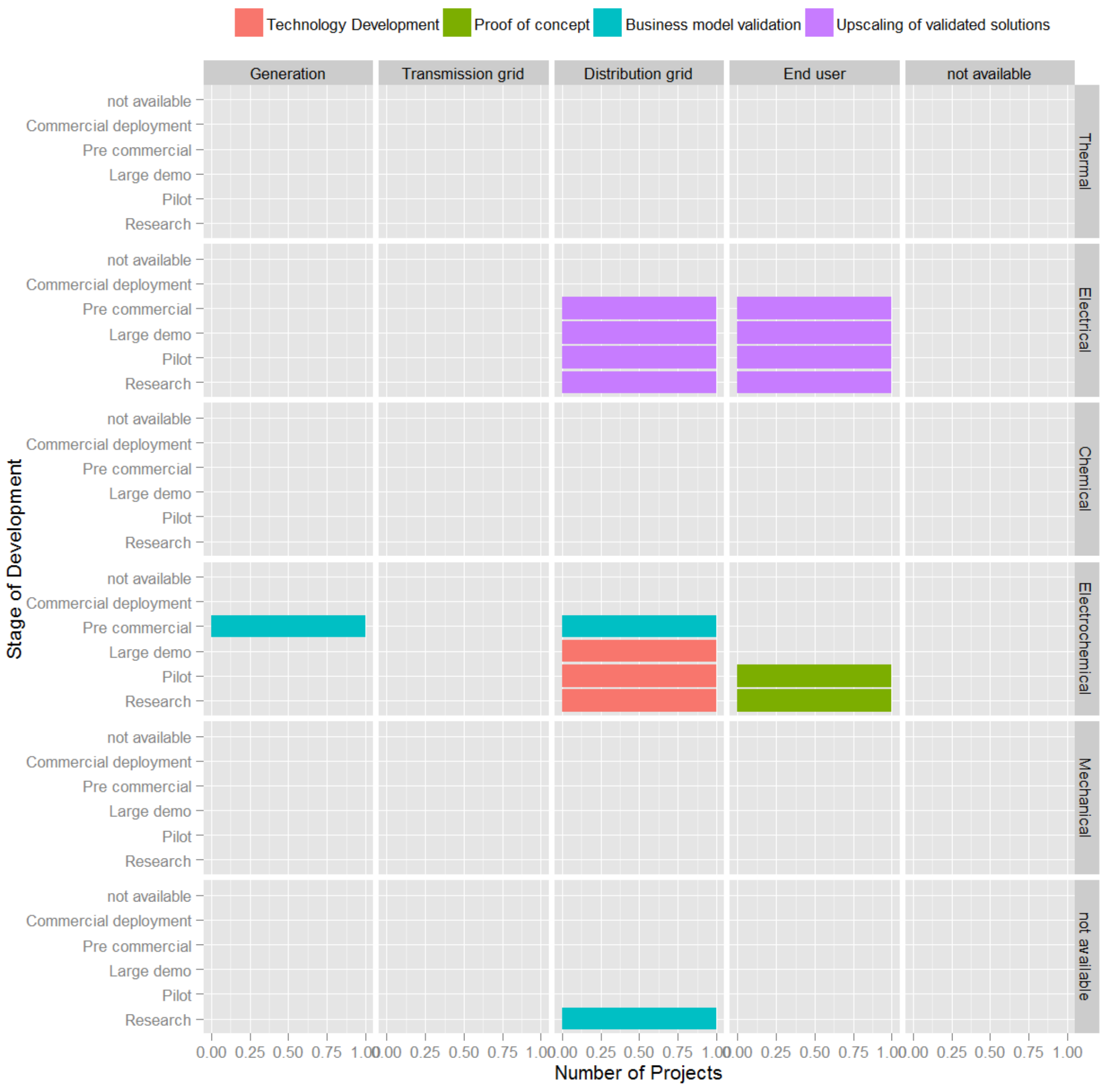

Figure 61: Storage readiness level according to the type of technology and the project's connection level.

5.14. Country fact sheet: UK

5.14.1. Overall situation

The UK is clearly a country about to make a major leap in storage development. The analysis of the EEGI storage mapping questionnaires shows that in the UK a total of 12 projects have been identified, amounting to a sizeable 311 million EUR of investment. The high average funding per project is explained by the presence of two large-scale pilots that make up two thirds of the entire budget.

Next to the numbers reported here, the UK is launching a number of additional support schemes that will add substantially to the country's total investment. Not all of it will be directed to storage, as the support measures mostly target low carbon energy systems. All in all, a whopping EUR 652 million is forecast to be spent on low-carbon technologies. The bulk of this will come from the Low Carbon Network Fund, which is funded through the distribution tariffs and is aimed at pilot/demonstration projects.

5.14.1.1. Number of projects

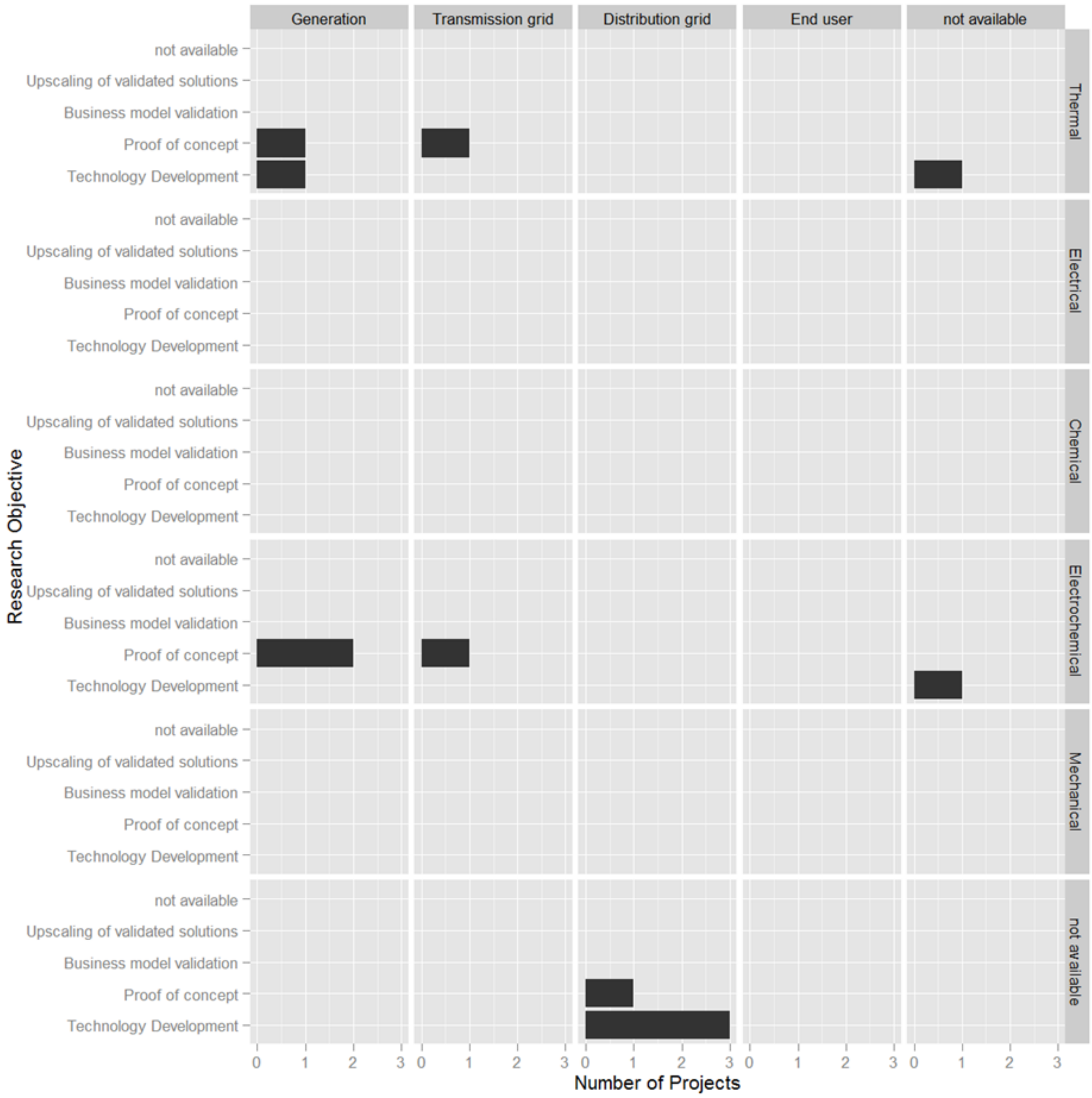

Figure 62: Number of projects according to the type of technology, the project's connection level and the projects readiness level.

5.14.1.2. Total budget

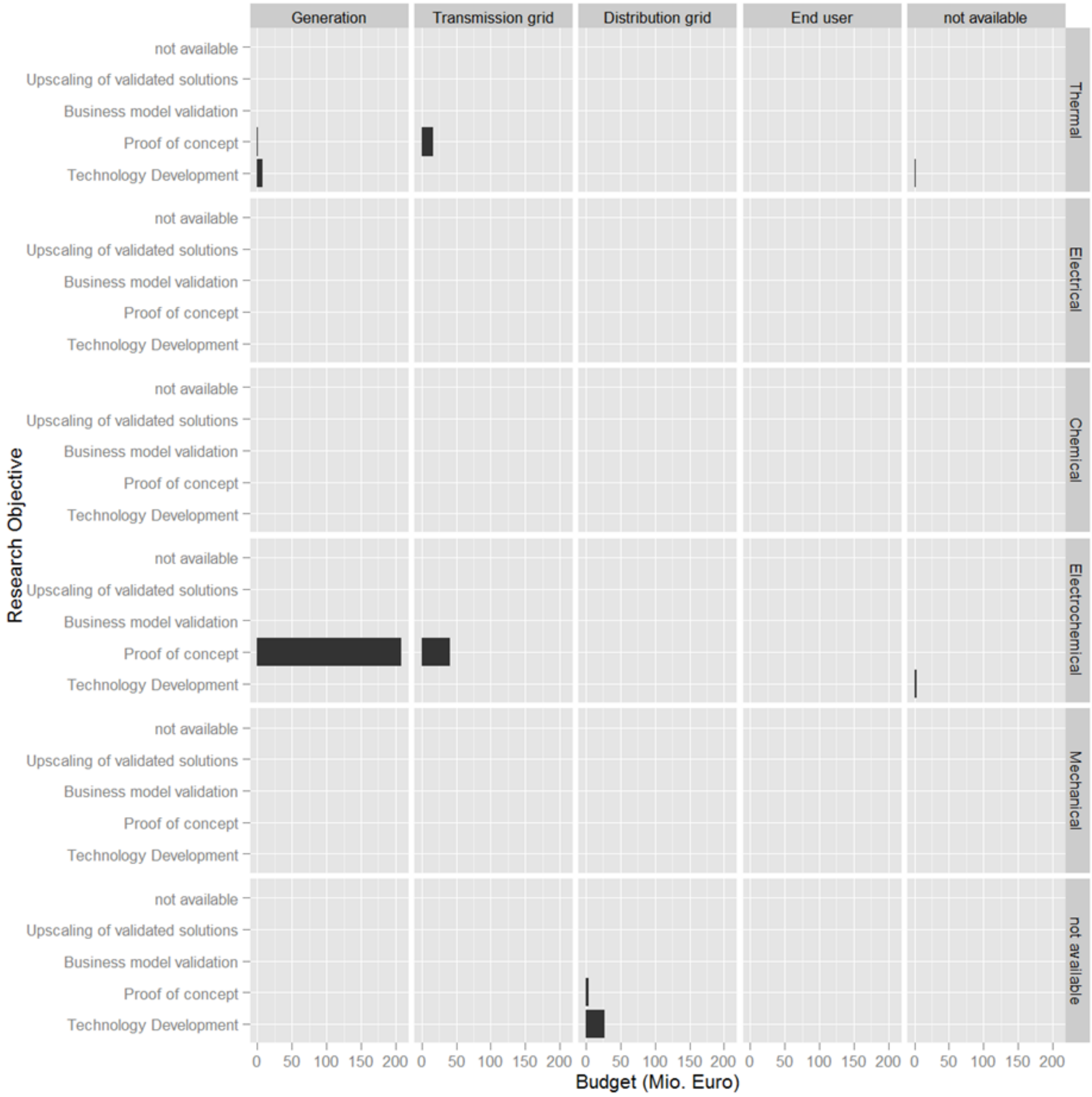

Figure 63: Project budget according to the type of technology, the project's connection level and the projects readiness level.

5.14.2. Specific storage related budget

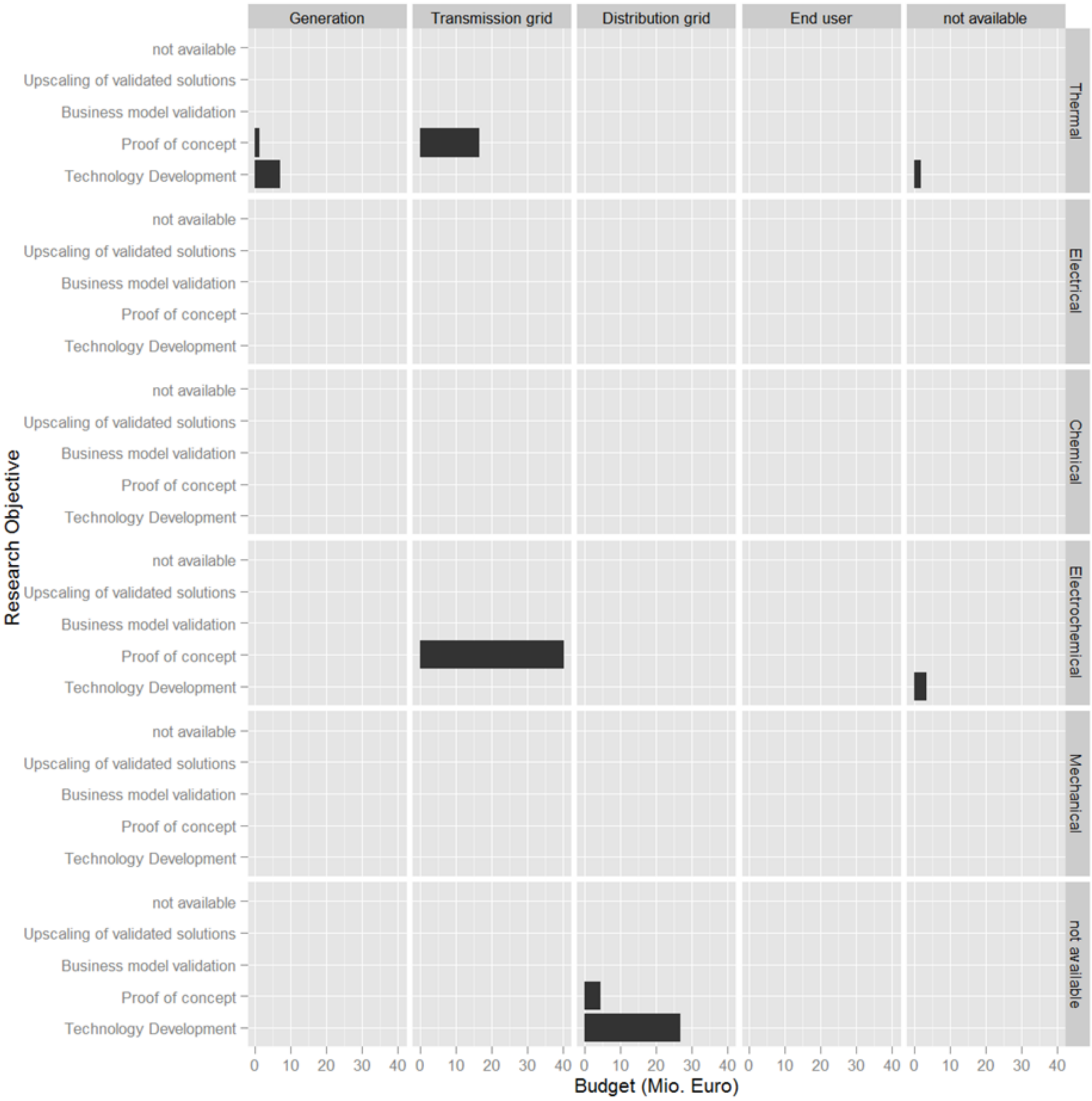

Figure 64: Specific storage related budget according to the type of technology, the project's connection level and the projects readiness level.

5.14.3. Project readiness level

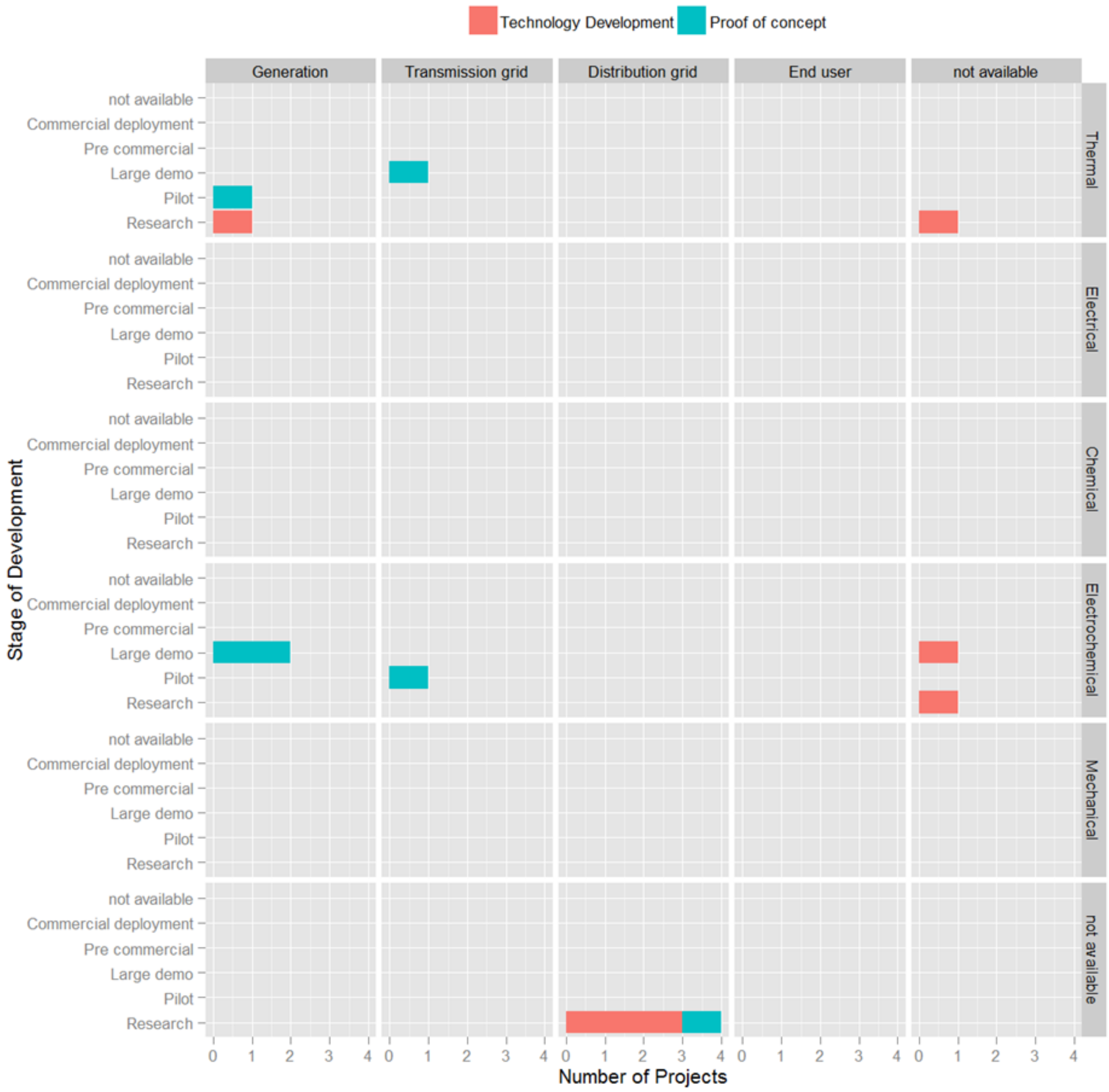

Figure 65: Storage readiness level according to the type of technology and the project's connection level.

5.15. Conclusions on the mapping per country

From the wide variety of pictures in all countries, there are a few remarkable trends to be captured.

First of all, there seems to be a tendency to some kind of regional specialization. This is most visible in Southern Europe, which puts a very strong focus on battery storage (although there is an overall tendency to look at electrochemical storage all over Europe). Mechanical storage (CAES and pumped hydro, mostly) is well developed in some pockets in Northern and Central Europe (mostly Norway, Austria and Denmark). Finally there are interesting tendencies in chemical storage (Power-to-Gas comes to mind) in countries like Germany and Spain.

Secondly it is remarkable how countries that provide for R&D&I financing from grid tariffs (i.e. Italy, Norway and the UK) seem to effectively be the ones with the larger, but also with the more advanced-stage projects. Most demonstration - and especially pre-commercial – projects are to be found here. The outlier among the outliers – the Orkney Islands Energy Storage Demo of 200 million EUR – is the prime example. This would certainly lend weight to the argument that financing from tariffs is an effective way of furthering grid developments and also realising their impact in the field.

Finally the contrast between the EU-15 and the newer Member States is visible here. In part this is of course due to the absence of many Eastern European countries from the EEGI, but the data suggest that developments are not at the same stage. This needs to be put in the local context of each country, but it may be a point of attention in the future policies on energy and regional cohesion in the EU.