Aachen University of Applied Sciences
Jülich Division

Masters of Energy Systems

Clustering for the Promotion of the Energy Industry

Thesis by:
Kurt Bastian

Jülich, February, 2010

A thesis submitted in partial fulfillment of the requirements
for the degree of:
Master of Science in Energy Systems

This thesis is produced and written independently.
Only the cited sources and references have been used.

Kurt Bastian

This master thesis was supervised by:

Prof. Ulrich Daldrup
Prof. Klaus Brüssermann

Table of Contents

1 Acknowledgements

There are many to who credit for the completion of this study is due. Most notably I must acknowledge Professor Ulrich Daldrup of Energy Hills who offered this project to me and encouraged me through every step. Then I must acknowledge the members of Energy Hills who were most cooperative with helping me collect the data and taking the time to meet with me and discuss what their role in the Energy Industry was. This was a very interesting project that I am very thankful to have been a part of.

Furthermore, I owe a great deal of thanks for the unwavering support of my friends and family back home in the USA. Without their support I may never have taken the step to study in Germany.

While in Germany I have also been privileged to have made such good international friends in Germany, notably David Castaño, Paris Chatzitakis, and Rodrigo Gutierrez who have been my family away from home.

2 Proposal of Master Thesis

2.1 Importance of subject and potential effects

Energy has become a critical theme in recent times. This is due to climate concerns, increases in energy costs, and consumption of a finite conventional energy supply.

Climate and environmental concerns are on the forefront of the European community and even the global community. The Energy Industry is a major source of alterations to our environment in form of emissions, whether exhaust into the air from power plants, cars, or heating systems or polluting water and soil from mining for materials: and these effects can cause health problems to people and the living environment. In an attempt to address these concerns and the potential affect on climate the European Union has created a law to reach certain environmental impact reduction goals for the year 2020 called the "202020" package. This incentive plan intends to reduce emissions by 20% of 1990 emission levels from 1990 by the year 2020, a 20% reduction in primary energy use from the baseline projected energy demand of 2020, as well as have 20% of energy production coming from renewable sources.

In addition to the environmental concerns, it has become very important for society to address these issues before they cause greater economic difficulty. With a great dependence on imported energy such as oil and natural gas, certain regions are subject to external pricing which continues to rise and supply which continues to be depleted. If not properly addressed fossil fuel poor regions could be left in a situation where they can no longer afford the energy they demand and result in major contraction of economy and society.

The Commission of European Communities put together a "Green Paper" on the European strategy for sustainable, competitive and secure energy, and this was their synopsis of the energy situation for Europe:

Europe has entered into a new energy era.

• There is an urgent need for investment. In Europe alone, to meet expected energy demand and to replace ageing infrastructure, investments of around one trillion euros will be needed over the next 20 years.
• Our import dependency is rising. Unless we can make domestic energy more competitive, in the next 20 to 30 years around 70 % of the Union's energy requirements, compared to 50% today, will be met by imported products – some from regions threatened by insecurity.
• Reserves are concentrated in a few countries. Today, roughly half of the EU's gas consumption comes from only three countries (Russia, Norway, Algeria). On current trends, gas imports would increase to 80 % over the next 25 years.
• Global demand for energy is increasing. World energy demand – and CO2 emissions – is expected to rise by some 60% by 2030. Global oil consumption has increased by 20% since 1994, and global oil demand is projected to grow by 1.6% per year.
• Oil and gas prices are rising. They have nearly doubled in the EU over the past two years, with electricity prices following. This is difficult for consumers. With increasing global demand for fossil fuels, stretched supply chains and increasing dependence on imports, high prices for oil and gas are probably here to stay. They may, however, trigger greater energy efficiency and innovation.
• Our climate is getting warmer. According to the Intergovernmental Panel on Climate Change (IPCC), greenhouse gas emissions have already made the world 0.6 degrees warmer. If no action is taken there will be an increase of between 1.4 and 5.8 degrees by the end of the century. All regions in the world – including the EU – will face serious consequences for their economies and ecosystems.
• Europe has not yet developed fully competitive internal energy markets. Only when such markets exist will EU citizens and businesses enjoy all the benefits of security of supply and lower prices. To achieve this aim, interconnections should be developed, effective legislative and regulatory frameworks must be in place and be fully applied in practice, and Community competition rules need to be rigorously enforced. Furthermore, the consolidation of the energy sector should be market driven if Europe is to respond successfully to the many challenges it faces and to invest properly for the future.
(Commission of European Communities, p. 3)

So to summarize, it is of utmost importance to the European community to find ways to make their energy supply more sustainable, competitive, and secure.

2.2 Intent of this Thesis

This thesis intends to investigate how clustering or networking within the energy industry could help make the energy supply more sustainable, competitive, and secure. Michael Porter, in an article entitled "Clusters and the New Economics of Competition" shows how clusters within an industry can be more productive, be more innovative, and stimulate new businesses (Porter, 1998). It would then seem that a cluster in the energy industry could be a great asset to solving the issues facing the energy industry. For this reason this thesis will investigate an energy cluster in Europe to determine if the advantages cited by Porter are present in the energy cluster and if this energy cluster is well positioned to make the energy supply more sustainable, competitive, and secure.

3 Definitions

3.1 Clustering

"Clustering" is an unofficial term for a network of organizations within a particular region, industry, and/or technology. Other words used to describe a network of organizations are federations, associations, interest groups, and societies. Clustering is intended to speed up the innovation process by connecting research and development with sustainable business models and investors to create a more stable and bigger industry. Clustering should also streamline and organize an industry so that it can optimize its functions and meet the needs of its customers and society.

Michael Porter, who is an expert in the economics of industrial clusters, defines clusters as:

"…geographic concentrations of interconnected companies and institutions in a particular field. Clusters encompass an array of linked industries and other entities important to competition. They include, for example, suppliers of specialized inputs such as components, machinery, and services, and providers of specialized infrastructure. Clusters also often extend downstream to channels and customers and laterally to manufacturers of complementary products and to companies in industries related by skills, technologies, or common inputs. Finally, many clusters include governmental and other institutions – such as universities, standards-setting agencies, think tanks, vocational training providers, and trade associations – that provide specialized training, education, information, research, and technical support." (Porter, 1998, p. 78)

From Porter's description of a cluster, there can be extrapolated four main properties of a cluster, or the network, and then there are certain types of members. The four main properties or requirements of a cluster are:

1. Location, or a geographic concentration
2. An particular field, or industry
3. Competing and complementary organizations (energy producers)
4. Supply chain (energy supply chain from resource to delivered product)

Member types within a cluster as described by Porter could be broken down as follows:

1. Companies
2. Research organizations
3. Educational Institutions
4. Public entities, or government agencies

Essentially this list is three main supporting institutions for the companies in the particular industry. For the purpose of this report it should be shown how this fits in the Energy Industry.

3.2 The Energy Industry

The Energy Industry is commonly defined as all the industries which produce and distribute energy. There is no current official classification of the Energy Industry: typically the Energy Industry has to be extracted from other industrial classification systems, such as the North American Industry Classification System (NIACS). The NAICS has sections of mining (#21) and utilities (#22) but does not specify the Energy Industry (US Census Bureau, 2007). Just from this assumption of mining and utilities the Energy Industry can be seen as fuel extraction (biomass, coal, oil, gas, nuclear fuels), distribution of the fuels, processing of fuels or converting to another carrier (hydrogen), conversion of fuels to useful heat and electricity, and the distribution of the converted energy to an end user. This would also include renewable forms of energy such as those utilizing solar, hydro, and wind energies. To put it another way, the energy industry is typically seen as the industries directly part of the technical processes of acquiring, producing, and distributing energy to meet the demands of society. This means that there are three traditional areas, or competences, within the Energy Industry: resource acquisition, conversion to more useful forms, and distribution of energy to the consumers.

For the purpose of this thesis, it is proposed that there is an additional area, or competence, in the Energy Industry. An overlooked, yet critical, player in the Energy Industry is the consumer. While the consumer is not readily seen as part of the Energy Industry, their role is becoming more recognized due to governments giving tax deductions for energy savings. There is a whole industry making the products or facilities that consume the energy produced by the Energy Industry. These organizations that make all of these energy consuming products are affecting how much energy is needed from the Energy Industry, and therefore are part of the Energy Industry. Reducing the demand of energy by creating more efficient products makes the energy consumers a major player in the Energy Industry. With the consumers included in the definition of the Energy Industry, it can be said that the whole supply chain of energy is the Energy Industry.

With this new definition of the Energy Industry including the whole energy supply chain, it is not necessarily the complete Energy industry. As Porter suggested in his definition of a cluster, there are other institutions that are critical to the functioning of an industry (Porter, 1998, p.3). For example, Universities are needed by the Energy Industry to produce qualified people to work in the Energy Industry. Granted that organizations in the Energy Industry are training their own employees, but before the employee is hired, the organizations often need them to have a certain level of competence in order to understand the training that they receive upon being hired. Research Institutes provide the Energy Industry with new and innovative materials and solutions that they may not have been able to develop on their own. Governing bodies act as an interface between the public and industries like the Energy Industry to protect both parties, and many regulations are formed by governing bodies that have great impact on the Energy Industry. Governing bodies are also part of the Energy Industry then, due to the regulating they do specific to the Energy Industry. Then there are numerous organizations providing services; technical, legal, financial, and organizational that are specializing their work toward the Energy Industry, and must then also be considered part of the Energy Industry.

So now the complete picture of the Energy Industry can summarized as five main sections of energy competence:

1. Energy Resource Extraction and Processing
2. Energy Conversion
3. Energy Distribution and Storage
4. Energy Consumption and Efficiency
5. External Entities

This is further illustrated in Figure 1.

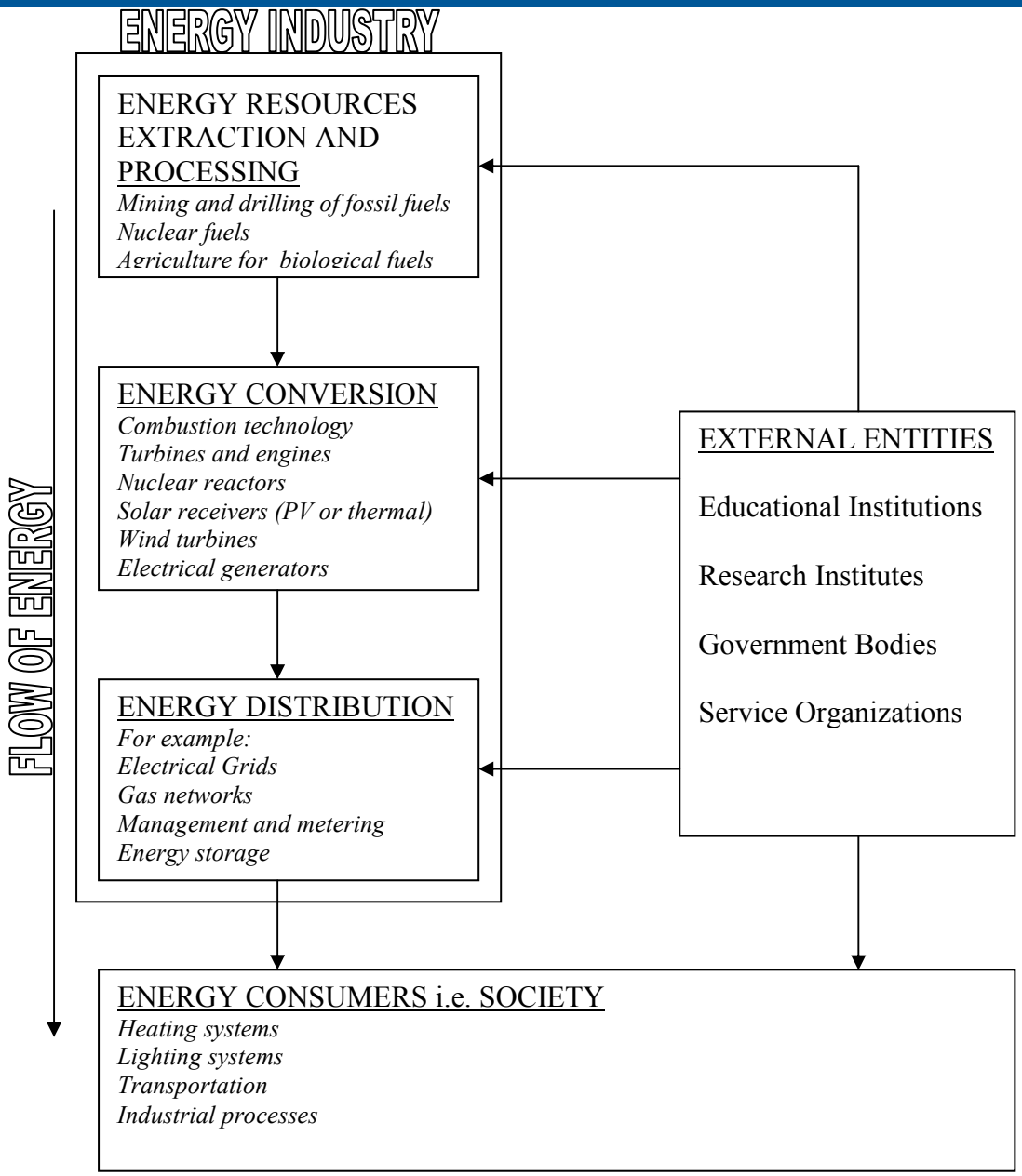

Figure 1. Diagram of the Energy Industry showing examples of activities in each section. The left side shows the supply chain of energy and the right shows the are external entitites which service and influence the Energy Industry.

3.3 Competence

For the sake of this study, competence in the Energy Industry should be defined. Competence in industry is the skill, knowledge, and ability to accomplish the goal of that industry. Competence then in the Energy Industry involves the know-how of each of the players in the Energy Industry to do perform their tasks. Without this know-how, it would be impossible to produce and use energy. Competence can be categorized into four main activities:

1. Manufacturing and Production: Knowledge on how to build, operate, and maintain power production facilities, as well as knowledge on the production of the products needed throughout the entire energy supply chain is a key competence.

2. Research and Development: another major competence for the Energy Industry is the ability to discover and develop new technologies and procedures that can help the Energy Industry do its job to meet the demands of the consumers and society as a whole.

3. Education and Training: the ability to educate and train the people to meet the skill requirements that the Energy Industry needs is another major competence required by the Energy Industry.

4. Services and Consulting: there is a lot of know-how in all of the services specific to the Energy Industry that is necessary for the Energy Industry to function.

4 Assessment of the energy cluster "Energy Hills"

4.1 What is Energy Hills

Energy Hills is an Energy Industry cluster within the Euregio Maas-Rhein region of Germany, the Netherlands, and Belgium which form a cross-border region (shown in Figure 2). The region has been a historical hub for energy production for northern Europe with the discovering of coal in the 1870's.

Figure 2. Map showing the Euregio Mass-Rhein region that is the base region for Energy Hills. Some members of Energy Hills are based outside of this region, but are nearby. (Euregio Maas-Rhein, 2010)

The network was founded in 2007 due to the request of regional organizations working with energy related issues. Over the last two years the cluster has grow to fifty-eight organizations (as of 2009) and is still growing.

4.2 Description of the assessment

In the beginning of 2009 Energy Hills began development of a questionnaire for its members to know what the competences were within the cluster, the size of the cluster, and what the cluster needed. An initial report by David Castaño and Kurt Bastian was submitted in June of 2009 with a 16 question survey conducted with 22 of the organizations in Energy Hills (Castaño & Bastian, 2009). This assessment was then continued in the autumn of 2009 with the rest of the members to complete the study and gain a picture of the complete cluster. From the results of this assessment the value and importance of clustering in the Energy Industry will be shown.

4.2.1 Assessing Competence Type

It was of primary importance in this assessment to understand the competences of each organization. More specifically, each organization's areas of expertise were highlighted with regard to activities in energy. At the first level this was sorted by organization type:

- Company
- Research Organization
- Educational Institute
- Public Entity

This established what type of member the organization was. From there it was found what type of activities they were doing:

- Manufacturing or Production
- Research and Development
- Training and Education
- Consulting or Services

While some organizations could purely be doing one type of activity, it was more likely that the organization had a combination of functions. For example, a company producing solar cells would mainly be in manufacturing and production, but they very

likely had a research and development department and also some training for new employees and some sort of education for customers. So each organization was asked to give a break-down of their types of activities based on number of employees and the amount of funding that were allocated to each activity. Furthermore, the specific competences in the Energy Industry were found by establishing what part of the energy industry each organization was operating in:

- Energy Resource Acquisition and Processing
- Energy Conversion
- Energy Distribution and Storage
- Energy Consumption
- External Services

4.2.2 Assessing Competence Level

At this point in the survey it became clear what the competences were and, relative to organization type, funding, and employees, *how much* of each competence existed within the energy cluster. What still remained to be seen what *how good* these competences were. Was their competence or area of expertise state-of-the-art? Was it world leading? Leading in the region, or perhaps in Europe? World leading research, technology, and business were identified from each organization to know the quality of the competence within the cluster.

There were also other indicators of level of expertise than just asking the organizations what world leading activities they were involved in. Were they being consulted internationally in their particular field? How much of their activity was outside of the cluster region, whether it be throughout the EU or worldwide was one indicator. Another measure of this consulting for being recognized as leaders in their field is how much third party funding they are receiving to further develop their particular competence. The qualification of their employees was also an indicator of level of competence, and so it was asked of each organization how many PhDs they had, how many academic level (Masters, bachelors, and Diploma) employees they had, and how

many university students they had working there. The age of each organization, or more specifically the time each organization has been involved in energy related activities, also shows a certain qualification measured in years of experience. These questions were asked to try to find out how innovative and prominent these organizations were in the Energy Industry.

4.2.3 Assessment of Stability

It was also important to look at the success of the Energy Industry within Energy Hills. There were two main indicators used to indicate growth in the region. The first was the most obvious one: each member was asked how much they have grown with regard to their budget from 2007 to 2008. It was too difficult to get an average growth rate that could be compared, as some companies were much younger than others, so just a yearly growth for the whole cluster was all that could be expected. The second indicator was the number of more recently started companies. This was to look at the recent growth in the Energy Industry.

To further understand the stability of the organizations in the energy cluster, the members were asked to report what were their securities or advantages that kept them in business and growing. Then, on the flip-side, each organization was asked to report what limitations they faced that restricted their growth. These two questions allowed each organization to show the advantages and limitations of working in the Energy Industry.

4.2.4 Assessment of Cluster Expectations

To finish the survey, members were asked why they joined the cluster Energy Hills and what their expectations were from joining and being a part of a cluster. This was to then be compared to their reported limitations to see how a cluster could meet the needs of the Energy Industry.

4.3 Summary of Findings

Of the 58 members of Energy Hills, 51 were interviewed. The seven members not interviewed were smaller organizations that were not currently active or large enough to be considered for this study. Most interviews took place at the company's headquarters, although some information was found via email communications. Most members reported all the values asked, but some members were not able to report their annual funding. Most members were not able to give specific values for the division of labor and funding among their different activities, such as research and development or education and training. Estimates for these values were often given, but the accuracy of these values could not always be confirmed.

To further complicate the data acquired, some organizations were connected with much larger organizations that were not officially members of the cluster, but it could be assumed were part of the competence of the organization. Very large organizations, like RWE, had such large funding and employee values that they overshadowed most other members in the figures.

The initial 22 interviews were conducted in February through March of 2009 as part of a project for Energy Hills to develop a questionnaire to asses each member's competences. This was a team project with David Castaño and Kurt Bastian working together. This questionnaire was then continued for the remaining members starting in October of 2009 until February of 2010 to complete the survey and use for the purpose of this thesis. (Castaño & Bastian, 2009) The persons interviewed and dates of the interviews are recorded in Appendix 2.

4.3.1 Areas of Competence in Energy Hills

The competence assessment results were organized to be presented in three different ways. The first was by organization type. This was to show the types of members there were in the Energy Hills cluster and in what distribution. The second was by activity type, meaning what kind of work they were doing. This was to highlight the type of work being performed in Energy Hills and in what distribution. The third presentation was by the actual activity subject in the Energy Industry. This was to show what specific technologies and activities in the Energy Industry are present in Energy Hills and in what distribution. Any further details on the competences within each organization in Energy Hills can be found in Appendix 4: Descriptions of Energy Hills Organizations.

4.3.1.1 Organizations

The members of Energy Hills were identified as one of four types of organizations: Companies, Research Organizations, Educational Institutes, and Public Entities. Companies typically refer to any private organization working in any part of the Energy Industry, although some are publicly owned companies. The other three organization types are external entities to the Energy Industry. Research organizations, Educational Institutes, and Public Entities were all external entities to the Energy Industry and their services where not exclusively serving the Energy Industry.

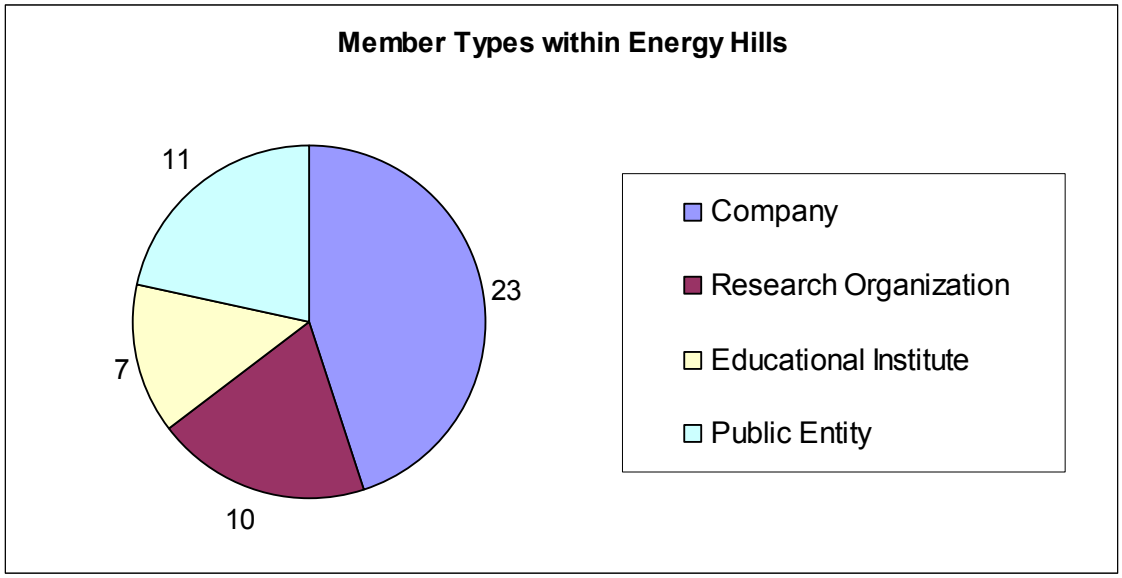

Figure 3. Number of members interviewed within Energy Hills. The total interviewed was 51 organizations.

Energy Hills has more Energy Industry companies than any other organization type. There are 23 companies, but a total of 28 external entities serving the Energy Industry in some capacity. This is a very significant percentage of external organizations with a stake in the Energy Industry. This was a determining factor in dividing the members into these four organization types: it was seen that the research organizations, educational institutes, and public entities were numerous enough to be shown separately instead of lumped together as external entities to the Energy Industry. The pie chart in Figure 3 illustrates this point, but does not take into account the actual size of the organizations.

One method of showing the size of each organization type is by human resources. The amount of people working in each organization type shows the relative size of each organization type to one another in Energy Hills. The proportion of each organization type in Energy Hills in Figure 4 is not much different from the proportions based simply on number or organizations shown in Figure 3. This means that that there are roughly the same number of people working in each organization, at least relative to organization type. For example, the size of the educational institutes is roughly proportional to the size of the companies in Energy Hills. These values do not consider certain things, however: some of the research institutes were part of a university

which had some employees being counted in the human resource figure making it possible that some employees were counted twice. Further complication in the representation of the size of the organization types was made by the fact that not all employees within each organization were actually working in an energy related field.

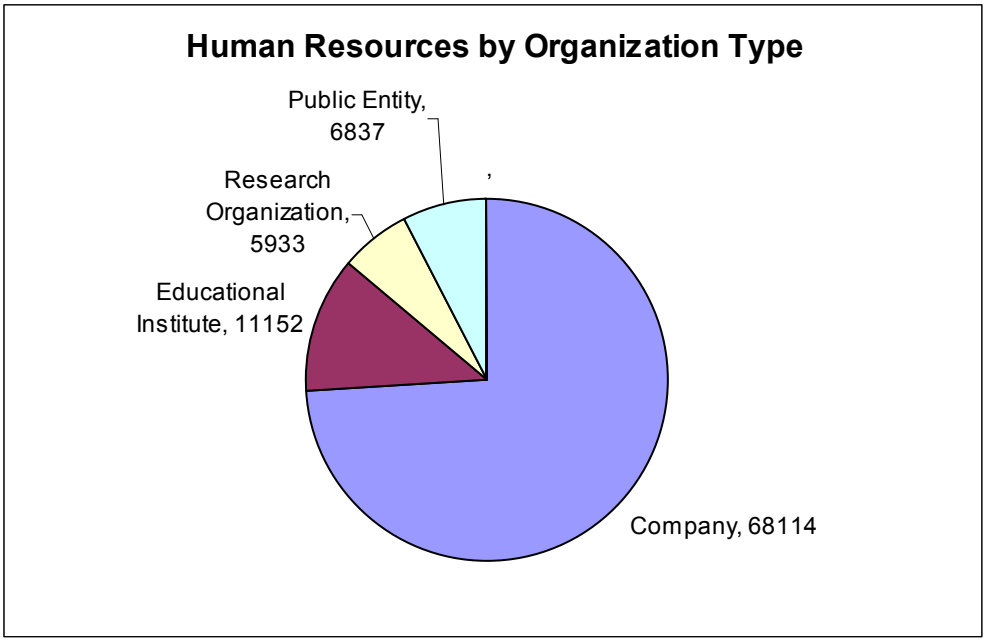

Figure 4. Number of employees within each organization type. As in Figure 7, RWE Power's employment figures dominate under guise of the Company organization type.

To try to actually understand the energy involvement of each organization type, organizations were asked to report how many of their employees were working in energy related work or competences. For example, a municipality has many employees, but perhaps only a small handful of them are actually working in energy related topics such as the public utilities, energy consumption, or energy policies. Not every organization could report this with the same level of accuracy, so estimates from each organization were used when an actual figure could not be produced. Some organizations were not able to report this figure at all, and so are not properly represented in the graphic in Figure 5. But most organizations were able to report this value, and it shows that the Public Entities and Educational Institutes have the least number of employees working in energy related subjects. Educational institutes in particular had a difficult time saying exactly how many employees were working in

energy related subjects since their educational programs may not all address energy directly, but their educational competence certainly crosses subject lines. So the graph in Figure 5 shows the number of people working in energy themes in Energy Hills, but does not necessarily show the amount of competence in each organization type.

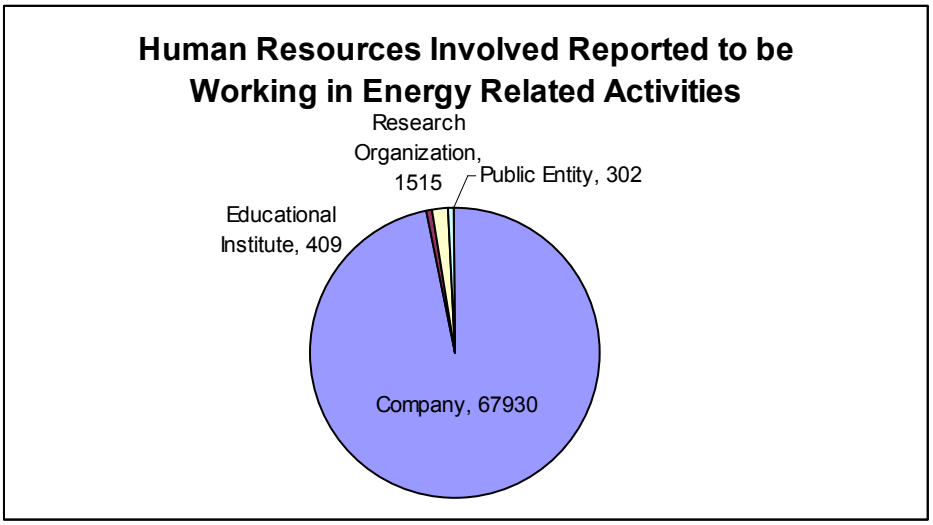

Figure 5. Employees in Energy Hills working directly in energy related work.

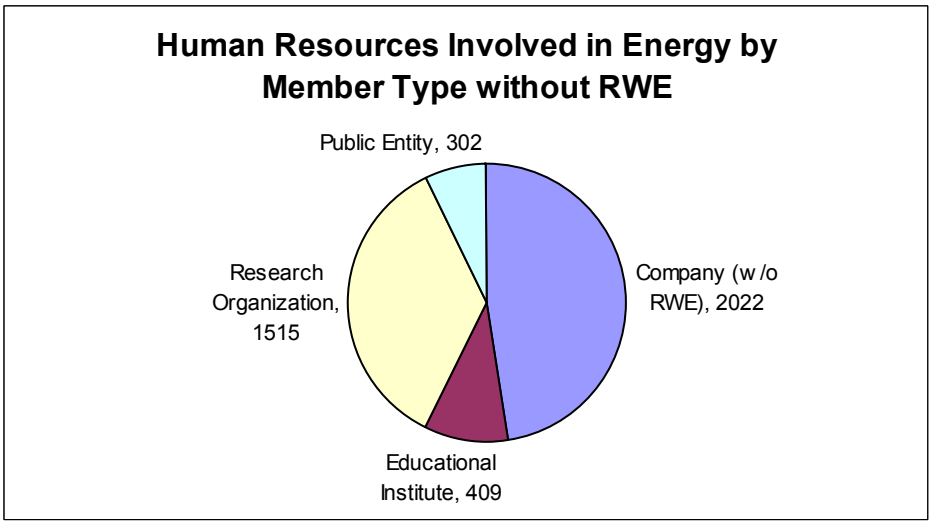

Figure 6. Number of employees reported to be working in energy related activities excluding RWE.

Figure 5 shows that there is a very high percentage of people involved in energy in companies, or the direct energy industry, within Energy Hills. This number of energy related workers in companies is largely due to RWE Power's membership in Energy Hills. RWE Power is part of the RWE group of energy providers. RWE works all over

Germany and other countries in Europe which was founded in Essen in North Rhine-Westphalia, the German state that is within the geographic region of Energy Hills. The total number of people employed by RWE is 65,908 employees. Due to the wide distribution of RWE it may be hard to place them in one region, but they were founded in Essen and grew in the brown-coal rich North Rhine-Westphalia to become the European-wide company that they are now, and so their competence can largely be attributed to the Energy Hills geographical region. It also follows that not all of the 65,908 employees of RWE are not within the Energy Hills geographical area, and may be seen as not counting as part of the Energy Hills employees. But when one considers the competence of an organization, it encompasses everything internal to the organization. RWE was formed in North Rhine-Westphalia and simply because it grew outside of the region does not mean that the competence is not accessible in the region.

Another indicator of the size of the different organization types is the amount of revenue generated in each organization. Not all organizations reported revenue values, so this value is perhaps less indicative of the actual size than the human resources, but only 5 organizations of 51 did not report, so it is representative of the majority. The only real bias of the lack of reporting figures was that 3 of those non-reporting organizations were research organization, and only helped to reduce the already lower figure for the research organizations in Table 1. Once again RWE dominated the revenue within Energy Hills with its 49 billion euro turnover.

Table 1. Revenue generated in Energy Hills listed by organization type. The Energy Revenue was as reported by each organization, and is a minimum amount for all of Energy Hills. Also, 8 organizations did not report revenue values.

Organization Type	Total	Energy Revenue
Company	52,410,600,000.00 €	52,376,800,000.00 €
Company (w/o RWE)	*3,410,600,000.00 €*	*3,376,800,000.00 €*
Education Institute	924,600,000.00 €	13,800,000.00 €
Research Organization	169,236,000.00 €	169,236,000.00 €
Public Entity	99,230,000.00 €	19,160,000.00 €
Total	**53,603,666,000.00 €**	**52,578,996,000.00 €**
Total w/o RWE	*4,603,666,000.00 €*	*3,578,996,000.00 €*

Since RWE dominated the revenue values so strongly, it was interesting to see what the distribution looked like without RWE included. In Table 1 it is revealed that the educational institutes have a larger share of the revenue, but this is not surprising since there are some large universities and schools that have broad studies. To get a more accurate image of energy competence in Energy Hills, the self reported values of energy related revenue were also recorded. It can be seen in this table that the educational institutes and public entities had a significant amount of revenue that they did not designate as energy related. Not all organizations were able to report this very accurately, but it gives an idea of energy related revenue among the members of Energy Hills.

4.3.1.2 Competences

If each organization were involved in only one competence type, there would be no need for this section: the competences would have been sorted simply by organization type. This is largely true, as research organizations are typically only involved in research and development, educational institutions are mostly involved in education and training, and so on. However it was found that many organizations had more than one of the four competence types described for the purpose of this survey, and so the human resources and revenue values are also presented by competence type to see if it shows anything different.

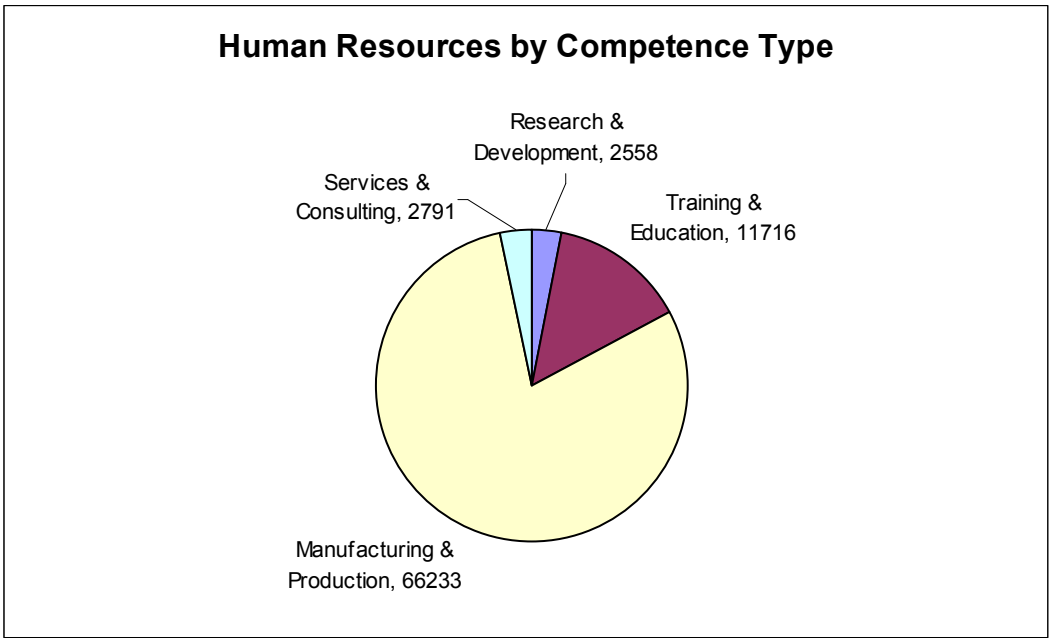

Figure 7. Number of employees total within Energy Hills, not taking into account whether they all work in energy or not.

Not all funding was reported as being in a certain competence type. It was intended to get an amount of R&D funding in Energy Hills, but this figure is very uncertain as some organizations could not say how much of their budget was for R&D. So of the 53,620,179,000.00 € total in Energy Hills, only 52,748,469,000.00 € was reported within a competence type.

Table 2. Revenue for Energy Hills by Competence Type in 1,000 €.

Organization Type	Research & Development	Services & Consulting	Training & Education	Manufacturing & Production	Total
Company	24,950	3,285,895	2,525	49,096,000	52,409,370
Company (w/o RWE)	*24,950*	*3,285,895*	*2,525*	*96,000*	*3,409,370*
Education Institute	7,000	-	114,800	-	121,800
Research Organization	169,416	-	-	-	169,416
Public Entity	-	40,370	6,400	-	46,770
Total	**202,479**	**3,326,265**	**123,725**	**49,096,000**	**52,748,469**
Total w/o RWE	*201,366*	*3,326,265*	*123,725*	*96,000*	*3,747,356*

As can be seen in Table 2, the manufacturing and production dominates just as the companies did with the power production human resource figures of RWE in Figure 7. Still, there are significant amounts of Research and Development, Services and

Consulting, and Training and Education in Energy Hills as indicated by the revenue and human resources.

4.3.1.3 Specific Energy Competences

Each organization was asked to describe exactly their activities in the Energy Industry, and based on these results a list of activities in Energy Hills could be developed. This was based on an interpretation of the description each organization gave of their activities and then slightly generalized to create categories of overlapping activities between companies. The competences are categorized based on sections of the Energy Industry: the number in the parenthesis next to the activity is the number of organizations in Energy Hills working in that particular area.

Energy Resources Extraction and Processing

- Coal & Brown Coal (3)
- Agriculture for biomass fuels (2)
- Biofuel production and storage (1)
- Hydrogen production (2)
- CO2 Sequestration and storage (4)

Energy Conversion

- Photovoltaics (11)
- Wind (6)
- Fuel Cells (4)
- Biomass combustion (4)
- Geothermal energy (4)
- Solar thermal applications (4)
- Power Plant operation (4)
- Material science for energy applications (3)
- Automotive technology (3)
- Nuclear power (3)
- Electric generators and equipment (3)
- Waste incineration (3)
- Fusion technology and plasma physics for energy applications (2)
- Gas turbines (2)
- Steam turbines (2)
- Microturbines (2)
- Combustion chambers and boilers (2)
- Combined heat and power (2)
- Hydroelectric power (1)
- Internal combustion engines (1)

Energy Distribution

- Grid management (12)
- Energy supply and trading (11)
- Smartgrids (10)
- Industrial park management (2)

Energy Consumption

- Energy auditing (8)
- Energy saving in the built environment (6)
- Lighting optimization (5)
- Heating, ventilation, and cooling (5)
- Energy efficiency of industrial equipment (3)

External Entities

- Education and Training (8)
- Climate and/or Emissions policy (8)
- Start up company assistance (7)
- Sustainable Society Considerations (6)
- Regional Development (5)
- Capital investment acquisition (4)
- Networking hub (3)
- Energy utilities IT services (2)
- Public Awareness (2)

There is a very broad array of competences within Energy Hills. There are activities in every part of the energy supply chain, as well as many activities external to the energy supply chain, but still strongly involved in energy related activities. It should be noted that the competences of all of the RWTH research institutes working in energy related areas where included (see Appendix 5: Institutes in RWTH Aachen Involved in Energy-Related Topics) and they are working in almost every one of Energy Hill's energy activities. Figure 8 highlights the most frequently reported competences among Energy Hill members. This in no way indicates the level of competence: some of the competences in Energy Hills where only one member is involved could be world leading, but it is interesting to know that many organizations are involved in some way with these particular activities.

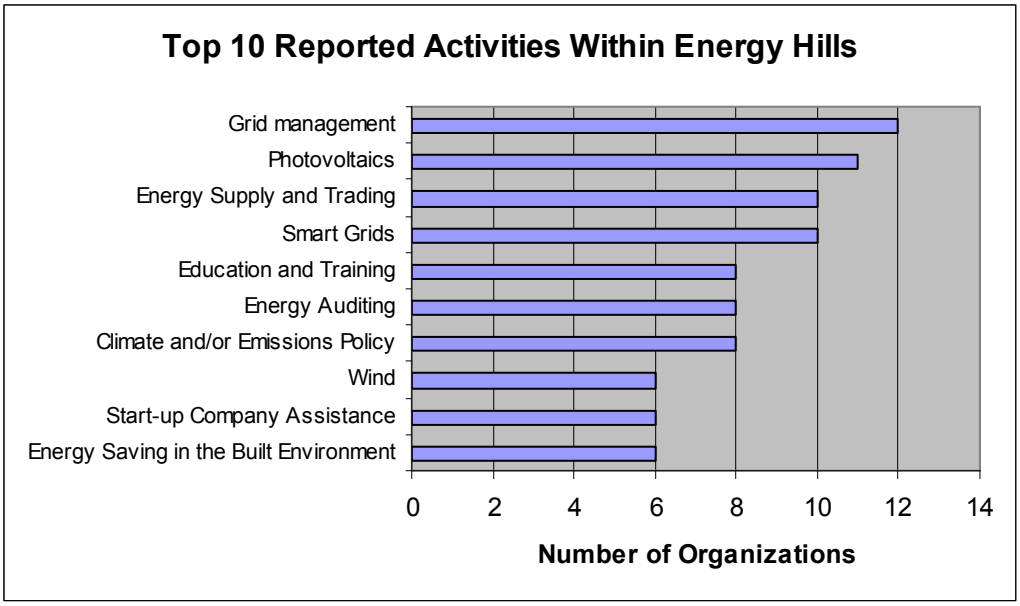

Figure 8. Most common energy related activities in Energy Hills.

4.3.2 Competence Levels

Once all of the competences of the members of Energy Hills were determined, it then became important to discover what the level of competence was. There was no one perfect metric for level of competence, but there were some indicators of a high level of competence that could be determined.

4.3.2.1 World Leading Competences

The first and most obvious indicator of a high level of competence is world leading competence. Some organizations within Energy Hills already have a world wide reputation. Four of the companies are or are part of a group in the Global Fortune 500 list of companies. These are leading companies that are internationally competitive and represent a high level of competence, even if the organization is only a part of a global Fortune 500 company.

Table 3. Global Fortune 500 Rankings for Energy Hills Organizations (Fortune, 2009)

Company	2008	2009
Siemens AG	37	30
RWE	114	89
Royal Philips Electronics	197	195
Vattenfall (NUON & Alliander)	396	357

Within Energy Hills there are also three major national research centers and a European university of excellence. There are a variety of world leading competences within Energy Hills, and here is a list of competences that were found through the survey of Energy Hills:

- High efficiency coal power plants including high temperature materials (RWE)
- Solar thermal power plants (Solar Institute FH)
- Carbon capture and storage (RWE)
- Lighting technology (Philips)
- Education of scientists and engineers in close collaboration with research institutes and industry (RWTH Aachen)
- Photovoltaics (ECN)
- Energy transfer networks (RWE)
- Computer Simulation (FZ - Jülich)

- Converting old waste sites into new materials and energy. (Closing the Circle project, Gemeente Houthalen-Helchteren)
- Smart metering system (Alliander AG)
- Wind turbines and energy efficiency of industrial equipment (Siemens AG)
- Improved CO2 capture via genetic improvement in plants (The Biology 1 Institute, RWTH)

Some other notable areas in which Energy Hills is a European leader include:

- Conventional power production (RWE)
- New energy company incubation (AGIT, Heerlen Muni.)
- Geothermal energy from old coal mines (Heerlen Muni., Open Uni. NL)
- Internal combustion engine development (VKA)
- Energy Trading (Trianel)
- Energy transfer networks (ProCom, SOPTIM, TUE)
- Largest research cooperation between a company and a university in the European Union. (EON ERC at RWTH)
- Some of the only industry initiated networks (CAR, Hycologne)
- One of the largest Research Centers in Europe (FZ)
- Within the EU, Technical University Eindhoven has achieved the third best University science citation impact score overall, after Cambridge and Oxford., mostly concerning electrical grid control and management (TUE)
- Only independent hydrogen cluster in Germany. 4th or 5th largest hydrogen network in Germany. (Hycologne)

- North Rhine-Westphalia is energy region #1 in Germany and has a very highly motivated energy industry in which EnergieAgentur.NRW has a unique cluster management to other energy clusters in Europe.

- KHLim is pioneering the connection between high schools and universities by developing stronger connections with both institutions. The projects in conjunction with Hogeschool Zuyd in the Netherlands, the EON research center in RWTH, and other educational institutions is unique in Belgium.

- The #1 technical school in the Netherlands. They are leading in their work with transitions between technology, application, and business models. (Hogeschool Zuyd)

- Pioneering of new energy policies and subsidies: first in Germany for wind and solar subsidies. (Stadt Aachen)

- A research platform for the German electrical utilities which rely on the studies, equipment, and certification work done at this center. (FGH)

International Revenue

A high level of competence in a field could be associated with work done outside of the region. It was found that many organizations in Energy Hills had work or projects in areas outside of the Euregio Maas-Rhein region. 65% of the business conducted in Energy Hills is outside of its region. It can be projected then that the competence of work performed within the Energy Hills region is of such a high level that other regions of Belgium, The Netherlands, Germany, the rest of Europe, and even the world work and do business with organizations in Energy Hills.

Table 4. Revenue generated in Energy Hills by location.

Organization Type	Euregio Maas-Rhein	Within EU	World-wide
Company	886,730,000.00 €	51,506,565,000.00 €	17,305,000.00 €
Company (w/o RWE)	886,730,000.00 €	2,506,565,000.00 €	17,305,000.00 €
Education Institute	775,400,000.00 €	146,050,000.00 €	3,150,000.00 €
Research Organization	146,190,000.00 €	21,381,000.00 €	1,665,000.00 €
Public Entity	104,130,000.00 €	100,000.00 €	0.00 €
Total	**1,913,563,300.00 €**	**51,674,096,000.00 €**	**22,120,000.00 €**
Total w/o RWE	1,912,450,000.00 €	2,674,096,000.00 €	22,120,000.00 €

Third Party Funding

It is also indicative of a high level of competence when an organization is receiving third party funding to continue their work. It was found that many organizations in Energy Hills were receiving third party funding to further develop energy related projects and programs. This type of funding is of particular interest because it shows that the work being performed at that particular organization is so valuable and interesting to the third party that they are willing to give financial support without and product or service in return. This is most common in educational and research institutes, but was also found among projects in industry and in public entities. Not all organizations were able to report how much third party funding they were receiving: it was sometimes hidden within certain projects, and some organizations did not give any revenue values, so the actual total is higher than the value obtained in this study. Third party funding received by Energy Hills members was also recorded and totaled € 300,000,000 for 2008. This figure was taken from the 18 members that reported how much of their funding was from a third party, and it is known that other members are receiving third party funding that was not reported.

Employee Qualification

Concerning the qualification of all of these employees working in energy, there were again a number of organizations that could not report how many: some gave estimates, while some others did not report at all. Because the largest organizations such as RWE and RWTH Aachen could not say the number of employees at each qualification level, there could be a significant amount of highly qualified people missing from the data in Figure 9.

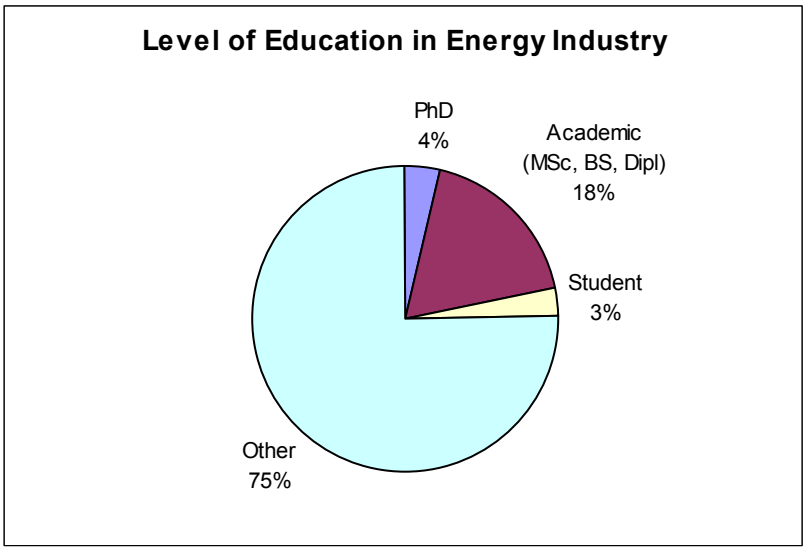

Figure 9. Employees based on level of education of those working in the Energy Industry. Three organizations (RWE, RWTH Aachen, and NUON Energie & Service) were unable to report the level of education of their employees, and were not included in this figure. 18,778 out of the 92,306 total Energy Hills employees are represented here.

In addition to the highly qualified people already working, there are also highly qualified employees being produced within the educational institutes in Energy Hills. Among the educational institutes in Energy Hills there were 95,677 students enrolled in 2008. The institutes could not say how many of their graduates go into energy related work per year when asked.

Age of Organizations

The members of Energy Hills have varying levels of competence in energy, and experience is one measure of competence of an organization. It is interesting to know then, the length of time each of the organizations had been involved in the energy industry. This measure is complicated by the fact that some members were spin-off organizations from a research institute or other company, and so to more accurately show the experience in the energy industry the total length of time the organization has been involved with energy was used. So if an organization was a spin-off of an older organization wherein their competence was rooted, the age of the mother organization was used.

Companies

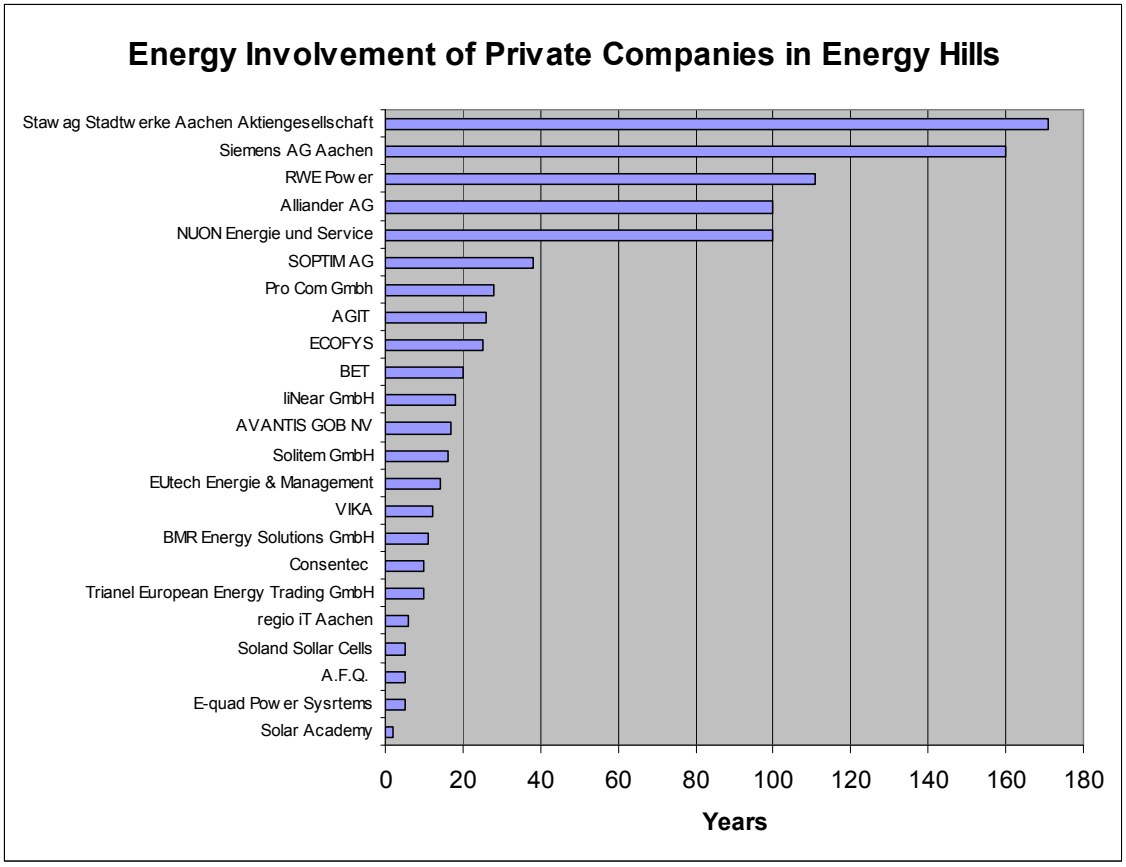

Figure 10. The twenty-three Companies in Energy Hills

The Companies in Energy Hills have a large range of experience in energy. The oldest ones, like the Educational Institutes, have a root in the early coal and other fossil fuel industries. Siemens is even older due to its very early industrial involvement in other regions, but RWE, Alliander, and NUON have roots in the Nord Rhein Westfallen region of Germany and the Limburg region of The Netherlands. Other newer Companies were founded around new energy technology or to meet the demands of a growing and more complex energy industry in the last 40 years.

Research Organizations

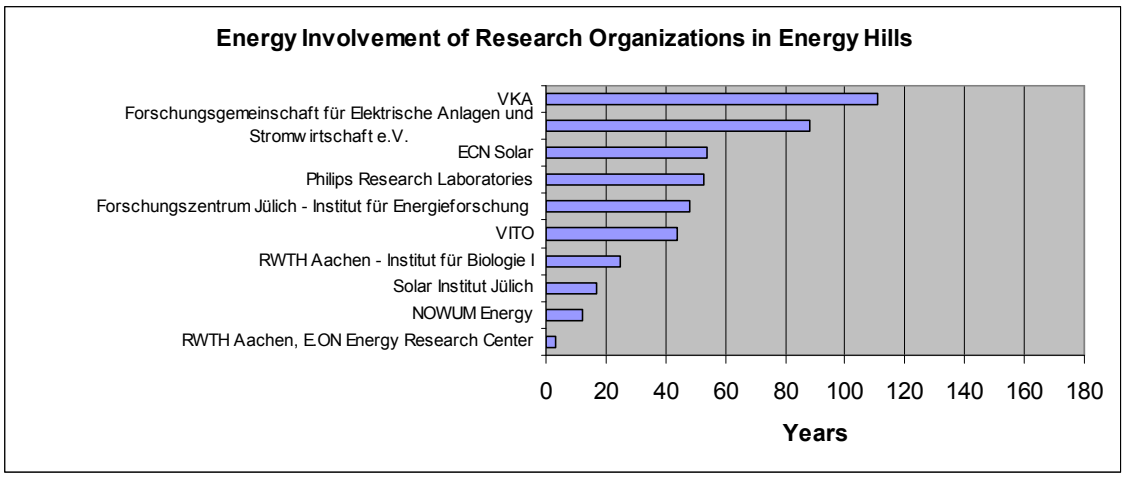

Figure 11. The ten Research Organizations in Energy Hills.

The EON Energy Research Center is a new research organization currently being put together by EON, a major energy company in Europe, and Technical University Aachen (RWTH) to bundle new energy research into one organization. ECN and FZ Jülich have a long history in energy research and have been involved in certain energy technologies since they were first conceived.

The Research Institutes in Energy Hills are almost all Institutes within universities. Only Philips Research Laboratories is with a private company. VKA has such a long history in energy due to its involvement with engine research almost from the beginning of internal combustion engines.

Educational Institutions

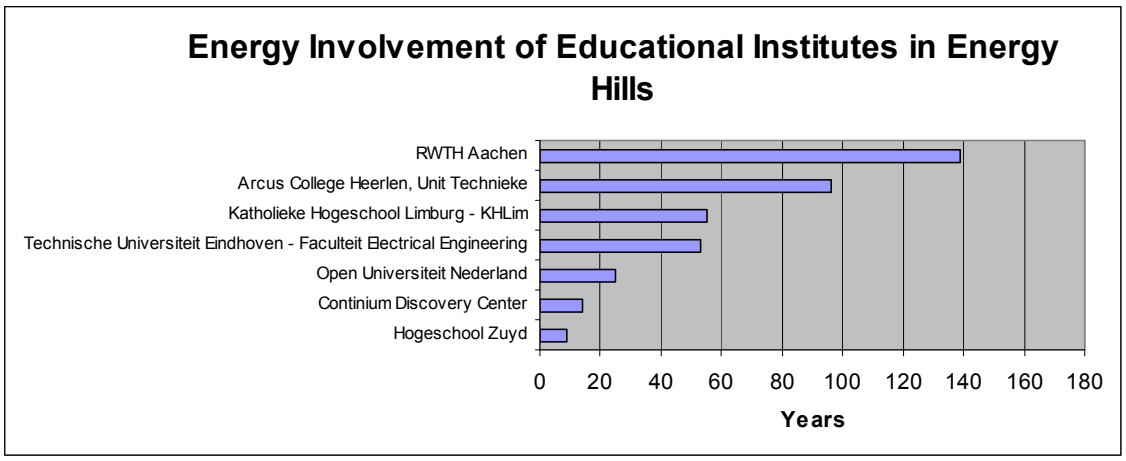

Figure 12. The seven Educational Institutes in Energy Hills.

It is only natural that Educational Institutes would have a long history, but as the years of experience shown in Figure 12 are only in regard to energy themes, there is a long history of energy in the region. With further discussion it was found that the coal industry founded in the region had a profound affect on the Educational Institutes in the region, in some instances the educational institute was founded in part by the coal industry. The Educational Institutes coming into energy themes more recently can be attributed to the closing of the regional coal mines and needing to find other solutions, but also to address rising energy demands and costs.

Public Entities

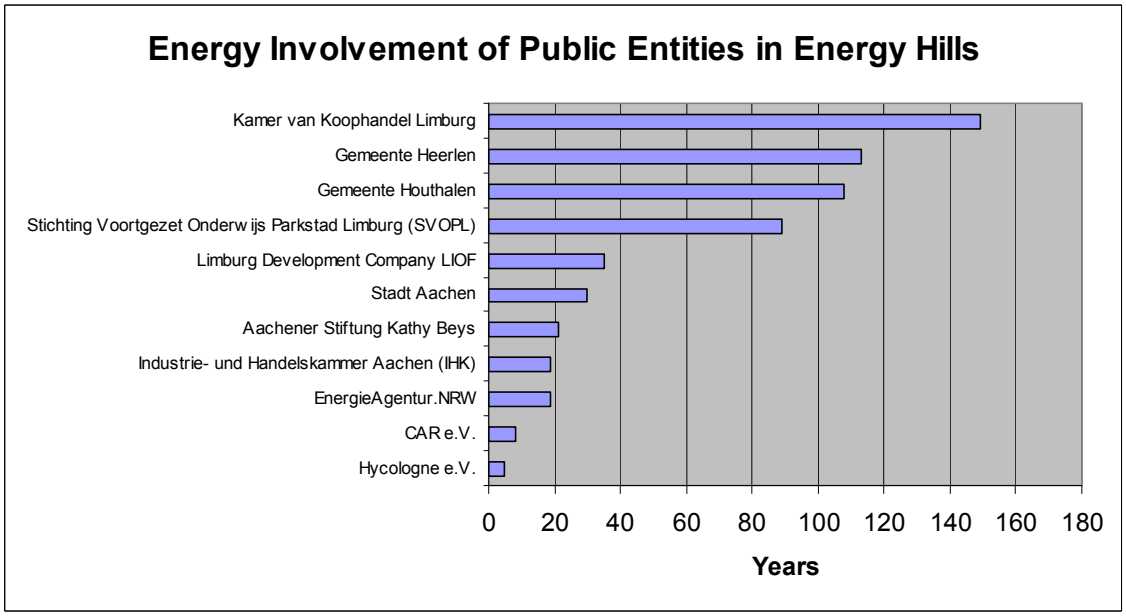

Figure 13. The eleven Public Entities in Energy Hills.

The Public Entities in Energy Hills include three municipalities which all have a fairly long history in energy related policy. Aachen only reported 30 years in energy related policy as it was not as active in coal mining policy as Heerlen and Houthalen were.

4.3.3 Stability

The stability of the Energy Industry in Energy Hills is also an indicator of competence. There were three measures of security in the survey of the member organizations: growth from 2007 to 2008 in funding, reported securities for continued growth, and reported limiting factors to further growth.

In an effort to discover the growth in the energy sector, the growth rate of funding was requested from the members of Energy Hills. This growth is shown from 2007 to 2008 in Table 5. The average growth rate, excluding RWE, was 10% indicating a very fast growing market. By comparing the two figures whether with or without RWE, one can see that the growth for each organization type was similar with the Public Entities reporting the least growth.

Table 5. Growth of organizations in Energy Hills from 2007 to 2008.

Organization Type	Total Revenue 2007	Total Revenue 2008	% growth
Company	45,563,537,457.06 €	52,410,600,000.00 €	15.0%
Company (w/o RWE)	*3,028,815,234.84 €*	*3,410,600,000.00 €*	*12.6%*
Education Institute	907,678,297.20 €	924,600,000.00 €	1.9%
Research Organization	150,828,480.59 €	169,236,000.00 €	12.2%
Public Entity	98,855,889.72 €	99,230,000.00 €	0.4%
Total	**46,722,013,424.58 €**	**53,604,779,300.00 €**	**14.7%**
Total w/o RWE	*4,186,177,902.36 €*	*4,603,666,000.00 €*	*10.0%*

Since RWE's reported growth from 2007 to 2008 was 15%, the overall growth of Energy Hills of 14.7% mostly just shows RWE's growth. To show the growth in the rest of Energy Hills RWE's revenue figures were also removed. It is apparent from the table that most of the growth occurred in the companies and research organizations within Energy Hills.

In the survey members were asked to report any securities and limitations for their organization. For organizations working in other fields in addition to energy, they were asked to report only securities and limitations that affect their operations in energy. In retrospect, some organizations would say that all of the securities or limitations mentioned applied to them, but it is assumed that the ones given were the most important to that organization.

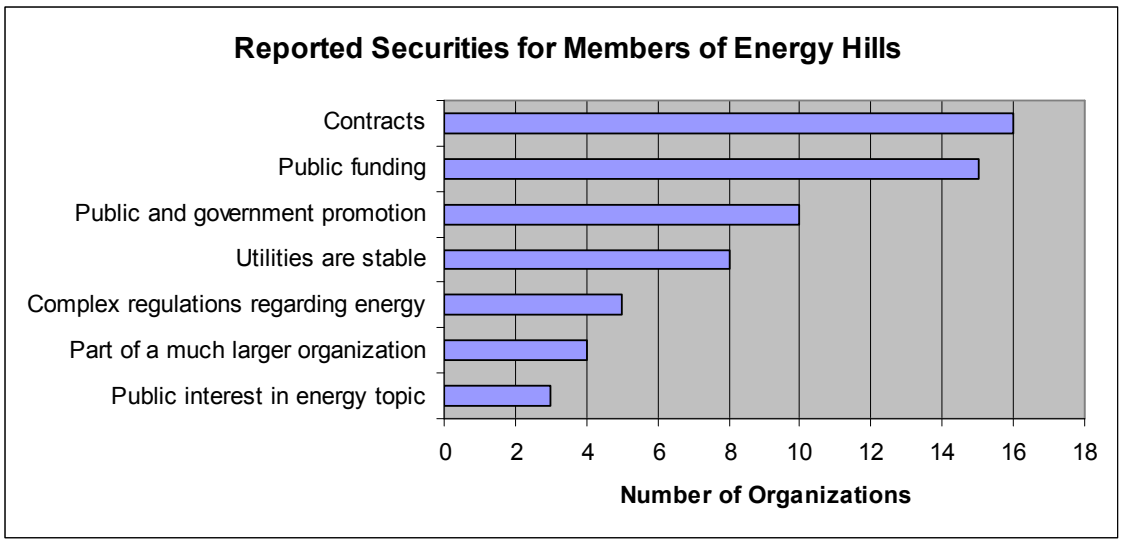

Figure 14. Securities reported by organizations with regard to the energy portions of their organizations. These are the top reported securities for all members of Energy Hills.

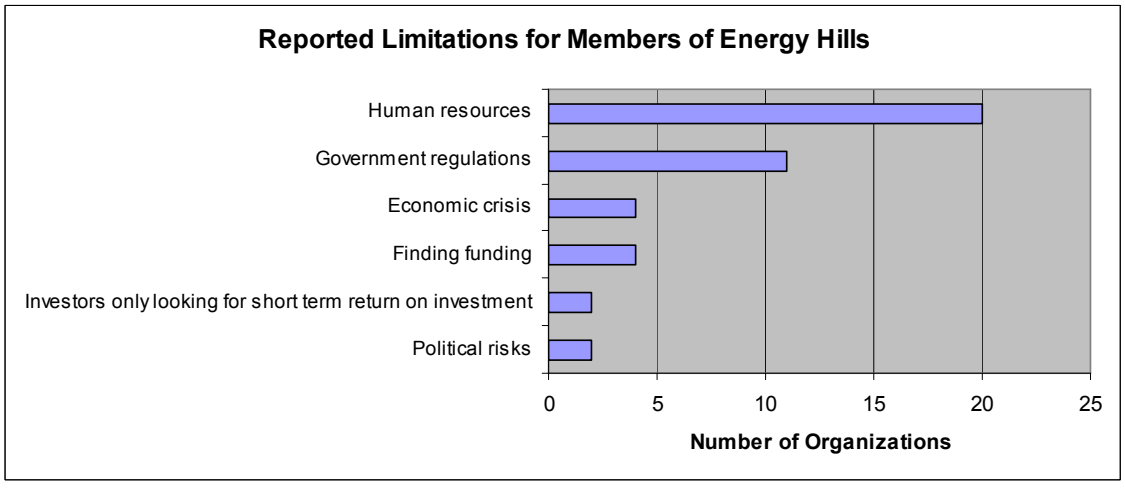

Figure 15. Limitations reported for all members of Energy Hills. The number one reported limitation was finding qualified personnel. Only 4 mentioned the economic crisis of the last 2 years being a limitation: most organizations responded that the economic crisis was not affecting them.

4.3.4 Value of the Cluster to its Members

At the end of the interviews, members were asked why they joined Energy Hills and what they were looking for in an energy cluster. While all responded that they were looking for networking, it became important to as what kind of networking they were looking for, and there were 13 main reasons, or values, for clustering that were given:

1. Find applications for research
2. Strengthen knowledge in the region
3. Cooperation for research facilities funding and use
4. Short term technology or theme clusters/think tanks
5. Finding clients
6. Cross border networking
7. Neutral independent energy network
8. Consult energy experts
9. Conferences, expositions, and publications
10. Finding projects
11. Publicity
12. Finding partners for projects
13. Information on energy activities

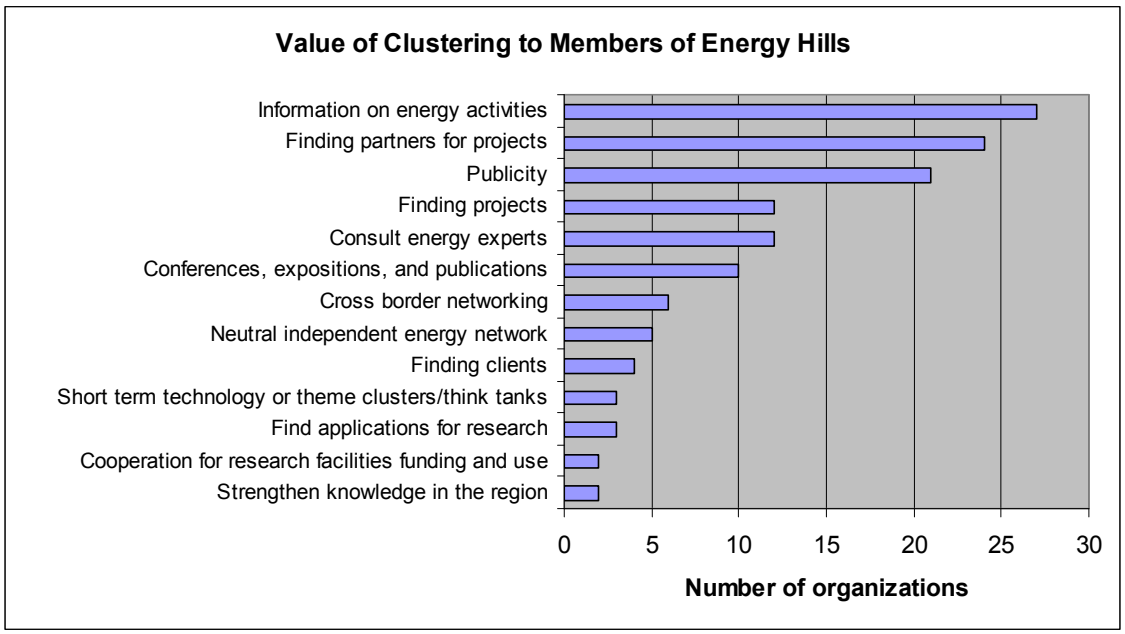

Figure 16. Reported reasons for joining an energy cluster given by members of Energy Hills.

A total look at what members reported in Figure 16 shows that the main reasons for joining an energy cluster are to find information on energy activities in the region, finding partners for projects, and for publicity. While these are the top three reasons given, it may be more interesting to see which types or organizations were reporting which reasons.

Figure 17 shows that Companies were mostly looking for information on energy activities in the region and publicity. However finding partners for projects and being part of conferences, expositions, and publications was also very important to them. Finding clients or projects may have been important to all companies, and perhaps implied it when they wanted to know activities in the region and have more publicity.

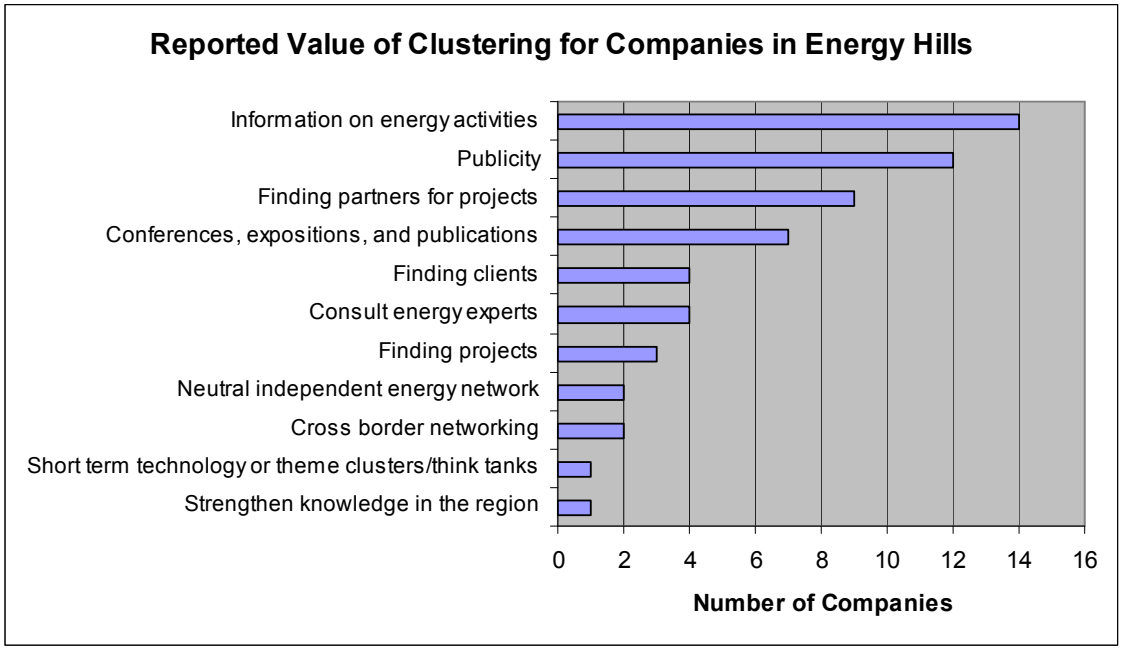

Figure 17. Company's reported reasons for clustering.

For Educational Institutes shown in Figure 18, the top reasons given for joining an energy cluster are to find partners for projects in their given fields, to find information on energy activities in the region, and to find projects for their company.

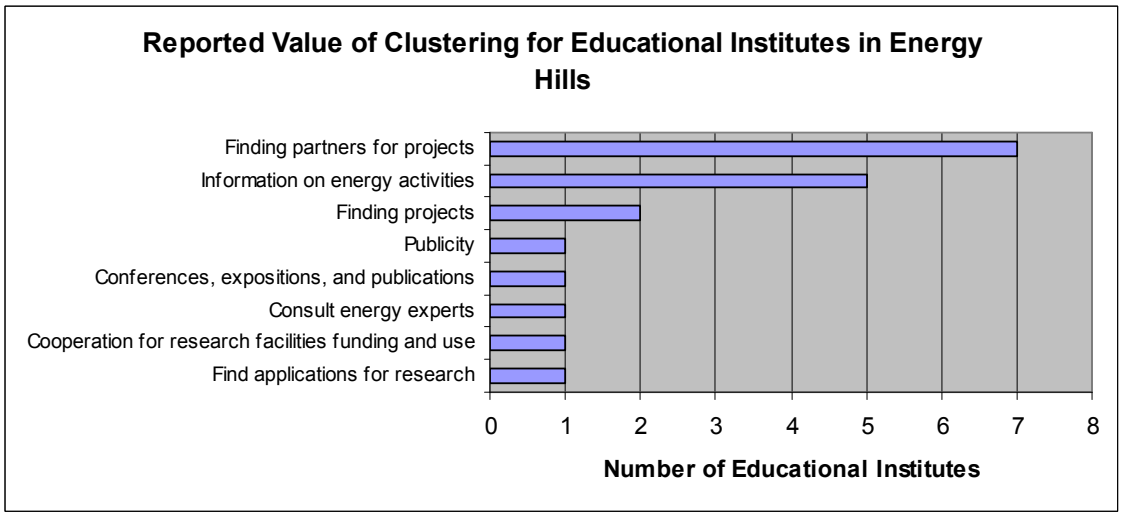

Figure 18. Educational Institute's reported reasons for clustering.

For Research Organizations, the number one reason given for joining an energy cluster was to find partners for projects. All three Large Research Organizations responded with this reason.

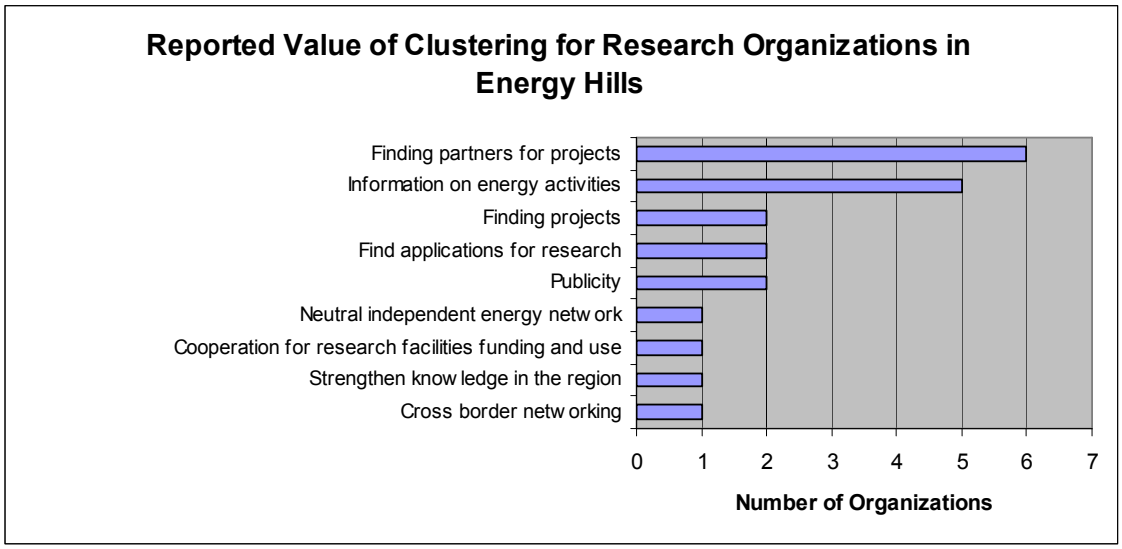

Figure 19. Research organization's reported reasons for clustering.

As seen in Figure 20, Public Entities were mainly looking for consulting from energy experts, but also publicity and finding projects worthwhile for investing in. One particular example of seeking consulting from energy experts was with the municipality of Houthalen that consulted the Energy Hills network regarding waste incineration plants, and the municipality was able to then negotiate with a local waste incineration plant in a more informed manner. All three municipalities reported that they were looking for energy experts to consult within Energy Hills.

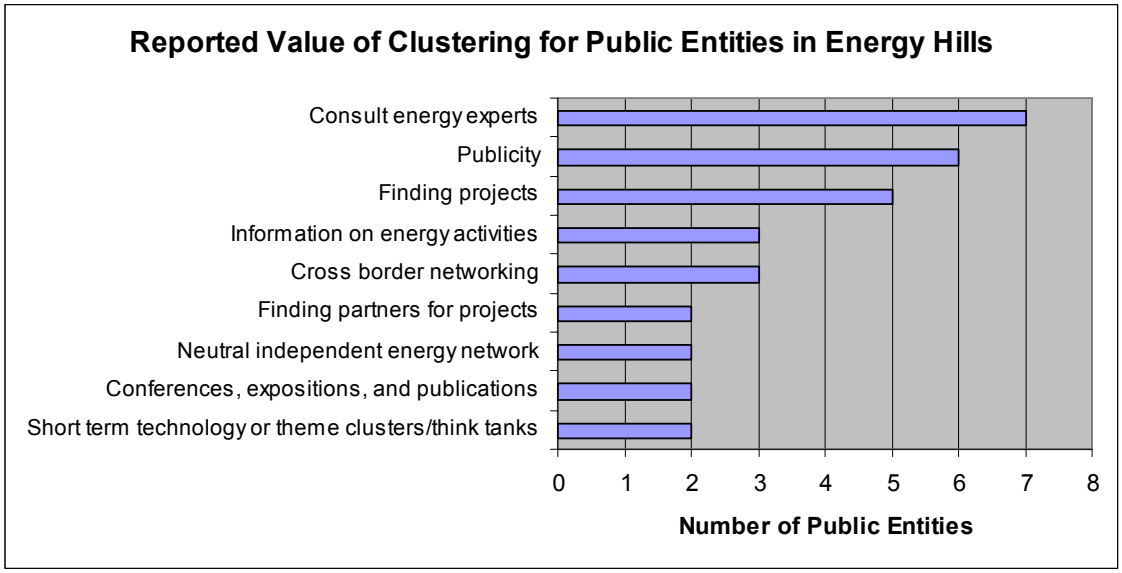

Figure 20. Public Entities' reported reasons for clustering.

5 Discussion of Results and Conclusions

As a quick overview of the Energy Hills Energy Industry cluster:

- 51 organizations: 23 companies, 10 research organizations, 7 educational institutes, and 11 public entities
- 92,000 employees, 70,156 of which are reported to be directly working in energy
- 95,000 students enrolled in universities or other educational institutes
- 746 PhD scientists and 3366 other professionals with a bachelor's degree or higher
- 53.6 billion € in funding, 52.6 billion € of which is reported directly related to energy activities
- 300 million € in third party funding and 200 million € just in research and development

In addition, there are some notable highlights within the Energy Hills cluster:

- 4 Fortune 500 companies
- 3 national research centers
- 1 German "University of Excellence"
- 83 research institutes dealing with energy related research (including institutes within research centers and universities)
- A long history of coal related energy production and transitions to other forms of energy production
- World leading competence in photovoltaics, electrical grid management, lignite coal power plants, and computer simulation

5.1 How Energy Hills is Meeting the Goals of Clustering

In the investigation of the Energy Hills it was found that Energy Hills meets all the criteria for a cluster. The properties extracted from Michael Porter's definition of a cluster are all met:

1. Location, or a geographic concentration: the EUregio region surrounding Aachen contains most of the Energy Hills members. Those that are not exactly in this region are close enough that they have a stake in the region and are active members in the Energy Hills network.
2. A particular field, or industry: the Energy Industry. Not only those organizations working in the supply chain of energy, but also the external organizations that interact with the Energy Industry in ways unique to the Energy Industry.
3. Competing and complementary organizations (energy producers): there are many organizations that are either competing or complimentary in the same activity or technology. Some of these subjects are photovoltaics, grid management, and wind: see Figure 8 for more subjects with many cluster members involved.
4. Supply chain (energy supply chain from resource to delivered product): within Energy Hills there is the complete local energy supply chain, especially with regard to power production with lignite, or brown coal, through RWE. Also with the high number of organizations involved with photovoltaics, much of the supply chain for the development and production of photovoltaics is within the Energy Hills cluster. See the complete outline of energy competences within the supply chain of energy under the heading

Specific Energy Competences.

Beyond Porter's definition of a cluster, he also specified three major benefits of a cluster: increased productivity, driving innovation, and simulating new business (Porter, 1998). These benefits were observed in the Energy Hills cluster:

5.1.1 Increased Productivity

A cluster should see increased productivity and growth. While it cannot be shown that the organizations would not have increased productivity outside of their cluster, it can certainly be shown that productivity has increased over the years within the cluster. There was significant growth from 2007 to 2008 in Energy Hills: energy related funding increased by 15%, and excluding energy giant RWE, energy related funding increased by 30%.

5.1.2 Driving Innovation

The Energy Hills cluster is driving innovation in many fields. With the 66 research institutes associated with RWTH Aachen, three national research organizations, and other research institutes and research departments within organizations, research and development in the Energy Industry has a very strong presence in Energy Hills. For 2008 the percentage of reported energy related research funding in Energy Hills was 20%.

Not only is there a significant amount of energy related research and development in Energy Hills, but there are also many world leading competences in the Energy Industry. As was presented in **World Leading Competences**, there are many technologies and processes that have been developed to a world leading level in Energy Hills.

5.1.3 Stimulate New Business

With regard to stimulation of new businesses, there are many organizations whose key competence is the stimulation of new business: 6 organizations are working in start-up company assistance in energy fields. This is reinforced by the number of new organizations in Energy Hills. Within the last 10 years 23 of the members of Energy Hills were founded, some of them spin-offs of research organizations in Energy Hills.

5.2 How Clustering can help the EU meet their requirements for the Energy Industry

The Commission of the European Communities published a Green Paper on the European Strategy for Sustainable, Competitive, and Secure Energy in 2006 outlining what their requirements were for the Energy Industry. It has been proposed in this thesis that clustering could help the EU meet these goals, and so it will be shown how the Energy Hills cluster is addressing each of these issues.

The following is the outline of concluding objectives the Commission of European Communities has for the Energy Industry shown in italics:

• **Sustainability** :

(i) developing competitive renewable sources of energy and other low carbon energy sources and carriers, particularly alternative transport fuels (European Union, 2006)

> There are many renewable sources of energy being developed within Energy Hills. By viewing the listing of energy competences in

Specific Energy Competences one can find a large number of competences in renewable energies, as well as alternative transport fuels competences.

(ii) curbing energy demand within Europe (European Union, 2006)

To reduce energy demand in Europe Energy Hills has many organizations working on energy efficiency to minimize consumption of energy. Some of the most common energy competences in Energy Hills are in Energy Auditing and Energy Saving Building Technology (Figure 8) which work to reduce the demand for energy.

(iii) leading global efforts to halt climate change and improve local air quality. (European Union, 2006)

Climate change is an important subject in Energy Hills: 7 organizations are working to develop climate change and emissions policies both from an economics and society perspective, but also from a technical research perspective. The city of Aachen has been a pioneer as one of the first German cities to create renewable energy subsidies.

• **Competitiveness**:
(i) ensuring that energy market opening brings benefits to consumers and to the economy as a whole, while stimulating investment in clean energy production and energy efficiency(European Union, 2006)

There are many investment and regional development firms in Energy Hills that are working with clean energy production and energy efficiency companies to promote growth in those fields.

(ii) mitigating the impact of higher international energy prices on the EU economy and its citizens(European Union, 2006)

There are 8 organizations in Energy Hills working with Energy Supply and Trading to reduce the impact of increasing energy costs.

(iii) keeping Europe at the cutting edge of energy technologies(European Union, 2006)

Energy Hills has 3 national research institutions, the largest university partnership with a major energy company (EON Energy Research Center), a European University of Excellence with 66 research institutes working in energy related technologies and processes, and further research being carried out within other organizations to assure that the energy technology is cutting edge in almost every subject in energy.

• **Security of supply**: tackling the EU's rising dependence on imported energy through

(i) an integrated approach – reducing demand, diversifying the EU's energy mix with greater use of competitive indigenous and renewable energy, and diversifying sources and routes of supply of imported energy(European Union, 2006)

Not only are the 8 Energy Hills organizations working with Energy Supply and Trading working towards this integrated approach, but also all those organizations working in renewable energy technology are striving to develop economically and environmentally sustainable energy sources.

(ii) creating the framework which will stimulate adequate investments to meet growing energy demand(European Union, 2006)

The municipalities in Energy Hills and Utility companies in Energy Hills are already working on this, and they are located in one of the most energy intense regions of Europe in the German state of North Rhine-Westphalia. This issue is already a top concern for the region of Energy Hills and many investments for new power plants and energy production related equipment are currently under construction.

(iii) better equipping the EU to cope with emergencies(European Union, 2006)

The network within the Energy Hills cluster is heavily involved in international energy trading and the energy production within its own region to be more sustainable.

(iv) improving the conditions for European companies seeking access to global resources(European Union, 2006)

There are 11 organizations in Energy Hills working on energy trading and supply, some of them working on the global level. While this does not mean that members in Energy Hills are improving the world-wide conditions for obtaining better access to global resources, they are competent in the issues surrounding the acquisition of global resources.

(v) making sure that all citizens and business have access to energy. (European Union, 2006)

The energy utilities in Energy Hills have a strong history in energy production and distribution and have a very secure and reliable energy network.

Furthermore, by creating a network of all the organizations in the highly competent energy cluster of Energy Hills, the objectives of the EU can be communicated more thoroughly to the Energy Industry to produce highly innovative and economically viable solutions. Since a cluster can increase productivity, drive innovation, and promote new growth in an industry, a cluster like Energy Hills could be critical to help address the energy issues of Europe. The European Union has clearly stated that a coordinated agenda in the Energy Industry is needed:

"The EU's agenda for 2020 has set out the essential first steps in the transition to a high-efficiency, low-carbon energy system. The EU needs to develop a vision for 2050 and a policy agenda for 2030. The fundamental technological shifts involved in decarbonising the EU electricity supply, ending oil dependence in transport, low energy and positive power buildings, a smart interconnected electricity network ***will only happen with a coordinated agenda for research and technological development, regulation, investment and infrastructure development***." (emphasis added)
(European Union, 2008)

From this we can clearly see that all of the subjects of interest to the European Union are addressed in some way in the energy cluster of Energy Hills, and therefore the coordination and promotion of the Energy Industry possible through an energy cluster is exactly what is needed to "coordinate the agenda for research and technological development, regulation, investment and infrastructure development".

5.3 Duty of a Cluster Organization

Based on the values that the organizations surveyed in Energy Hills have for clustering, it could then be said that if clustering were to give these values added to the members, clustering would be promoting the entire Energy Industry. It can be seen from the top limitations facing the members of Energy Hills that finding qualified people and projects for their organizations is a major concern of the energy industry (Figure 16). By providing a network of communication between educational institutes, research institutes, companies, and public entities, all of the available qualified people and projects could be more easily found. From the top securities listed by members of Energy Hills (Figure 14) it can be seen that obtaining contracts for projects is a key security which a cluster must make more readily available to promote the industry, as finding projects was a major interest for many members to be a part of a cluster. The main values that each member type is looking for is as follows:

Educational Institutions: are looking for partners for projects and information on energy activities in the region. They want to tailor their educational programs to what the energy industry wants and find projects from industry to better prepare their students for working in the energy industry.

Research Organizations are looking for partners for projects in their fields of research and information on energy activities in the region to form partnerships on projects. They are also seeking contacts with industry to secure money for projects and infrastructure, knowledge of what industry sees as valuable research. The sharing of infrastructure costs for research facilities is also an important value added that they want from a cluster.

Companies: are looking for networking that would lead to project acquisition and information on energy activities in research could be of interest to them

Public Entities are looking for consulting from experts in various energy topics to make good policies and for good publicity and projects that would help develop their region.

These are the top values added that different players in the energy industry are looking for from a cluster organization.

5.4 Recommendations for further study

The biggest problem that faced this study was the inability of some organizations to provide the figures or information requested. This was due either to a fear of having their figures published or simply not having sorted out this particular information in their bookkeeping. To improve this study an annual energy competence report should be made by each member of Energy Hills to assure that the data is accurate and complete. This would allow for a more accurate study of the Energy Industry in the region so that the advantages of clustering could be fully realized.

It was stated by the Commission of the European Communities regarding the collection of data in the Energy Industry that:

> "The problem that requires action is the **lack of consistent data and information** on investment projects (in their different phases) and the related **shortcomings**. Data, whatever source, is not always complete, reliable or fit for the required analysis: for example, EUROSTAT data deals with past developments while prospective data/information is necessary for investment projects. Council Regulation (EC) n°736/96 should in principle allow a monitoring of investment projects at EU level. The Commission shall be notified once a year of major investment projects or major decisions affecting investment projects in the petroleum, natural gas and electricity sectors. However, this Regulation is no longer consistently enforced nor adapted to today's energy challenges. No other horizontal instrument at EU level exists."
>
> (European Union, 2009)

So if Energy Hills could continue to develop this survey to gather all of the data necessary to properly address the European Union's objectives for the Energy Industry, then Energy Hills would not only be able to promote their own network of organizations, but would be a pioneer in the documentation and networking of the Energy Industry.

6 Appendix 1: Members of Energy Hills

There were 51 members of Energy Hills that participated in this study. While there are more members of Energy Hills, some were not interviewed because they were not available within the time frame of the survey or were not currently active in Energy Hills. The members by organization type that were interviewed are as follows:

Companies:

1. Solar Academy
2. E-quad Power Systems
3. A.F.Q.
4. Soland Sollar Cells
5. regio iT Aachen
6. Consentec
7. BMR Energy Solutions GmbH
8. VIKA
9. EUtech Energie & Management
10. Solitem GmbH
11. AVANTIS GOB NV
12. liNear GmbH
13. BET
14. ECOFYS
15. AGIT
16. Pro Com Gmbh
17. SOPTIM AG
18. NUON Energie und Service
19. Alliander AG
20. RWE Power
21. Siemens AG Aachen
22. Trianel
23. STAWAG

Educational Institutions

1. Hogeschool Zuyd
2. Continium Discovery Center
3. Open Universiteit Nederland
4. Technische Universiteit Eindhoven - Faculteit Electrical Engineering
5. Katholieke Hogeschool Limburg - KHLim
6. Arcus College Heerlen, Unit Technieke
7. RWTH Aachen University

Research Organizations

1. E.ON Energy Research Center, RWTH Aachen
2. Forschungszentrum Jülich - Institut für Energieforschung
3. ECN Solar
4. NOWUM Energy
5. Solar Institut Jülich
6. RWTH Aachen - Institut für Biologie I
7. Philips Research Laboratories
8. VKA
9. VITO
10. FGH

Public Entities:

1. Hycologne e.V.
2. CAR e.V.
3. EnergieAgentur.NRW
4. Industrie- und Handelskammer Aachen (IHK)
5. Aachener Stiftung Kathy Beys
6. Stadt Aachen
7. Limburg Development Company LIOF
8. Stichting Voortgezet Onderwijs Parkstad Limburg (SVOPL)
9. Gemeente Houthalen

10. Gemeente Heerlen
11. Kamer van Koophandel Limburg

Members not interviewed:

1. G.O.B. Euroservices c/o Stawag Stadtwerke Aachen Aktiengesellschaft
2. OzonNeutral gemeinnuetzige GmbH
3. Rengers Architektur Consult
4. Pohl Consulting
5. Management Engineers GmbH & Co KG International Consultants
6. Hermann-Josef Werhahn
7. Business Club Aachen Maastricht

7 Appendix 2: References

1. Porter, Michael E. "Clusters and the New Economics of Competition" Harvard Business Review November-December 1998 Reprint 98609 Copyright 1998 by the President and Fellows of Harvard College

2. Castaño, David & Bastian, Kurt. "Energy Hills Energy Audit Assessment" Fachhochschule Aachen, Abteilung Jülich Masters of Energy Systems Assignment in partnership with Energy Hills. Supervised by Prof. Ulrich Daldrup. Submitted June 2009

3. US Census Bureau, North American Industry Classification System 2007: Listing of NAICS codes were found at the site: http://www.census.gov/cgi-bin/sssd/naics/naicsrch?chart=2007 as of February 15, 2010

4. European Union, 2006. The Commission of European Communities "Green Paper" "European Strategy for Sustainable, Competitive and Secure Energy" which can be found at: http://ec.europa.eu/energy/strategies/2006/2006_03_green_paper_energy_en.htm as of February 15, 2010

5. Euregio Maas-Rhein, 2010. Picture for Figure 2 found at: http://www.euregio-mr.org/emr_site/site_de/emr/home.php as of February 15, 2010

6. Fortune, 2009. Global Fortune 500 figures were found on:

   http://money.cnn.com/magazines/fortune/global500/2009/industries/19/index.html as of February 15, 2010

7. European Union, 2008. "EU Energy Security and Solidarity Action Plan: 2nd Strategic Energy Review", Brussels, 13 November 2008, MEMO/08/703 which can be downloaded from http://europa.eu/rapid/pressReleasesAction.do?reference=MEMO/08/703&type=HTML as of February 15, 2010

8. European Union, 2009. COMMISSION STAFF WORKING DOCUMENT Accompanying document to the Draft Council Regulation (EC) concerning the notification to the Commission of investment projects into energy infrastructure within the European Community and Repealing Council Regulation (EC) n°736/96 EXECUTIVE SUMMARY OF THE DRAFT IMPACT ASSESSMENT {COM(2009) xxx final} {SEC(2009) xxxx} can be found at: http://ec.europa.eu/environment/climat/emission/pdf/exec_summ_ia_leakage_list4_9.pdf as of February 15, 2010

All data not cited otherwise from this study were obtained via interviews with each organization. This includes all figures and statistics for Energy Hills presented in this report. Interviews that were performed with David Castaño in the initial development are indicated with an asterisk (*).

Companies:

1. *Solar Academy
   Interview date: 19.06.2009
   Elbert-Jan Achterberg
   +31 (0)45 711 1540
   achterberg@solaracademy.nl
2. *E-quad Power Systems
   Interview date: 12.03.2009
   Dipl.-Ing. Marcus Mehlkopf
   02407-90492-10
   mehlkopf@microturbine.de

   Dipl.-Ing. Dipl.-Wirt. Ing. Bernhard Peters
   02407-90492-10
   peters@microturbine.de
3. *A.F.Q.
   Interview date: 13.03.2009
   R.L. Bimmel
   +31 65326 7345
   robbimmel@msn.com
4. *Solland Solar Cells
   Interview date: 14.04.2009
   Dr. Martin Fleuster
   +31(0)652454938 (mobile)
   mfleuster@sollandsolar.com
5. *regio iT Aachen
   Interview date: 10.03.2009
   Josef Bendel
   0241 41 359 9650
   josef.bendel@regioit-aachen.de

   Jörg Röhlen
   0241 41 359 1751
   joerg.roehlen@regioit-aachen.de

   Dr. Dina Franzen
   0241 41 359 1762
   dina.franzen@regioit-aachen.de

   Jochen Bordfeld

0241 41 359 1772
jochen.bordfeld@regioit-aachen.de

6. *Consentec
   Interview date: 12.03.2009
   Dr.-Ing. Dipl.-Wirt.Ing Christoph Maurer
   +49 241 93836 0 /mobil: +49 179 475 7728
   maurer@consentec.de
7. BMR Energy Solutions GmbH
   Interview date: 10.22.2009
   Georg Melchers
   +49 (0) 2454936910
   g.melchers@bmr-energy.com
8. *VIKA
   Interview date: 19.06.2009
   Dr. Bernhard Frohn
   +49(0)241474660
   b.frohn@vika.de
9. *EUtech Energie & Management
   Interview date: 05.03.2009
   Dr. -In. Jörg Meyer
   +49(0) 241 963 1970
   meyer@eutech.de
10. *Solitem GmbH
    Interview date: 20.02.2009
    Dipl.-Ing. Peter Keuter
    +49(0)241 980 906-17
    p.keuter@solitem.de
11. AVANTIS GOB NV
    Interview date: 18.11.2009
    René Seijben and
    +49 (0) 241 93 600
    reneseijben@avantis.org

    Sabine Keiner
    +49 (0) 241 93 600
    sabinekeiner@avantis.org
12. *liNear GmbH
    Interview date: 04.03.2009
    Jürgen Frantzen
    +49 (0) 241/889 800
    jf@linear.de
13. *BET
    Interview date: 04.03.2009
    Dr.-Ing. Michael Ritzau
    +49 241 47062-410
    michael.ritzau@bet-aachen.de
14. ECOFYS

Interview date: 04.03.2009, updated 13.11.2009
Ir. Wim M.C. Aarts
+31(0) 621 505223
w.aarts@ecofys.com

15. *AGIT
    Interview date: 09.02.2009
    Katrin König M.A.
    +49(0) 241 963 1020
    k.koenig@agit.de

    Frank Reimann B.Sc.
    +49(0) 241 963 1063
    f.freimann@agit.de
16. Pro Com Gmbh
    Interview date: 22.10.2009
    Dr. Max Scheidt
    +49 (0) 241 51804167
    max.scheidt@procom.de
17. *SOPTIM AG
    Interview date: 06.02.2009
    Dr. Hans Röllinger
    +49(0)24191879-0 *mobile:* +49(0)1722422075
    hans.roellinger@soptim.de
18. *NUON Energie und Service
    Interview date: 13.03.2009
    Frank Obernitz
    +49 (0) 24 52 / 15 22 06
    frank.obernitz@nuon.com

    Jakob Wöllenweber
    +49 (0) 2452 152302
    Jakob.woellenweber@alliander.com
19. Alliander AG
    Interview date: 18.11.2009
    Jakob Wöllenweber
    +49 (0) 2452 152302
    Jakob.woellenweber@alliander.com

    Geraldine Heppener
    +49 (0) 2452152696
    geraldine.heppener@alliander.com
20. *RWE Power
    Interview date: 16.02.2009
    Tilman Bechthold
    +49(0) 2181 26-3877
    tilman.bechthold@rwe.com

Jörg Kerlen
+49(0) 201 12- 41410
joerg.kerlen@rwe.com

21. Siemens AG Aachen
    Interview date: 30.11.2009
    Claus Blankertz
    +49 (0) 241451511
    claus.blankertz@siemens.com
22. STAWAG AG
    Interview date: 01.02.2010
    Rosa Hemmers
    +49 (0) 241 181 1273
    rosa.hemmers@stawag.de
23. Trianel European Energy Trading GmbH
    Interview date: 02.02.2010
    Elmar Thyen
    +49 (0) 24141320-413
    e.thyen@trianel.com

Educational Institutions

1. Hogeschool Zuyd
   Interview date: 03.12.2009
   Dr. Jacques Kimman
   +31 (0) 45 400 6750
   j.kimman@hszuyd.nl
2. Continium Discovery Center
   Interview date: 10.11.2009
   Hans Gubbels
   +31 (0) 455676025
   h.gubbels@continium.nl
3. *Open Universiteit Nederland
   Interview date: 04.03.2009
   Prof. Dr, F. Paquita Pérez
   +31 (0) 45 5762363
   paquita.perez@ou.nl
4. Technische Universiteit Eindhoven - Faculteit Electrical Engineering
   Interview date: 19.11.2009
   Prof. ir. W.L. Kling
   +31 40 247 4442
   w.l.kling@tue.nl

   Prof.dr.ir.P.P.J van den Bosch
   +31 40 247 3760
   p.p.j.v.d.bosch@tue.nl

   Not interviewed: Prof.dr. E. Lomonova
   +31 40 247 3573

e.lomonova@tue.nl

5. Katholieke Hogeschool Limburg – KHLim
   Interview date: 28.11.2009
   Willy Inderherberge
   +32 (0) 11 23 07 70
   Willy.inderherberge@khlim.be
6. Arcus College Heerlen, Unit Technieke
   Interview date: 25.11.2009
   Henk ter Stege
   +31-45-5679290
   hterstege@arcuscollege.nl
7. *RWTH Aachen
   Interview date: 11.03.2009
   Dr. Regina Oertel
   +49 241 80 94023/94566
   regina.oertel@zhv.rwth-aachen.de

Large Research Organizations

1. RWTH Aachen, E.ON Energy Research Center
   Interview date: 22.10.2009
   Prof. Antonello Monti
   +49 241 80 49700
   amonti@eonerc.rwth-aachen.de

2. Forschungszentrum Jülich - Institut für Energieforschung
   Interview date: 05.11.2009
   Dr. Isolda Arzberger
   +49 (0) 2461 61-4003
   i.arzberger@fz-juelich.de

   Dr. Thomas Feck
   +49 (0) 2461611809
   t.feck@fz-juelich.de
3. *ECN Solar
   Interview date: 06.03.2009
   Ton Veltkamp
   +31 (0) 224 564251
   veltkamp@ecn.nl
4. VITO nV
   Interview date: 10.02.2010
   Carlo Mol
   +32 (0) 14335885
   carlo.mol@vito.be

Public Entities:

1. *Gemeente Heerlen
   Interview date: 11.02.2009
   Elianne Demollin – Schneiders

+31 (0) 455604696
e.demollin@heerlen.nl

2. Hycologne e.V.
   Interview date: 23.11.2009
   Boris Jermer
   +49 (0) 2233-406130
   jermer@hycologne.de
3. CAR e.V.
   Interview date: 30.10.2009
   Matthias Popp
   +49 (0) 151 11 693 278
   mapopp@gmail.com
4. EnergieAgentur.NRW
   Interview date: 24.11.2009
   Dr. Frank-Michael Baumann
   +49 (0) 171-5502129
   baumann@energieagenture.nrw.de
5. Industrie- und Handelskammer Aachen (IHK)
   Interview date: 04.12.2009
   Paul Kurth
   +49 (0) 241 4460-106
   Paul.kurth@aachen.ihk.de
6. Aachener Stiftung Kathy Beys
   Interview date: 12.11.2009
   Stephan Baldin
   +49-241-40929-0
   baldin@aachener-stiftung.de
7. Stadt Aachen
   Interview date: 04.12.2009
   Julia Körmendy
   +49 (0) 241 432 7619
   julia.koermendy@mail.aachen.de
8. Limburg Development Company LIOF
   Interview date: 26.11.2009
   Jaques Mikx
   +31 (0) 43 3280280
   jmikx@liof.nl
9. Stichting Voortgezet Onderwijs Parkstad Limburg (SVOPL)
   Interview date: 02.11.2009
   Dr. J.H.M Monsewije
   +31 (0) 455712597
   Jhm.monsewije@svopl.nl
10. Gemeente Houthalen
    Interview date: 12.11.2009
    Paul Boutsen and Alain Yzermans (Mayor)
    mobile + 32 477 63 29 20
    paul.boutsen@cleantechcampus.be

11. Kamer van Koophandel Limburg
    Interview date: 04.02.2010
    Marjolein Smit
    +31 (0) 88 9876 484
    msmit@limburg.kvk.nl

Research Institutes:

1. *NOWUM Energy
    Interview date: 02.13.2009
    Karl-Heinz Ertl
    +49 (0) 241/6009-53039
    ertl@fh-aachen.de
2. *Solar Institut Jülich
    Interview date: 02.12.2009
    Prof. Dr. Bernhard Hoffschmidt
    +49(0)2461-99-3520/3522
    hoffschmidt@sij.fh-aachen.de
3. RWTH Aachen - Institut für Biologie I
    Interview date: 21.10.2009
    Prof. Dr. Fritz Kreuzaler
    +49 (0) 241-8026655
    molbio@bio1.rwth-aachen.de
4. *Philips Research Laboratories
    Interview date: 11.03.2009
    Ulrich Schiebel
    +49 (0) 241 6003 309
    ulrich.schiebel@philips.com
5. *VKA - Verbrennungskraftmaschinen Aachen
    Interview date: 18.02.2009
    Prof. Dr.-Ing. Stefan Pischinger
    +49(0)241 80 96 201
    pischinger@vka.rwth-aachen.de

    Dipl.-Ing. Michael Wittler
    +49(0) 241 80 95 370
    wittler@vka.rwth-aachen.de
6. Forschungsgemeinschaft für Elektrische Anlagen und Stromwirtschaft e.V.
    Interview date: 01.20.2010
    Bernhard Schowe-von der Brelie
    +49 (0) 241 80 94900
    bernhard.schowe@fhg-testsystems.de

8 Appendix 3: Areas of Competence of Energy Hills Members

Energy Resources Extraction and Processing

- CO2 Sequestration and storage (4)
  - Institut für Biologie 1
  - EON Energy Research Center
  - Katholieke Hogeschool Limburg – KHLim
  - RWTH Aachen
- Coal & Brown Coal (3)
  - RWE
  - RWTH Aachen
  - Aachener Stiftung Kathy Beys
- Agriculture for biomass fuels (2)
  - Institut für Biologie 1
  - RWTH Aachen
- Hydrogen production (2)
  - HyCologne e.V.
  - RWTH Aachen
- Biofuel production and storage (1)
  - STAWAG AG

Energy Conversion

- Photovoltaics (11)
  - Gemeente Heerlen
  - ECOFYS
  - ECN Solar
  - Solland Solar Cells
  - Solar Academy
  - Forschungszentrum Jülich Institute für Energieforschung

  - Limburg Development Company LIOF
  - Katholieke Hogeschool Limburg – KHLim
  - Siemens AG
  - RWTH Aachen
  - Hogeschool Zuyd
- Wind (6)
  - RWE
  - ECOFYS
  - BMR Energy Solutions
  - Katholieke Hogeschool Limburg – KHLim
  - RWTH Aachen
  - Siemens AG
- Solar thermal applications (4)
  - Solar Institut Jülich
  - Solitem GmbH
  - VIKA
  - RWTH Aachen
- Power Plant operation (4)
  - Solar Institut Jülich
  - RWE
  - NUON Energie & Service
  - RWTH Aachen
- Fuel Cells (4)
  - VKA
  - Forschungszentrum Jülich Institute für Energieforschung
  - Katholieke Hogeschool Limburg – KHLim
  - RWTH Aachen
- Biomass combustion (4)
  - RWE
  - NOWUM Energy
  - ECOFYS
  - RWTH Aachen

- Geothermal energy (4)
  - Gemeente Heerlen
  - VIKA
  - EON Energy Research Center
  - RWTH Aachen
- Material science for energy applications (3)
  - Solar Institut Jülich
  - Forschungszentrum Jülich Institute für Energieforschung
  - RWTH Aachen
- Automotive technology (3)
  - VKA
  - CAR e.V.
  - Hogeschool Zuyd
- Nuclear power (3)
  - RWE
  - Forschungszentrum Jülich Institute für Energieforschung
  - RWTH Aachen
- Electric generators and equipment (3)
  - EON Energy Research Center
  - Technische Universiteit Eindhoven - Faculteit Electrical Engineering
  - RWTH Aachen
- Waste incineration (3)
  - RWE
  - Gemeente Houthalen
  - RWTH Aachen
- Fusion technology and plasma physics for energy applications (2)
  - Forschungszentrum Jülich Institute für Energieforschung
  - Technische Universiteit Eindhoven - Faculteit Electrical Engineering
- Gas turbines (2)
  - Forschungszentrum Jülich Institute für Energieforschung
  - RWTH Aachen

- Steam turbines (2)
  - RWTH Aachen
  - RWE
- Microturbines (2)
  - E-Quad Power Systems
  - NOWUM Institute
- Combustion chambers and boilers (2)
  - RWE
  - RWTH Aachen
- Combined heat and power (2)
  - E-quad Power Systems
  - STAWAG AG
- Hydroelectric power (1)
  - RWTH Aachen
- Internal combustion engines (1)
  - VKA

Energy Distribution

- Grid management (12)
  - SOPTIM AG
  - RWE
  - BET
  - ProCom GmbH
  - EON Energy Research Center
  - Alliander AG
  - Technische Universiteit Eindhoven - Faculteit Electrical Engineering
  - RWTH Aachen
  - FGH
  - STAWAG AG
  - Trianel European Energy Trading GmbH
  - VITO nV

- Energy supply and trading (11)
  - SOPTIM AG
  - RWE
  - BET
  - ECOFYS
  - Consentec
  - ProCom GmbH
  - Forschungszentrum Jülich Institute für Energieforschung
  - RWTH Aachen
  - STAWAG AG
  - Trianel European Energy Trading GmbH
  - VITO nV
- Smartgrids (10)
  - SOPTIM AG
  - EON Energy Research Center
  - Alliander AG
  - Katholieke Hogeschool Limburg – KHLim
  - Hogeschool Zuyd
  - RWTH Aachen
  - FGH
  - STAWAG AG
  - Trianel European Energy Trading GmbH
  - VITO nV
- Industrial park management (2)
  - NUON Energie & Service
  - Siemens AG

Energy Consumption

- Energy auditing (8)
  - LiNear GmbH
  - EUtech Energie & Management

  - VIKA
  - EON Energy Research Center
  - Stichting Voortgezet Onderwijs Parkstad Limburg
  - EnergieAgentur.NRW
  - RWTH Aachen
  - Kamer van Koophandel
- Energy saving in the built environment (6)
  - VIKA
  - EON Energy Research Center
  - Arcus College Heerlen, Unit Technieke
  - Siemens AG
  - Hogeschool Zuyd
  - RWTH Aachen
- Lighting optimization (5)
  - Philips Research Laboratories
  - VIKA
  - Alliander AG
  - Siemens
  - STAWAG AG
- Heating, ventilation, and cooling (5)
  - LiNear GmbH
  - VIKA
  - Katholieke Hogeschool Limburg – KHLim
  - Siemens AG
  - RWTH Aachen
- Energy efficiency of industrial equipment (3)
  - Technische Universiteit Eindhoven - Faculteit Electrical Engineering
  - Siemens AG
  - RWTH Aachen

External Entities

- Education and Training (8)
  - Solar institute Jülich
  - Open Universiteit Nederland
  - Solar Academy
  - Stichting Voortgezet Onderwijs Parkstad Limburg
  - Continium Discovery Center
  - Arcus College Heerlen, Unit Technieke
  - Katholieke Hogeschool Limburg – KHLim
  - RWTH Aachen
- Climate and/or Emissions policy (8)
  - ECOFYS
  - Gemeente Heerlen
  - EUtech Energie & Management
  - Forschungszentrum Jülich Institute für Energieforschung
  - RWTH Aachen
  - Stadt Aachen
  - NOWUM Energy
  - VITO nV
- Start up company assistance (7)
  - AGIT
  - AFQ Consultancy
  - Gemeente Houthalen
  - AVANTIS GOB
  - Limburg Development Company LIOF
  - Industrie- und Handelskammer Aachen (IHK)
  - Kamer van Koophandel
- Sustainable Society Considerations (6)
  - Stichting Voortgezet Onderwijs Parkstad Limburg
  - Forschungszentrum Jülich Institute für Energieforschung
  - Continium Discovery Center
  - Aachener Stiftung Kathy Beys
  - RWTH Aachen

  - VITO nV
- Regional Development (5)
  - Gemeente Heerlen
  - Gemeente Houthalen
  - Industrie- und Handelskammer Aachen (IHK)
  - Stadt Aachen
  - Kamer van Koophandel
- Capital investment acquisition (4)
  - AGIT
  - AFQ Consultancy
  - AVANTIS GOB
  - Limburg Development Company LIOF
- Networking hub (3)
  - CAR e.V.
  - HyCologne e.V.
  - EnergieAgentur.NRW
- Energy utilities IT services (2)
  - Region IT Aachen
  - ProCom GmbH
- Public Awareness (2)
  - EnergieAgentur.NRW
  - Arcus College Heerlen, Unit Technieke

9 Appendix 4: Descriptions of Energy Hills Organizations

9.1 COMPANIES

9.1.1 SOPTIM AG

SOPTIM provides IT Solutions for the energy industry, developing high tech software for grid energy management.
SOPTIM AG was founded as a spin off GmbH company from RWTH in 1971. In 2001 they became an AG.
It is well known for its Energy logistics which includes assessing customer's electrical power demand and supply and the billing structure between.
SOPTIM offers consulting services in energy economics and energy control; this includes the complete spectrum from information and business management to the integration of application architecture. The software is also used for optimizing the grid from the demand side to minimize the use of resources from the power suppliers. This involves enormous quantities of data and requires sophisticated indexing systems.

What makes SOPTIM unique:
SOPTIM's high end Software, Energy Market Communication, Energy Data Management, and Energy Network Operation Management are among the things which make SOPTIM unique compared to its competitors in the market.
Most of SOPTIM's software is used throughout Germany, and even in Switzerland and Austria to a lesser extent. German power companies such as RWE, E-ON, and Vattenfalls utilize SOPTIM's services and software along with many other companies.
SOPTIM has grown almost 20% in the last year, and averaging around 15-10% growth yearly since 2001. SOPTIM has great security in its business as most of its clients are the power companies and power demand has been continually increasing in size and complexity requiring new solutions.

www.soptim.de
info@soptim.de
+49(0) 241 918 790
Im Süsterfeld 5-6 D-52072 Aachen,
Germany

9.1.2 AGIT

AGIT is an economic agency, which performs consulting and provides funding for new technology oriented enterprises.
AGIT was founded in 1983 as one of the first incubator companies. Today AGIT has grown to a size of 36 employees.
AGIT takes technology company proposals and guides them through all the processes of creating a sustainable company. AGIT promotes investment not only by knowing the technology developments in the region but also by advising international investors in the technology potential and growth of the region. The technology that AGIT promotes is divided into five clusters: Information Technology (IT), Biomedical, Automotive, Plastics, and most recently Energy.

What makes AGIT unique:
AGIT is the first incubator company in Europe, consulted internationally for their expertise in the incubator concept. They have facilities for about 500 companies which consist of 13 office buildings and an exposition area for networking events. By providing these facilities as variable costs in a rich environment with marketing and networking assistance, companies have a greater chance to succeed. One hundred new companies are released every year as independent companies and 95% of all the companies that have been released are still in existence. As a benefit to the region this translates to anywhere from 500 to 1500 new employment positions created every year.
AGIT's business is entirely within the Aachen-Heerlen region. The company has been stable for the last years, meeting the demand of new companies. AGIT has secure funding coming from the government, shareholders, and third party funding giving the opportunity to breed new companies in the future.

www.agit.de
k.lenkitsch@agit.de
+49(09 241 963 1054
Dennewartstraße 25-27 52068 Aachen
Germany

9.1.3 RWE

RWE is among Europe's five largest utilities active in the generation and transmission as well as the sale and trading of electricity and gas.
RWE is over 100 years old, working in the energy sector. According to its last annual report (2008) RWE has a total number of employees of 65 908.
RWE has daughter companies each one of them in charge for a certain energy sector.
RWE Power is Germany's biggest power producer. The company produces lignite and generates electricity from coal, lignite, nuclear fuel, and gas.
RWE Innogy pools RWE's renewable energy activities. They mainly consist of onshore and offshore wind farms in Europe as well as hydroelectric power plants and biomass projects.
RWE Dea produces gas and oil, focusing on Europe and Nord Africa.
RWE Supply & Trading encompasses RWE Gas Midstream and is responsible for the commercial optimization of all RWE's non-regulated gas activities and the European energy trading business.
RWE Energy is RWE's sales and grid company for customers in Continental Europe. The company operates in twelve regions in and outside Germany. RWE energy provides electricity, gas, water as well as related services from a single source.
RWE npower is responsible for RWE's UK energy business. The company has an integrated business model. Operations include the generation of electricity from coal, gas and oil as well as the sale of electricity and gas.

What makes RWE unique:

- RWE is constructing a 47% efficient brown coal power plant.
- Owns the largest block of 1000MW and 43% efficiency and is building two new blocks also of 43% efficiency and 1000MW each.
- RWE uses CCS (Carbon Capture and Storage) technology. This technique ensures that CO2 produced by the power plant is largely captured and then stored under ground—to keep it from escaping into the atmosphere.
- RWE also uses the IGCC (integrated gasification combined cycle) technology. This process gives one the option of manufacturing products gas such as synthetic natural gas, hydrogen and fuel from the coal gas, instead of electricity. The planned IGCC plant is scheduled to go online in 2014.
- In addition to IGCC, the separation of carbon dioxide from flue gas ("CO2 scrubbing") enables the generation of electricity from coal in a climate-friendly manner. The advantage offered by CO2 scrubbing is that it can be implemented in existing power plants by retrofitting them with appropriate units.

- RWE helps developing countries reduce their greenhouse gas levels within the scope of the United Nations' "Clean Development Mechanism." In return, we receive certificates that can be credited to our emissions balance, subject to an annual cap of 18 million metric tons of CO2 equivalent.

- RWE is looking forward of building an innovative wave power plant in the Outer Hebrides' natural environment. The power station's turbines would be driven by airstreams created by the waves. In time, it could supply electricity to 1,500 homes and avoid four metric tons of CO2 per household per year, which would otherwise result from the use of fossil fuels.

- RWE will be able to remove more than 90% of the carbon dioxide from the waste gases produced during combustion and then store it under ground.

- Nuclear energy R&D work. Accounting for about 25% of Germany's power production, it is clearly the most important source of CO2-free electricity generation. Some projects to mention are the CAL nuclear project in Essen, the THTR in Hamm which consist in a fast Breeder reactor, and research projects in nuclear waste disposals.

RWE is working all around Europe, being stable within Germany and a constant growth the past years of 10% outside Germany. RWE is a secure company is able to supply energy over the next 260 years with its own resources.

www.rwe.com
info.rwepower@rwe.com
+49(0) 201 12 01
Huyssenallee 2 45128 Essen
Germany

9.1.4 Solitem

SOLITEM develops high efficient parabolic trough collector (PTC) systems in various temperatures and pressures for heating and cooling, as well as to produce steam, hot water, and other process heat applications.
Solitem was founded in 1999, but the idea of creating the company started in 1993. Solitem has 50 employees among Germany and Turkey where its manufacturing facility is located.
These high-efficient PTC systems are suitable for roof mounting with automated tracking, pre-cleaning, and protective over-night "sleeping mode" function.

Sectors where this technology is more suitable for its best performance are:

- Food & Beverage Industry
- Breweries
- Wineries
- Textile Industry
- Industrial Laundries
- Retail Industry (Supermarkets /Shopping Centers)
- Hospitals/Clinics
- Hotels/Resorts
- Airports
- Universities

What makes Solitem unique:

- Collector & Tracking System
- High precision instruments
- Three main uses for the same technology (heating, steam generation, and cooling)
- Know-how from the collector's technology and software
- Manufacturing and automated production
- Photo geometry Lab
- Online monitoring
- Financial support for customers

Solitem has its headquarters in Aachen, its manufacturing is done in Turkey, and Solitem is working all around Europe (Germany, Spain, Italy, etc.), North America (USA and Mexico), and Asia (India).
Solitem's inquiries have increased seven-fold compared to the last year, and around the world there is high potential for the application of Solitem's technology.

www.solitem.de
info@solitem.de
+49(0)241 980 906-0
Süsterfeldstraße 83 52072 Aachen
Germany

9.1.5 BET - Büro für Energiewirtschaft und Technishe Planung GmbH

BÜRO FÜR ENERGIEWIRTSCHAFT UND TECHNISCHE PLANUNG GMBH

BET is a leading energy consultancy offering consulting services in all matters related to the liberalized electricity and gas markets.
It started as Spin-off Company from the RWTH Aachen in 1988. Up to now the company has a work force of 70 employees spread out in the areas of consulting and research.
Consultancy on grid access, optimized energy procurement, and IT systems rank among BET's core services. BET also provides expertise on topics related to market regulation and plan or optimize grid and power plants systems.
The six professional teams of BET which covers all the competences of the company are:

- Third Party access to electric and gas grids
- Calculation of network tariffs
- Modeling power plant construction marketing and electric and gas markets
- Energy trading
- Process and IT Systems for utilities
- Decentralized Generation including CHP and renewables

BET develops models, simulations, and analysis strategies with software in combination with knowledge of related laws and regulation to give advice on power and pricing requirements and forecasting future demand. BET's clients include:

- Communal, regional, and private grid operators and energy traders
- independent power producers (IPP)
- joint ventures
- industrial and commercial companies
- local authorities
- ministries
- national and international regulatory authorities
- science and research institutes
- political policy makers

- industry associations

What makes BET unique:

- Software and model tools (STAR TOOL) used in the consulting services which make BET more accurate and more efficient.
- The experience, high knowledge, and close connection between the technical and the economical aspects in the energy.
- Network planning, deep knowledge, and understanding of how the energy network works.

Thirty percent (30%) of the business of the company is done within the region, a sixty percent (60%) is done in the rest of Germany, and the last ten percent (10%) is done in Switzerland, Belgium, Netherlands, Luxembourg, and Austria.
Since BET's beginning the company has grown every year 20%. The average value of 600 contracts per year, which range from days to up to 3 years, gives BET security for the next years.

www.bet-aachen.de
info@bet-aachen.de
+49 241 47062-0
Alfonsstraße 44 52070 Aachen
Germany

9.1.6 LiNear GmbH

LiNear is a CAD Software company that has developed a special CAD application for heating, sanitary, ventilation, and cooling systems in buildings. LiNear was founded in 1993 but was involved in the CAD applications since 1991. Presently LiNear has a total of 42 employees.
LiNear CAD Software is based in Autodesk platform to be incorporated in AutoCAD. This application incorporates specifications and 3D models of pipes, fittings, materials, and components from manufacturers for improved accuracy. This, coupled with automatic system design features, makes for fast and accurate design of building climate control systems.
The software is in a model-centric[1] technology base, letting the design changes automatically reflect across the project, helping to keep the entire team coordinated. Automated tasks and comprehensive symbol libraries are incorporated to increase productivity, eliminate errors, and provide accurate information to installation and constructing. LiNear provides training and support for their applications and are continually updating the software to meet new demands of their customers and the industry. This software design tool has energy use simulation capability helping designers to design more efficient buildings with the equipment available on the market.

What makes LiNear unique:

- LiNear is the first worldwide leading product in CAD design for heating, sanitary, ventilation, and cooling systems in buildings.
- The combination of engineering skills and software development to make a very complete and competent design tool.
- Manufacturer's products are embedded in the software making it much easier to create highly accurate designs, as well as giving users of LiNear a better performance in the design, calculation of costs, and ordering of parts.

LiNear's software is purchased an 80% between Germany, Austria, and Benelux, and the other 20% all around the world. This is seen in its 10% growth shown the last

[1] **Model-based (or -centric)** design is an approach that puts 3D models at the center of design. It uses a set of standards and processes created specifically to employ 3D models as the design authority and the source for all design data. These processes create a framework that allows engineers to maximize their companies' return on investment (ROI) on their existing CAD software. Because the 3D model is the central source of design data, it becomes accessible by all team members and the flow of information is released as soon as the design cycle begins. In essence, Model-Based Design opens a larger pipeline, allowing the team to receive, understand, and evaluate designs faster than the traditional step-by-step approach.
Source: http://www.designworldonline.com/articles/3106/245/3D-CAD-and-Model-centric-design.aspx

years. Contracts and upgrades of the software give LiNear security to continue the next years in developing and researching in CAD technologies.

www.linear.de
info@linear.de
+49(0) 241 889 800
Kackertstraße 7-11 D-52072 Aachen
Germany

9.1.7 EUtech GmbH

EUtech is an internationally recognized engineering consultancy that works for industry, the public sector (governments, ministries, and municipalities) and utilities. EUtech was founded in 1995 as GbR and later on in 2004 changed to a GmbH. EUtech has a total number of employees of 26.

EUtech's core competence is in energy engineering and consulting. This area encompasses industrial energy analyses, energy efficiency benchmarking, implementation of energy management systems, international energy efficiency studies, and project management. EUtech could also establish itself as a leading consultant for climate change projects – both with regard to technical and strategic issues. Depending on the individual project the focus may be on technical, economic, political or organizational issues – each area covered by experts that have many years of experience in their particular field.

EUtech has a broad knowledge base in emissions policy, energy efficiency policy, and energy economics that they use to consult regarding energy efficiency, climate change, and CO_2 emissions related projects. They have their own methodology regarding energy audits and develop analysis software to support their consulting.

What makes EUtech unique:

- Very good know-how, high quality of the results, short project duration
- The methodology (workflows) used let EUtech run projects faster with high quality, it gives a quick turn-around.
- The small size of the company gives flexibility
- Climate analysis software
- In house engineering services via EUtech's sister company EUtech Scientific Engineering.

EUtech has 80% of its activities in Germany, 10% in the rest of the EU, and 10% internationally between China, Mexico, Pakistan, Serbia, Switzerland, Turkey, Tunisia, and Uganda. The company has shown a growth rate from 15-20% per year since 1997. The company relies for the next year in its mean number of contracts; the market for EUtech is stable and secure.

www.eutech.de
info@eutech.de
+49(0) 241 963 1970
Dennewartstraße 25-27 52068 Aachen
Germany

9.1.8 ECOFYS

Ecofys has a clear mission: a sustainable energy supply for everyone. This is the goal that everyone in our company believes in and strives for. In a company that is a leader in renewable energy and energy efficiency, knowledge and innovation are key factors in turning the ideas of today into the viable realities of tomorrow.

An experienced market leader

Established in 1984, Ecofys specializes in energy saving and renewable energy solutions. We offer research and consultancy services as well as product development. Over the years Ecofys has conducted extensive research and completed projects for many energy companies, housing corporations, building companies, international and local authorities, and energy consumers around the world. With more than 250 employees, we're one of the largest consultancy firms in sustainable energy and climate policy.

Broad expertise

Ecofys offers a wide range of high quality services, based on our extensive knowledge of renewable energy and energy saving solutions. Areas of expertise include solar energy, wind energy, biomass, hydrogen technology, energy supply and climate policies. Our experts are organised around different markets. Technical, financial, legal and planning disciplines are combined to develop balanced and cost-effective solutions.

Innovative and forward thinking

Ecofys is always at the forefront of climate and energy market developments. Because of our activities in strategic research and our contributions to international and local policy development we lead the way in applying these advancements in our projects. We also continue to develop new products of our own, or in partnership with other organisations.

Your partner from concept to completion

Ecofys has all the skills and expertise to offer you a complete service, from concept to completion. We work with you closely to achieve your policy or project objectives, whether you want us to implement part of a project or develop a turn-key solution.

www.ecofys.com
info@ecofys.com
+31(0) 30 6223300
Kanaalweg 16-G 3526 KL Utrecht
The Netherlands

9.1.9 Regio iT Aachen GmbH

regio iT aachen
gesellschaft für informationstechnologie mbh

Regio iT Aachen is an information technology company providing IT support for local municipalities and utility companies.
Regio iT Aachen was founded in 2003 and since then it has been involved in the energy sector providing IT support. Currently the company has a total number of 231 employees.
The competence they bring to the energy sector is their experience in providing IT support to the utility companies and the integration of processes. Regio iT Aachen specializes in the auto reporting, website management, and all data management for an organization. Regio iT Aachen uses SAP, IBM, and Microsoft iT solution packages to fulfill all data management. Utility companies have very specialized data management needs and Regio iT Aachen has a great deal of experience with the utility companies in the Aachen region.

What makes Regio iT Aachen unique:

- Region iT Aachen links all sectors of an organization from where information and data can be collected, regardless of the platform, hardware, and software, and then this information is live streamed processed in one IT solution package.
- Has a new data centre for hosting and regional data processing in-house.

Regio iT Aachen focuses an 80% within the region and the other 20% focuses all around Europe. The company has shown over the last years a yearly growth rate of 10% which is tied to the energy sector growth. Regio iT Aachen is controlled by public entities which make it very stable and secure; this is also due to the structure of the ownership and the municipal contracts Regio it Aachen receives.

www.regioit-aachen.de
info@regioit-aachen.de
+49(0) 241 413 590
Lombardentstr. 24 52070 Aachen
Germany

9.1.10 E-quad Power Systems GmbH

E-quad is a company who designs combined heat and power systems around capstone microturbines.
E-Quad is a spin-off in 2004 from NOWUM, an Institute of the FH in Jülich, and was founded as a GmbH in 2007 and currently has a total of 6 employees.
Their activities include designing the fuel regulation and pre-conditioning system for a variety of fuels: natural gas, diesel, LPG, CNG, and Benzene. They also design the heat exchanging systems to meet heating requirements for the given applications, such as hot water for heating or process heat and even steam generation. They design these systems custom for on-site power in office buildings and hotels, and also for industrial applications.

What makes E-quad unique:

- E-quad is one of very few companies designing small scale gas turbine systems for on-site power in Germany.

E-quad's main market is Germany with 95% of its business within Germany and has started to open its market to Europe. The remaining 5% if its business is in Italy and the Czech Republic. The company has shown a growth rate over the last years of 100%. E-quad should be able to continue growing in the future with the number of contracts the company has.

www.microturbine.de
info@microturbine.de
+49(0) 240 7904 9210
Kaiserstr. 100/TPH3-C 52134 Herzogenrath
Germany

9.1.11 Consentec GmbH

CONSENTEC Consulting für Energiewirtschaft und –technik GmbH is a consulting and software company specializing in engineering and economic issues related to energy supply with a main focus in electricity and gas networks.
Consentec was founded in 1999 as a spin-off of The Institute of Power Systems and Power Economics of the RWTH Aachen University. Currently Consentec has a total number of 16 employees.
Consentec supports its clients by consultancy, technical and economic investigations, software solutions (both individual and standardized), training, and expert reports. Since its foundation, Consentec has continuously worked for utilities and network operators as well as for industry associations and authorities like the European Commission, ministries and regulators. Consentec's staff members and founders can draw upon profound knowledge and long-standing professional experience in the field of system engineering and economics of power and gas supply, as well as a comprehensive international contact network to the companies and institutions involved in operation and regulation of the energy supply sector.

What makes Consentec unique:

- Consentec has an outstanding position in the energy and grid consultancy business because of their scientific approach with technical, economic and regulatory background, and also their strong ties with RWTH Aachen University and the scientific community they have available to them.
- Consentec is capable of addressing abstract topics and modeling them with scientific methods and models including self developed software for calculation and simulation of energy grids.

Consentec has 50% of its market within Germany and the other 50% is within the rest of Europe. Consentec has shown a 10% growth per year in employees over the last years.

www.consectec.de
info@consentec.de
+49(0) 241 938 360
Grüner Weg 1 52070 Aachen
Germany

9.1.12 NUON Energie & Service GmbH

NUON Energie & Service is a part of NUON group and is responsible for the management of six industrial parks, four of which are in the EUREGIO region.
NUON Energie & Service GmbH was founded in 1999, but NUON group has been involved in the energy sector for 100 years. Currently NUON Energie & Service has a total of 150 employees.
NUON Energie & Service responsibility includes all of the site management: mainly power production, distribution via a public grid, and water treatment. There are many industries in each of these parks that all have different power and water needs, and NUON Energie & Service not only meets these needs, but does regional development by promoting renewable energy companies in the region. This work is critical to keeping industry in the region.

What makes NUON unique?

- NUON Energie & Service is unique in that they are part of the NUON/Vattenfalls energy group which is the fourth largest producer of energy in Germany and the ninth largest in Europe.
- The Company's industry Park services for special new technology companies, most recently a fuel cell power plant company from Australia.
- NUON Energie & Service regulates a pilot public grid in Heinsberg that is a test bed for Smart Grid technology and management.

The company has shown to be stable throughout its history. Some securities of NUON Energie & Service which make the company continue to perform are the concept of industrial parks in energy, by being part of NUON Group, and the company's aggressive business plan.

www.nuon.de
nuon@nuon.de

9.1.13 Solland Solar Cells BV

Solland Solar is a manufacturer of crystalline silicon based solar cells located in the industry park Avantis between Heerlen and Aachen. It has 360 employees and was founded in 2004. Its major shareholder is DELTA, a Dutch multi-utility company.
Solland Solar focuses much of its R&D effort on developing more efficient solar cells at lower production costs with the goal of making PV-generated electricity competitive with end-consumer grid electricity costs. Solland Solar works in collaboration with different German and Dutch R&D institutes such as ECN and RWTH Aachen to develop the solar cells of the future. Currently there is a production capacity of 170 MW per year for solar cells installed at Solland Solar, and further expansion is planned.

What makes Solland Solar Cells unique:

- A special feature of Solland Solar is its location right on the border between Germany and the Netherlands.
- This location also puts Solland Solar in close proximity to both ECN and RWTH, both of whom they collaborate with in solar cell research and development with special attention to manufacturing.
- Solland Solar has a small R&D cell production line that within joint projects is also used by the RWTH.
- Solland Solar has developed a new type of solar cell, the Sunweb cell, that has all contacts on the backside of the cell. This gives higher cell efficiencies and enables the use of new module concepts.

Solland Solar is shipping to the international PV market, but with special focus on Germany, The Netherlands, and Belgium. In 2008 the company showed a growth rate of more than 100%. Solland Solar's competitive advantages are between others the high quality in manufacturing, the label Made in Germany, and the technological leadership demonstrated with the development of the Sunweb cell and module technology.

www.sollandsolar.com
info@sollandsolar.com
+31(0) 45 88 00 641
Bohr 10 6422 RL Heerlen / Bohr 12 52072 Aachen
The Netherlands / Germany

9.1.14 AFQ consultancy project- & interimmanagement new business development

AFQ consultancy
project- & interimmanagement
new business development

AFQ is a one man consulting organization founded in 2004 for innovative new businesses. AFQ advises on business plan strategy, which typically involves helping with fund acquisition and meeting legal requirements such as certifications.
AFQ has a strong involvement in the energy industry, as many of its clients are in the energy industry. They have experience with utility companies, smart grid technology and solutions, solar and insulation technology start-ups, and next generation clean rooms.

What makes AFQ unique:

- AFQ has a unique position consulting with a cross-border network between the Netherlands and Germany with EU-wide language capabilities.

The company focuses in the regional market, and for the past few years AFQ has been stable.

robbimmel@msn.com
+31(0) 65326 7345
P.O. Box 9 6240 AA Bunde
The Netherlands

9.1.15 Solar Academy

The Solar academy provides training for managers, engineers, and operators in the photovoltaic industry. They were formed in 2007 as a spin-off from ECN Solar. The courses they offer are as follows:

- General Introduction to Photovoltaics
- Technical Introduction to Photovoltaics
- Introduction to Thin-Film
- Manufacturing and Quality Control
- Solar Cell Metrology
- Custom courses for applications, economics, and design of photovoltaics

The Solar Academy was created by the demand for education for the rapidly growing photovoltaic industry. This is currently being done by offering courses largely based on the demand of industry to train workers, engineers, and managers on concepts and information specific to photovoltaics.

The Solar Academy is unique in that it is open to everyone and is tailored to the photovoltaic industry and preparing workers to be qualified for the photovoltaic industry in a practical way: "hands-on and minds-on". They also have access to equipment and professionals through its ties with ECN Solar, Solland Solar, and the other players in the photovoltaic industry in the region.

www.solaracademy.nl
+31 (0)45 711 1540
Snellius 3A, 6422 Heerlen
The Netherlands

9.1.16 BMR Energy Solutions GmbH

BMR Energy Solutions GmbH is a consulting group for renewable energy projects. BMR got started in finding suitable locations for wind projects in 1998, and from there developed into creating a whole turn-key renewable energy projects as a GmbH in 2001. These turn key projects involve making the business plan, the technical design, going through the approval process outlined by the Federal Immissions Control Act, and then identifying the suppliers and potential investors.

A great deal of BMR's expertise is in wind energy projects, but they are now also working with photovoltaics and bioenergy themed projects. Since 2004 they have been consulting in energy management and energy efficiency as well. While BMR's experience lies in creating these so called "turn-key" renewable energy projects, BMR has also offers services in project management to help oversee the installation and operation of the project. BMR is well connected with partners in industry, businesses, energy suppliers, municipalities, commerce and the financial sector to assure that their projects are completed and meet the economic and ecological requirements in the most optimal and sensible way.

BMR's experience in complete project development, high flexibility, and connection with the complete chain of players in sustainable energy solutions development make them highly competitive in the challenging sustainable energy market.

www.bmr-energy.com
+49 (0) 24549369-0
Kirchberg 4, D-52538 Gangelt
Germany

9.1.17 AVANTIS GOB n.V.

AVANTIS GOB is a cross-border development organization that runs a science and business park on the Dutch-German border between the Dutch city Heerlen and the German city Aachen. Their area of competence is in understanding the high tech industries and helping new high tech businesses by providing a good location in their science and business park and integrating new businesses in the research and innovation rich region. The concept for AVANTIS started in 1992 after the Treaty of Maastricht was signed to promote new technology business parks in the region. Since its inception in 1998, AVANTIS has been involved with the energy industry as it is a major part of the high tech industry of the region.

Avantis GOB's main asset is the science and business park which is directly on the Dutch and German border, such that the border runs right through the park. This gives Avantis a unique position to have both Dutch and German companies within the park, and the companies starting in the park can choose which country they want to be headquartered in. Avantis knows the legal requirements for businesses starting in both countries, and can help a new company decide which country is more advantageous to be headquartered in.

There are currently twenty-three organizations in the Avantis science and business park employing a total of 700 people. Of these 700 employees, 400 of them work in energy related fields, highlighting the importance of energy to Avantis. One such organization is Solland Solar, a photovoltaic cell manufacturer. Avantis has a great deal of knowledge about the photovoltaic industry in the Netherlands and Germany through its many contacts and experience with the tax structures in both countries.

Avantis is unique among other science and business parks with its cross border location being the only park where the third supplementary protocol between Germany and the Netherlands concerning double taxation applies.

www.avantis.org
+31 (0) 45 56 88 110
Snellius 8, NL-6422 RM Heerlen
The Netherlands

9.1.18 ProCom GmbH

ProCom supports utilities by delivering high-quality solutions for power production planning and energy trading planning. The company was formed in 1977, and began working strongly in the energy industry starting in 1981. Their solutions apply to power & heat producers, gas suppliers, and power & gas traders. The solutions are based on their IT platform BoFiT which they develop continuously to meet today´s and tomorrow´s customers´ demands. A team of expert consultants implement the solutions in close cooperation with the customer.

ProCom is a market leading company in Europe (customers in Germany, Switzerland, Austria, Denmark, Poland, Italy, UK) supplying solutions for an optimal planning of resources (power plants, contracts, …). The major European market areas are served (EEX, Nord Pool, APX, GME,…). A major advantage of ProCom is their close cooperation with client's project teams to deliver the solutions on-site.

www.procom.de
+49 (0) 241 51804 0
Luisenstrasse 41, 52070 Aachen
Germany

9.1.19 Alliander AG

Alliander is a grid management daughter company of NUON. It was formed as a result of the Independent Network Operation Act unbundling of NUON nV in July of 2009. Through being a part of NUON, a major energy provider in the Netherlands, Alliander has been involved in the energy industry since 1900 as a grid company. Alliander is the grid management portion of the former NUON nV and has three daughter companies: Liander, Liandon, and Liandyn. Liander manages the gas and electricity networks in NUON's service area, Liandon designs and realizes complex energy infrastructures, and Liandyn creates custom public lighting and traffic control solutions.

Alliander AG is the German subsidiary of Alliander and with its headquarter in Berlin. Alliander AG manages the electrical and gas network in Heinsberg and the city lights of Berlin, Hagen (Westphalia), and Rüsselsheim. Included with managing the city lights of Berlin is the management of the traffic lights. Alliander AG was formed in July of 2009, but draws on the competence of its history as the grid manager in the Netherlands to create a cutting-edge grid management for Heinsberg, purchase by Alliander in 2001, which incorporates the latest in smart grid technology. This includes more focus on the more practical lower voltage grids for distributed energy grids with the test Smart Grid in Heinsberg which includes smart metering in homes in Heinsberg in conjunction with smart metering research. Alliander AG is also working with fuel cell units with regard to their role in a smart grid. They currently have a fuel cell unit installed in a home in Heinsberg that is part of a project with Ceramic Fuel Cells Limited, an Australian fuel cell company currently in an industrial park in Heinsberg. Alliander AG also works with LED lighting, low energy lighting, and lighting optimization within their city lighting projects.

Alliander AG's most outstanding feature is their cross-border function utilizing their grid management knowledge from NOUN eV in the Netherlands and applying that to the German grid to create the best smart metering system in the world. They have been a pioneer in distributed energy grid management and due to their experience have been very fast to optimize their distributed networks.

www.alliander.com
+49 (0) 2452152302
Boos-Fremery-Straße 62, 52525 Heinsberg
Germany

9.1.20 Siemens AG Aachen

SIEMENS

Siemens has always been a major player in the energy industry: Siemens has 160 years of experience in industrial infrastructure. Siemens AG in Aachen has two specialties that they perform within the whole Siemens network: Industrial energy use analysis and management and wind energy. In 1999 the industrial solutions division of Siemens was established in Aachen, and in 2007 a wind division of Siemens was established after having acquired a wind company in Aachen. Regarding industrial energy Siemens AG in Aachen works to optimize the energy efficiency of all 320 industrial facilities within all of Siemens. Major topics that they address in the industrial facilities include:

- Waste heat recovery systems
- Industrial automation
- Lighting systems
- Photovoltaics
- High efficiency drives and motors
- Building technology, including climate control systems

Wind is the other major part of Siemens AG in Aachen is wind energy. Siemens has a wind center in Copenhagen in Denmark, but the Aachen office addresses most of the mechanical designs for Siemens wind power generators. They specialize in gearboxes, offshore materials, and aerodynamics. The electrical designs and further testing is all performed in the Copenhagen wind headquarter

Siemens Energy Sector is the world's leading supplier of a wide range of products, solutions and services for power generation, transmission and distribution as well as for the production, conversion and transport of the primary fuels oil and gas. They are the only supplier worldwide with comprehensive know-how encompassing the entire energy conversion chain and, in particular, plant-to-grid connections and other types of interfaces. Their Energy Sector has some 85,000 employees worldwide. In fiscal 2009, it generated external revenue of €25.4 billion and profit of €3.3 billion. Siemens is also a leading provider of wind turbines worldwide with an installed capacity of around 9,000 megawatts and more than 7,800 turbines.

www.siemens.com
+49 (0) 241451511
Neuenhofstraße 194, 52078 Aachen
Germany

9.1.21 STAWAG AG

STAWAG AG is the energy provider for the city of Aachen. STAWAG has existed in some form since energy distribution existed in Aachen. In 1838 gas street lamps were put into use in Aachen, and became the first city energy program. By 1880 Aachen had a large network of gas city lighting and also had city water distribution. In 1901 the city took control of the electrical company in Aachen, and by 1912 the city controlled the electricity, gas, and water distribution in Aachen. In 1967 STAWAG Stadtwerk Aachen AG was formed. In addition to trading energy, they provide services to help their clients improve their energy efficiency both in technical and financial aspects. Here are the areas they are working in:

- Electrical supply – energy trading, pricing, grid management, electrical metering
- Gas supply – gas network management, pricing, biogas production plant They also have the only bioethanol fuel tanks in Aachen
- Wastewater management – water testing and metering
- Public lighting – lighting efficiency optimization projects involving timed lights, lighting optimization, and more efficient lighting elements.
- Heating - District heating and co-generation industrial waste heat utilization

In addition to these standard responsibilities of a city utilities company, STAWAG has innovative projects to help protect the environment and increase efficiency.

- Intelligent Energy – a program that currently has 250 smart metering systems for electricity, gas, and water to help owners optimize their usage.
- Fuel Cells – combined heat and electricity systems for homes
- Electro-Mobility – a program to bring electrical vehicles and electrical charging stations to Aachen and reduce emissions in the city
- Supplying Biogas – constructing biogas production plants that connect into the city's natural gas grid.

STAWAG is innovative in renewable energy subsidies and was part of the first subsidy in all of Germany that was made in Aachen for renewable energies.

www.stawag.de

Lombardenstraße 12-22, 52070, Aachen
Germany

9.1.22 Trianel European Energy Trading GmbH

Trianel bundles the interests of communal utility companies. The company was formed in 1999 in response to the liberalization of the energy market in Germany to meet the demand for energy trading. Their focus is in the areas of energy sourcing, trading, production, and efficiency to strengthen the position of their shareholders and other customers. Trianel brings utility companies together to overcome the huge financial investments required for power generation assets to build modern high efficiency power plants. They have 47 shareholders in Germany, Austria, and Switzerland, most of which are utility companies. Some themes that Trianel is involved with are as follows:

- Electro-mobility
- Gas storage
- Gas power plants
- Hard coal power plants
- Smart metering
- Smart grids
- Fuel cells
- Energy efficiency

Trianel has overseen the construction of an 850MW combined cycle power plant in Hamm, Germany which started operation in 2007. They have other power generation facility projects that are currently underway:

- A 750MW coal-fired power plant in Lünen, Germany
- A 400MW offshore wind park near Borkum, Germany
- A 750MW combined heat and power plant in Krefeld, Germany

Trianel is a leading communal network organization within the German energy industry that is outside of the German oligopoly made up of E.on, RWE, Vattenfall, and EnBW.

www.trianel.com
+49 241/413 20-0
info@trianel.com
Lombardenstraße 28, 52070, Aachen
Germany

9.2 RESEARCH ORGANIZATIONS

9.2.1 ECN Solar

ECN is the largest energy research center of the Netherlands that performs research and offers engineering services and education in the areas of solar energy, wind energy, Biomass, coal, Hydrogen, Nuclear, smart grids, energy efficiency, energy aspects in the built in environment, and policies studies. ECN is well known worldwide due to its high competence and contribution in the energy sector.
ECN Solar Energy is a foundation part of the ECN group founded in 1955 and currently has a total of 90 employees. ECN Solar Energy's main contribution to energy sector includes research and application Sustainable Energy Techniques, License Agreement, Co-development, and Contract R&D.
ECN Solar Energy offers a wide range of R&D activities on PV materials and processing technology and also cell and module design. These are available for transfer and implementation on laboratory, pilot, and production scale. ECN Solar Energy's extensive facilities for solar cell processing and characterization are well suited to study almost all R&D issues currently relevant for the PV industry. As a fully private and independent organization ECN Solar Energy can work on a non-disclosure and exclusivity basis. The combination of skills, experience and facilities makes ECN Solar Energy a perfect partner in joint R&D activities, in fundamental studies as well as in technology development.
Two main areas dominate ECN Solar Energy's present R&D program: crystalline silicon and thin-film PV technologies. The major part of this program is carried out in co-operation with national and international partners.

What makes ECN Solar unique:

- ECN Solar Energy has fully equipped PV characterization labs.
- ECN Solar Energy is one of the four leading Solar PV institutes.
- ECN Solar Energy is addressed to focus on applied research among all its areas of competence.
- ECN Solar Energy has an industrial scale module line and industrial cell baseline facilities and equipment, which give the institute a better understanding in the applied research concept.

ECN Solar has work all around Europe mainly in The Netherlands, Germany, Norway, and Spain. From 2000 to 2009 ECN Solar has grown 70% per year in its number of

employees. Long term subsidy and contracts up to four years are securities that ECN Solar has to continue research in the area of sustainable energy techniques.

www.ecn.nl
veltkamp@ecn.nl
+31(0) 224564251 / 4761
1755 ZG Petten
The Netherlands

9.2.2 Forschungszentrum Jülich GmbH

Starting from nuclear research in the 1960's, institutes have undergone several structural changes and restructuring since the start of Forschungszentrum Jülich due to changes in research fields and technologies. E.g. Fusion activities have started in the 1970's, fuel cell research in the 1990's and the "youngest" branch is photovoltaics, the institute having been founded in 2000. In 2007, the organizational units listed below have been assembled under the common roof of "Institut für Energieforschung" (Institute of Energy Research).
See also http://www.fz-juelich.de/portal/index.php?index=1148.
Materials Synthesis and Processing (IEF-1)
Microstructure and Properties of Materials (IEF-2)
Fuel Cells (IEF-3)
Plasma Physics (IEF-4)
Photovoltaics (IEF-5)
Safety Research and Reactor Technology (IEF-6)
Systems Analysis and Technology Evaluation (IEF-STE)
Fuel Cell Project (IEF-PBZ)
Nuclear Fusion Project (IEF-KFS)
Since its inception it has been involved in nuclear energy research, being the initial purpose of the centre, but since has created seven departments and two large project units related to energy.

The Research Center in Jülich is focused on three research areas: Health, Information, and Energy & Environment. The Institute of Energy Research within the area of Energy & Environment handles the Research Center's energy related research.

Institute of Energy Research
The Institute of Energy Research (IEF) investigates modern energy conversion technologies. The topics it covers range from photovoltaics and fuel cells, through nuclear fusion and nuclear safety research, right up to innovative coal and gas power plants. This gives rise to an unrivalled breadth of research topics, all bound together by scientific methods and systems analysis. The institute consists of the following sections:

Materials Synthesis and Processing (IEF-1)
The institute IEF-1 deals with the development of materials, structural elements and components as well as their processing for innovative systems of energy conversion, particularly in the area solid oxide fuel cell (SOFC) and thermal barrier coatings for advanced power stations. In this connection, powder synthesis and production of ceramic and metallic materials, as well as mixed materials for bulk and layered

elements, is carried through.

Further topics being working on are those which are either closely related to the above main points - like the high-temperature stable composites C/SiC as a possible alternative material for new generations of gas turbines - or those based on the central area of powder technology and coating process, like the manufacturing of powder-metallic elements consisting of NiTi shape memory alloys or the development of metals with improved functional porosity.

Microstructure and Properties of Materials (IEF-2)

The research activities of IEF-2 are concentrated on the development and characterization of high temperature materials advanced gas and steam powerplants, solid oxide fuel cells (SOFC) and for plasma facing materials for future fusion devices.

The scientific competences of the institute are focussed on the investigation of physical- mechanical properties of high temperature structural metallic materials, structural ceramics and metallic and ceramic coating systems. Compound materials consisting of high strength materials combined with ceramic or metallic top layers are considered to be used for plasma facing components. This requires new approaches for materials testing and investigation especially in the area of materials characterization and analysis including transmission electron microscopy (TEM).

These methods are important to investigate the high temperature corrosion behaviour of high temperature components in aggressive environments and deposits and to develop new coating systems with improved environmental resistance and mechanical as well as chemical compatibility.

The methods of Knudsen effusion and high pressure mass spectrometry available allow the determination thermochemical properties of materials and corrosive deposits.

Fuel Cells (IEF-3)

IEF-3 is one of nine sub-institutes within the Institute of Energy Research at Forschungszentrum Jülich GmbH. The research work carried out by IEF-3 should yield groundbreaking results of social, ecological and economic relevance in comparison with other international research facilities. This aspect of the work should be achieved via fundamental research in close coordination with technical development work into relevant scientific-technical areas of expertise. International cooperation with partners from research and industry is of particular importance in this respect. The IEF-3 is focussed on implementing results from research in innovative products, procedures and processes in collaboration with industry, and is keen to make a contribution towards bridging the gap between science and technology. Cooperation with universities, universities of applied sciences, training workshops and training centres is designed to promote opportunities for further education and training. Fuel

cell types under investigation are SOFC, DMFC and HT-PEFC. Further activities are carried out in the fields of fuel processing and electrochemistry.

Plasma Physics (IEF-4)

The Institute for Energy Research / Plasma Physics conducts a research and development programme in the areas of high temperature plasma physics and thermo-nuclear fusion. As a central research facility the institute operates the tokamak TEXTOR. Special fields of expertise are plasma-wall-interactions, diagnostics, materials research (see IEF-2) and simulation.

All research and development activities for controlled nuclear fusion within the European Union are carried out under a joint coordinated program sharing efforts (EURATOM). The activities of the EURATOM/Research Centre Jülich Fusion Association are an integral part of this European program.

A special agreement between the European fusion laboratories and the EU Commission, the "European Fusion Development Agreement" (EFDA), regulates research and development work in the field of technology, for ITER and for the operation and scientific use of the European JET experiment in Culham, United Kingdom.

Photovoltaics (IEF-5)

IEF-5 is active in the field of Si thin film PV going from materials research over cell processing technologies to the development of new cell and optical concepts.

Safety Research and Reactor Technology (IEF-6)

The institute for Safety Research and Reactor Technology (IEF-6) is involved in the following research activities: Nuclear Systems, Fuel Cycles, Waste Management, and Simulation & Validation. The IEF-6 makes important contributions to the development and the operation of safe, reliable and sustainable nuclear energy systems with focus on nuclear waste management.

Systems Analysis and Technology Evaluation (IEF-STE)

Many of the issues at the centre of public attention can only be dealt with by an interdisciplinary energy systems analysis. Technical, economic and ecological subsystems which interact with each other often have to be investigated simultaneously. The group Systems Analysis and Technology Evaluation (IEF-STE) takes up this challenge focusing on the long-term supply- and demand-side characteristics of energy systems. It follows, in particular, the idea of a holistic, interdisciplinary approach taking an inter-linkage of technical systems with economics, environment and society into account and thus looking at the security of supply, economic efficiency and environmental protection. This triple strategy is oriented here to societal / political guiding principles such as sustainable development. In these fields, IEF-STE analyses the consequences of technical developments and provides scientific aids to decision making for politics and

industry. This work is based on the further methodological development of systems analysis tools and their application as well as cooperation between scientists from different institutions.

Fuel Cell Project (IEF-PBZ)

IEF-PBZ is an organizational unit with the task to coordinate Solid Oxide Fuel Cell activities within Forschungszentrum Jülich.

Nuclear Fusion Project (IEF-KFS)

IEF-KFS is an organizational unit with the task to coordinate the fusion-relevant work within Forschungszentrum Jülich incl. the representation in the international framework.

Both IEF–PBZ and -KFS have organisational functions and do not carry out research for themselves, therefore are not considered as departments but as “organisational units”.

The Research Center in Jülich is one of the largest research centers in Europe and also operates one of the largest supercomputers in the world.

www.fz-juelich.de
+49 2461 61-1810
Wilhelm-Johnen-Straße D-52425 Jülich
Germany

9.2.3 VITO nV

VITO is a Flemish Institute for Technological Research performing strategic research in sustainability. VITO was formed in 1991 when it separated from the Nuclear Research Center (SCK) in Mol, Belgium. The SCK, previous to 1991, had sustainable energy research projects in addition to their nuclear energy research which had grown to numerous and large, and so these sustainable energy projects formed into VITO. VITO has three main areas of research:

1. Industrial Innovation: In an effort to support Flemish companies VITO conducts research in technologies and methods to develop sustainable production processes. There are three units:

    - Material technology unit: Researches the implementation of plasma technology, powder design and lasers.
    - Separation and conversion technology unit: Investigates the possibilities of (bio) process technology and membrane technology and (secondary) raw materials.
    - Environment analysis and techniques unit: Develops new measurement methods for organic and inorganic substances.

2. Quality of the Environment: The quality of the environment affects the health of people and the potential for economic development. VITO works to determine the quality of environments and ways to develop the environment in sustainable ways.

    - Remote sensing unit: Develops and uses instruments which physically display the environment.
    - Environmental modeling unit: Maps the (future) use of space and evaluates related air, soil and water quality
    - Environment risk and health unit: Develops and uses instruments for analyzing the consequences of the environment on human health.

3. Energy: Sustainable energy supply is a major concern of society. VITO investigates methods and technologies to develop a high level of sensible energy use and utilize locally available energy resources.

- Energy technology unit: Researches and develops intelligent, decentralized energy-generation systems so that they can optimally contribute to active and flexible energy structures, whereby the use of renewable and small-scale decentralized generation can be maximized ("smart grids").
- Transition energy and environment unit: Implements technical and economic models to investigate the possibilities available to regions, countries and business sectors for dealing with future energy and environment conditions.

The Industrial Innovation and Quality of the Environment areas are not always directly related to energy, but are relevant for energy concerns, as industrial innovation can be applied to energy related industries and the quality of the environment is a key issue for the Energy Industry. The Energy area of VITO is primarily focused on decentralized energy solutions. All of their technologies are studied within the context of a smart grid:

- Fuel cell systems
- Energy storage: thermal storage in materials and electrical storage in batteries
- Photovoltaic systems
- Micro Combined Heat and Power (CHP)
- E-Mobility: connecting vehicles to the electrical grid
- Grid management, systems integration and control, and virtual power plants
- The built environment with regard to city planning and intelligent buildings
- Energy trading

Energy related equipment and facilities at VITO include:

- Smart grid test facility
- Fuel cells and battery test facility
- Hybrid drive train test facility
- Emission measurement

The Belgian government consults VITO on energy issues and the transition to sustainable energy solutions. They are a pioneer in planning smart city planning for Belgium, and have the largest smart grid test facility in Belgium.

www.vito.be
+32 (0) 14335511
vito@vito.be
Boeretang 200, BE-2400, Mol
Belgium

9.2.4 EON Energy Research Center

E.ON ERC was initiated by a major R&D donation of E.ON AG to RWTH Aachen University. A major public private partnership was agreed upon in 2006 for a duration of 10 years. The E.ON Energy Research Center has five institutes with all of their research devoted to different topics and aspects of energy.

ACS Institute for Automation of Complex Power Systems This professorship concerns the automation, modernization and restructuring of distribution systems for electric energy. In particular, this involves the integrative control and protection from power failures on all voltage levels as well as more intelligent control of the capacity flow (Smart Grids). In addition, real-time communication between the various focal points within the network has to be guaranteed. This mainly raises questions about communication stability and security. Moreover, this institute aims to develop concepts which should prove themselves for a "virtual energy supply company" – going beyond the concept of just a "virtual power plant". These concepts also concern how to coordinate the electricity input of numerous local small and minipower plants so as to be able to utilize the generated electricity for the locally, nationally and internationally linked power supply without compromising the well-recognized, high degree of reliability of the current power supply.

EBC Institute for Energy Efficient Buildings and Indoor Climate The research of this institute aims to reduce the energy consumption of buildings and increase indoor climate quality. This energy-focused consideration of buildings comprises the generation of energy and its distribution, the storage of energy and its dispensation to the room as well as the thermal behavior of the construction body and the building envelope.

Unlike other energy approaches typically applied nowadays, Professor Müller uses an exergybased analytical technology which, in particular, involves sensible utilization chains for energy transformation. This method enables a thermodynamically valid evaluation of the entire energy supply chain – starting from the supply structure and the energy transformation chain extending down to the energy streams within a building.

In all methods for reducing the energy requirements of buildings, the planned research work will always compare the expenditure (energy) with the benefit (climate comfort), so that new concepts for the supply of buildings can be compared with existing solutions. New developments have to account for future needs and requirements.

FCN Institute for Future Energy Consumer Needs and Behavior The Institute for Future Energy Consumer Needs and Behavior is a new research institute at RWTH Aachen University. It is focused on applied theoretical and empirical research in energy economics, management and policy, with a particular thematic focus on the adoption and diffusion of innovative technologies and on energy consumer needs and behavior.

We apply economic and management science theory to the sustainable production and use of energy. Research is undertaken both stand-alone and in collaboration with other social, engineering and natural scientists. Explicit consideration of behavioral aspects and motives, attitudes and needs of firms, private households and governments that shape their energy-using behavior is sought for.

Strong emphasis is put on the adoption and diffusion of innovative technologies in supporting a sustainable energy development. In contrast to 'pure' academic research often found in mainstream economics (highly stylized, ahistorical), the aim is to explicitly account for the technological basis and its change and, wherever possible, socio-economic aspects.

GGE Institute for Applied Geophysics and Geothermal Energy Within the framework of the founding of E.ON ERC, the Institute for Applied Geophysics and Geothermal Energy (GGE) at RWTH Aachen University stems from the former Institute for Applied Geophysics. The research at GGE focuses on the fields of geothermal energy and geological CO_2-sequestration by using numeric simulation technology, petrophysics and borehole geophysics. As a whole, the research profile is determined by application-oriented tasks.

With respect to numeric simulation technology, one focus of research is developing programs for the 3D-simulation of reactive flow and substance- and heat transport as well as programs for the 3D-inverse parameter estimation with applications regarding pore storage and hot-dry-rock reservoirs. Borehole measurements and their interpretation occur mainly for determining the sequence and properties of the drilled rock but also for determining paleotemperatures on the earth's surface from the inversion of borehole data and for quantifying mini currents in deep subsurface areas on hand of their heat shading. With regard to petrophysics, mainly thermal and transport properties are the focus of research. Our research work takes place in cooperation with other institutes and research institutions as well as in collaboration with partners in industry.

Concerning teaching, the GGE is involved in the B.Sc./M.Sc. programs "Applied Geosciences" and "Georesource Management" at RWTH Aachen University as well as in the international M.Sc. program "Applied Geophysics" that is coordinated together with the IDEA League universities, TU Delft and ETH Zurich. Furthermore,

the GGE is a member of the graduate college AICES (Aachen Institute for advanced study in Computational Engineering Science) and is associated with the Center for Computational Engineering Science (CES).

PGS Institute for Power Generation and Storage Systems The Institute for Power Generation and Storage Systems (PGS) will focus on dispersed electrical power generation with a focus on renewable sources. Presently, the focus is on the both economically and ecologically interesting power range of 1 – 10 MW. From a technology point of view PGS will work in the area of power electronics as well as electrical storage systems. Besides components, system oriented research will also be carried out, to realize sustainable, high efficient as well as cost effective solutions.

PGS, formerly the high-power medium-voltage research group of the Institute for Power Electronics and Electrical Drives (ISEA) of RWTH Aachen University, has been working for over 40 years on medium-voltage power electronics and electrochemical storage systems. Whereas PGS has its research foci on high-power systems (> 1 MVA) for utility applications (devices, converters and systems), including power semiconductor components, converter technologies and controls, ISEA continues researching low-voltage power electronics and storage systems (e.g. photovoltaic, drives, automotive, traction, industry applications). PGS as well as ISEA are headed by Professor Rik W. De Doncker, who is supported by Professor Dirk Uwe Sauer, head of the research area on Electrochemical Energy Storage Systems both at ISEA and PGS.

Besides public founded research projects, one focus of PGS/ISEA are research and development activities in close co-operation with national and international companies within the already mentioned application areas. In addition PGS/ISEA offers engineering services (e.g. measurement/characterization, engineering opinion and consulting) for companies in nearly all fields of activity.

At this time, this partnership is the largest research cooperation between a company and a university in the European Union.

www.eonerc.rwth-aachen.de
+49 241 80 49660
Mathieustr. 6 52074 Aachen
Germany

9.2.5 Philips Research Laboratories Aachen

PHILIPS

Philips Research is one of the world's largest corporate research organizations developing new technologies and investigating potential growth areas for Philips.
Philips Research Aachen is part of the bigger organization Philips which was created in 1956. Currently the research institute has a total of 300 employees.
Philips Research Aachen has its main research focus in Health Care and Lighting. Research in lighting includes a full range of light sources for illumination and special applications. In recent years the focus has shifted towards solid state light sources (LED, organic LED (OLED) and semiconductor lasers). Lighting related electronics (ballasts, drivers and controls) are also within their scope.
The research in lighting by Philips Research Aachen involves materials selection and development, the development of complete light sources (lamps), and the electronic control of all of the lighting technologies they work with. Concerning energy management they are developing intelligent sensor based lighting controls including the use of daylight to minimize energy consumption in buildings.

What makes Philips Research unique:

- Philips is No.1 in the world in developing new lighting technology for a wide range of applications. The Philips research lab in Aachen is part of this world leading lighting innovation.
- They have a fully equipped research lab campus.
- They custom build their own tools and test stands for their research, including highly specialized characterizing equipment.
- They have a combination of engineers, physics, chemists, and medical experts making a diverse and complete working team to do very thorough research.
- They have a particularly strong lead in LED and OLED research, but also in power electronics and controls.

The research institute has been stable for the last years and by being part of Philips Group the institute is very secure to continue doing research in all its fields.

www.research.philips.com
+49(0) 241 6000 301
Weißhausstraße 2 52066 Aachen
Germany

9.2.6 Solar Institute Jülich

The Solar Institute Jülich researches and consults in the area of Energy Systems focusing mainly in solar and thermal technologies as well as other energy related topics.
The Solar Institute was founded in 1992 as an institute of Aachen University of Applied Sciences. The Solar Institute Jülich (SIJ) has a total of 55 employees.
The Solar Institute Jülich specializes in five main areas of research and development as well as offers consulting services within these areas:
Solar thermal systems is one of the specialties of the Solar Institute from low-temperature (<100°C) to high-temperature (>800°C) absorbers as well as the development of solar technologies for developing countries and power generation technologies.
The Solar Institute Jülich develops simulation software with ever increasing accuracy and complexity of the systems to achieve better performance and more realistic simulations of power plant operation and life cycle analysis.
Porous structures are used in a wide variety of technical fields. The SIJ develops simulation programs based on Matlab/Simulink or uses proven finite element method calculation programs such as ANSYS or COMSOL for optimizations such as improving the shape of the porous structure.
The technologies involving porous structures that the SIJ works with include particle filtration and separation for automotive and power production applications, high temperature absorbers, air to air heat exchangers, waste gas technologies, and 3D foam structures.
Solar architecture at the Solar Institute involves research and development of advanced simulation tools and sophisticated measurement technologies for assessing energy utilization for buildings. Some areas of research are geothermal heat exchangers to heat air, daylight utilization, energy flow control of technologies particularly in the ventilation and cooling systems, and building simulation using the software LACASA developed by the SIJ based on Matlab/Simulink.
Sea water desalination and water purification at the SIJ includes developing optimized desalinization plants that produce many times the output of conventional solar stills with the same energy input. In waste water treatment, the SIJ is tackling the problem of mechanically removing salts and oils from the waste water flows.
Training, learning, and further education is another important subject at the SIJ that includes scientific seminars and events for a broad range of target audiences. In this context, the presentation of ongoing research activities within other education programs has proven to be an ideal platform for transferring know-how from their research results to power plant engineers. The SIJ offers the Summer School Renewable Energy for a two week course every summer to learn about practical potential uses for renewable energy.

What makes Solar Institute Jülich unique:

- Solar Tower Power Plant – world class development in materials, process, and control of solar thermal plants with a test plant in Jülich
- Assessment tools for building energy auditing – leader in Germany
- Automotive fuel purification – working with auto manufacturers in Germany and Aachen.
- Highly dynamic numerical simulations for power plant life cycle.
- Head of the networking group power plant and energy
- Summer School Renewable Energy
- *Helping Other Help Themselves* is a unique social project that has been promoted by SIJ ever since it was founded. The SIJ has been working on development of appropriate solar systems for developing countries. Support for many of these projects comes from the foundation Solar Global e.V., which arose out of the SIJ and to which many SIJ employees are associated. Solar cookers for individual families as well as for large-scale kitchens and company canteens were developed and deployed in projects around the world. A solar bakery oven on solar power was made in Burkina Faso, in Argentina's Altiplano projects to improve living conditions by installing solar-powered building heating has been done, and solar cookers, PV pumps, solar home systems, and hybrid PV-wind systems have been installed in multiples sites in Chile, primarily to supply schools.

Since its beginning the institute has grown 300% and in just last year grew by 30%. Among the securities of the company are the long term contracts up to 3 years and cooperation contracts with the DLR (Deutsches Zentrum für Luft- und Raumfahrt).

www.sij.fh-aachen.de
info@sij.fh-aachen.de
+49(0) 2461 99 3532
Heinrich-Mußmann-Straße 5 52428 Jülich
Germany

9.2.7 NOWUM -Energy

NOWUM-Energy works with energy related engineering projects that are typically too small for other institutions and companies to work on themselves.
NOWUM is an institute from the FH-Aachen created in 1997. It started as a project in the university and was encouraged by the university itself to become an institute. Nowadays the institute has 19 employees working in diverse projects in relation to energy.
The projects mostly involve Micro-turbines, production of biogas fuel from biomass, Energy Efficiency and Emission Trading. Among these technologies NOWUM develops analysis and operational software and offers consulting.

What Makes NOWUM unique:
NOWUM is a leader in Europe with its Know-How and test facilities concerning Micro-Turbines. NOWUM's experience in Emission Trading started in the 1990s. Concerning Biomass, NOWUM is characterized by its specialty and knowledge in Biogas.
NOWUM works in projects and gives advices all over Germany meeting the demand of the small and medium size projects. NOWUM is a stable company since 2006, before that time it presented lot of growth since its creation. Contracts held presently by NOWUM come with guarantees for the next years.

www.nowum-energy.com
info@nowum-energy.com
+49(0) 241 6009 53020
Ginsterweg 1 52428 Jülich
Germany

9.2.8 VKA

VKA is an institute for internal combustion engine research and development.
VKA is an institute of RWTH Aachen Founded in 1898 as an institute of RWTH. Currently VKA has 200 employees working in all fields of internal combustion engines.
This encompasses everything about internal combustion engines including:

4. More efficient and cleaner combustion processes for traditional and alternative fuels optimized experimentally and in close concurrent cooperation with simulation tools.
5. Engine acoustics
6. Exhaust after treatment Both in the chemical or catalyst laboratory and directly at the engine test bench.
7. Engine design for production as well as the implementation of innovative solutions particularly to increase the number of variable components, such as a system for variable valve timing or variable compression ratio.
8. Hybrid propulsion taking into account the whole power train and fuel cell systems.
9. Electronics and controls for engines and vehicles.

What makes VKA unique:
Equipment

- 21 Engine Test Cells
- 1 Transient Test Cell
- 4 Transparent Engines for Optical Investigations
- Fuel Cell Test Bench
- Chassis Dynamometer in an environmentally controlled chamber for official emissions testing
- Synthesis Gas Catalytic Converter Test Cell

Facilities:

- Chemical Laboratory

- Measuring Techniques/Test Methods Lab
- Electronics Laboratory
- Photo Studio and Design Department
- IT Department
- Engine Workshop
- Machine Workshop

The work of the institute lies mainly in Germany, but also all around Europe. VKA has shown for that last years a growth of 10%. Being part of the university and having public funding and as well as projects in the range of 9 months, VKA has very good security to continue performing research and consulting in its specialty areas.

www.vka.rwth-aachen.de
office@vka.rwth-aachen.de
+49(0) 241 80 96 200
Schinkelstraße 8 D-52056 Aachen
Germany

9.2.9 Institut für Biologie I – RWTH Aachen

The Biology 1 Institute largely works with gene technology in plants to increase productivity, grow in harsh environments, require less or no fertilization, and make plants resistant to disease. The institute was founded shortly after the University's founding in 1871 and has been working in energy related biological topics since 1984. Their work is useful to the Energy Industry to increase biomass production by increasing growth rates, increasing arable land, reducing fertilization requirements, and eliminating certain diseases and pests for typical biomass plants. This is all in an effort to make biomass a more viable source of energy. More specifically, the institute is working on:

10. Increase CO2 absorption through gene technology to enhance photorespiration and therefore increase biomass production
11. Adapting plants to grow with salt water
12. Hydrogren storage in plants
13. Nitrogen fixation, reducing or eliminating the need for fertilizers
14. Viral and fungal resistance of plants

Of the topics that the Biology 1 Institute is working on, the most unique and outstanding area of expertise is that they were the first to demonstrate improved CO2 fixation by genetic improvement.

www.bio1.rwth-aachen.de
+49 (0) 241-8026633
Worringerweg 1 52061 Aachen
Germany

9.2.10 Forschungsgemeinschaft für Elektrische Anlagen und Stromwirtschaft e.V.

The Research Group for Power Systems and Electrical Utilities (FGH) is a non profit organization that acts as a research and development platform for its network of members and partners in the electrical utility and power industry. Many of these members include most of the electric power companies in Germany, but they also cooperate with university research institutes, such as those at RWTH Aachen University to further broaden their research activities. In 1921 FGH was formed to establish grid standards for the then developing German electrical grid. In 1999 a transfer of some of the duties of the group left Mannheim and became a second location in Aachen under the umbrella of the other research institutes at RWTH: this was finalized in 2002. Throughout its existence the group has been involved in energy regarding grid management and power electronics. Their main functions include:

- FGH Certification Office: is an accredited certification office according to DIN EN 45011 by TGA for the certification of medium voltage generation sources,
- FGH Test Systems GmbH: testing of medium and high voltage equipment. A major provider of Low-Voltage-Ride-Through (LVRT) mobile laboratories to test grid compliance of decentralized energy sources up to 8MW in power output. This testing mostly concerns wind power generation, but includes other dispersed power generation units such as photovoltaic plants and combined heat and power (CHP) plants.
- the standardization of grid requirements for generation facilities on a national and international level
- Grid calculation software including load flow and failure statistics for grid operators.
- High voltage testing of electrical insulation and isolation components and optimization of other industrial power electronics components
- Smart grid technology regarding communication standards for power substations including monitoring and control strategies.
- Seminars and training for grid managers and workers

Other subjects that FGH is involved in and special equipment they have:

- Smartwheels project and the development of a test bench for electromobility and battery systems
- A low voltage test grid in laboratory

- Access to AIF (the German Federation of Industrial Research Associations) funds for Small and Medium-sized Enterprises (SME)

FGH is unique in its position as a major research platform for the electrical utilities industry which relies on the studies, equipment, and certification work at FGH.

www.fgh-ma.de
Aachen: +49 (0) 241 997857-0
Roermonder Straße 199 52072 Aachen

Mannheim: +49 (0) 621 8047 - 100
Hallenweg 40 68219 Mannheim
Germany

9.3 Public Entities

9.3.1 Heerlen Municipality

The energy industry has been a primary focus for the city of Heerlen since coal mining began in the late 1800´s. The city had to accommodate the coal mining industry and its employees and ensure the safety of the miners and its citizens. The city has had to adapt to changes in the coal economy and encourage new industry as the coal mining ended. Today Heerlen has many programs targeting the energy industry including Employment Climate change Promotion of new energy, Tourism - Green metropolis, and the Mine-water project. The Mine-water project is the largest and most ambitious of these projects. It involves the founding of an n.V. company for new geothermal heating and energy from the old mines in the region. The goal is to utilize available energy and create 4000 new job positions for the year 2020, as well as meet the 20-20-20 climate change targets. The city of Heerlen has been consulted by other cities around the world such as German, Swedish, and Chinese municipalities that face the same problem of an old mining community, particularly with regard to the Minewater project.

The New Energy Incentive including the Solar Cluster, Energy Storage Cluster, and Geothermal Cluster which includes the Mine Water Project are unique features to the Heerlen Municipality. The municipality has a growing priority of public and political interest in energy. The popular demand for alternative energy solutions and more employment ensures programs involving the energy industry for the future years of the municipality focus.

www.heerlen.nl
gic@heerlen.nl
+31 (0) 45-5605050
Geleenstraat 25-27 Heerlen
The Netherlands

9.3.2 Hycologne e.V.

Initiated in 2004 in the chemical industry which is a major consumer of energy.
January 2007
HyCologne is a regional hydrogen and fuel cell cluster in the Rhine area around Cologne. They work to establish hydrogen as an energy carrier in and around Cologne. Within its members HyCologne organizes meetings to network organizations relevant to hydrogen as an energy carrier. They are involved in international fairs and events relevant to hydrogen and activities for public awareness for hydrogen technology. This includes developing hydrogen safety programs, general public education programs, and fire department training programs. HyCologne currently has 18 member organizations:
START Hürth GmbH – regional development and services for start-ups

1. Wirtschaftsförderung Rhein-Erft GmbH - *Agency for regional economic development*
2. Stadtwerke Hürth AöR – *public service provider for energy*
3. Stadt Köln
4. Stadtwerke Brühl GmbH
5. Praxair Deutschland GmbH – *manufacturer of industrial, process, and specialty gases*
6. Rhein-Erft-Kreis
7. Wasserstoff-Cluster im Rheinland
8. DLR - Deutsches Zentrum für Luft- und Raumfahrt
9. Elektrochemische Generatoren GmbH – *systems integrator for fuel cell systems*
10. TÜV Rheinland
11. Regionalverkehr Köln GmbH – *operator of a regional bus fleet of more than 600 vehicles*
12. Infraserv GmbH & Knapsack KG – *process development and engineering services*
13. Stadt Hürth
14. Fachhochschule Köln - Institut für Automatisierungstechnik
15. Southern Fuel Cell Coalition – *strategic partner of HyCologne*
16. EnergieAgentur.NRW – *strategic partner of HyCologne*
17. Hydrogen Bus Alliance – *strategic partner of HyCologne*

With these 15 members and 3 strategic partners HyCologne is working on networking among its members for relevant projects. They also help by raising capital and finding third party funding for projects. Current projects include:

- Development of a hydrogen infrastructure for hydrogen fueled buses and hydrogen fueling stations utilizing the waste hydrogen from the local chemical industry. The initial refueling station and 2 buses are planned to be operational in 2010
- Stationary Combined Heat and Power (CHP) fuel cell power plant units for energy production to utilize the hydrogen waste stream from the seven sodium chloride electrolyzing plants around Cologne
- Planned activities and projects
- mobile and portable fuel cell systems
- turbine- and powerplant technology
- hydrogen infrastructure and logistics
- H2 refueling and storing
- consulting services for public and private organizations

Hycologne is the only independent hydrogen cluster in Germany. It is an entrepreneur driven cluster that is “ground up”, meaning that private organizations networked among themselves to form HyCologne instead of being a state initiated venture and is neutral when consulting among its members. HyCologne is the 4th or 5th largest hydrogen network in Germany.

www.hycologne.de
+49 2233 406 123
Goldenbergstrasse 2, 50354 Hürth
Germany

9.3.3 CAR e.V.

C.A.R. is an automotive cluster organization that was formed initially as a response in 2001 to automotive organizations in the Aachen region looking for qualified employees and research and engineering services. C.A.R. currently provides organizing networking events including job recruiting fairs and helps networking of automotive research with benchmarking and orchestrating associated events and meetings. With regard to the energy industry C.A.R. is interested in addressing the problems of dwindling fossil fuel supplies and climate change issues. This has become an issue for those in the automotive industry by way of changing regulations and developing new solutions, and so C.A.R. works to network the industry with the politics to help make better policies and network industry with the research found in institutes and universities so that industry and the research institutes can more effectively communicate and help one another.

The automotive cluster C.A.R. was solely formed by industry demand as a private organization and is financed by membership fees: most other cluster organizations are organized by government and funded with subsidies, and are “top-down”, whereas C.A.R. was created “bottom-up”.

www.car-aachen.de
+49 (0) 241 963 3230
Dennewartstraße 25-27, 52068 Aachen
Germany

9.3.4 EnergieAgentur.NRW

EnergieAgentur.NRW is an energy public services organization designed to offer a platform for strategic alliances among energy organizations within the region. EnergieAgentur.NRW has a network of companies, universities, and research institutes to assist in forming co-operations and alliances in order to speed up the process of getting innovative new products on the market. In 1990 Energieagenture NRW was a climate initiative. In 1996 with political party changes there became a NRW State Initiative on Future Energies which was then merged with Energieagenture NRW in 2007 to form EnergieAgenture.NRW. The network with EnergieAgentur.NRW consists of 8 sub-networks which are on the following subjects:

15. Innovative Power Plants
16. Biomass
17. Fuels and Drive Systems of the Future
18. Photovoltaics
19. Geothermal
20. Energ-Efficient and Solar Construction
21. Fuel Cells and Hydrogen
22. Wind Energy

The engineers in EnergieArgentur.NRW provide initial consultancy for organizations regarding energy savings and will do an initial energy audit to find heat losses in buildings and find economical ways to reduce energy costs.
They also organize training seminars for a variety of stakeholders in energy: continuous training institutions, energy supply utilities, federations, institutions of higher education, local authorities and companies in NRW. To the general public they offer campaigns for public awareness. In the past they offered campaigns such as “Wood Pellets Action” and “NRW Heat Pump Marketplace” to teach people about home heating alternatives. These campaigns were carried out by way of brochures, radio broadcasts, internet portals, and market guides to make it as accessible to the public as possible.

NRW is energy region #1 in Germany and has a very highly motivated energy industry in which EnergieAgentur.NRW has a unique cluster management to other energy clusters in Europe.

www.energieagentur.nrw.de
+49 (0) 211-866420
Haroldstr. 4, 40213 Düsseldorf
Germany

9.3.5 Industrie- und Handelskammer Aachen (IHK)

IHK is the Chamber of Industry and Commerce which acts as a registry for the Düren, Aachen, Heinsberg, and Euskirchen Districts in Germany surrounding Aachen. They have over 60,000 companies registered in these four districts, with as many as 300 of them being involved in energy related themes. Since 1990 IHK has become very active in energy themes, but has been an observer since its inception in 1804 of energy activities since the beginning of energy business in the region. While the IHK is looking for overall regional development to promote successful businesses, they recognize the importance of the energy industry and the significant amount of energy related companies in the region. They act as a lobbyist for their registered companies to properly represent their needs to politicians, but also to help create transparency of activities in Energy and network projects within the 4 district region. With this networking of projects they not only help find investors for projects but also lobby for public money. One recent development of IHK to help create transparency of activities and network projects is a new website dedicated to energy.

www.energieregion-aachen.de is a website IHK developed to highlight the projects, events, and activities on climate and energy efficiency in the region.

IHK is unique in the region due to its access to the whole spectrum of companies within their jurisdiction and is the only organization able to do so.

www.aachen.ihk.de
www.energieregion-aachen.de
+49 241 4460-0
Theaterstraße 6-10, 52062 Aachen
Germany

9.3.6 Aachener Stiftung Kathy Beys

Aachener Stiftung Kathy Beys promotes the dematerialization of society through the writing and distribution of publications, holding of forums and public events, and being involved in local public projects to educate society on how it can reduce its impact on the environment and reduce its material usage. Since its inception in 1988 the foundation has been involved in projects on sustainable development and climate change within the energy industry. Relating to the energy industry are its activities concerning sustainable development and climate change. One example of this is the Inden project which concerns the utilization of the open cast brown coal mines in Nord-Rhein-Westfallia. The Aachen Foundation is working with policy makers and the social planners to help develop a plan to reutilize this depleted mine in a beneficial and environmentally responsible way. There are other projects the foundation is involved with on the local, regional, and national level concerning sustainable development and climate change.

Aachener Striftung Kathy Beys is one of few other German foundations work in this area.

www.aachener-stfitung.de
+49-241-40929-0
Schmiedstr.3, 52062 Aachen
Germany

9.3.7 Stadt Aachen

Aachen is very old city, with its municipality set up around the year 800 by Charlemagne. Centered in a very old coal region, the city of Aachen has been developing policy for a society that has always had industrial needs and has seen many industrial shifts. The Technical University Aachen RWTH is a leading technical university in Europe and has made Aachen a hub for research, innovation, and technology. Due to the pioneering nature of its inhabiting institutions, businesses, and people the city of Aachen has had to be innovative in its policies and work to create and maintain a good environment for continued innovation, new businesses, and attracting students and young professionals to stay in Aachen.

In the last 20-30 years energy has become a more important topic for the municipality with the climate discussion in Europe and the subject of renewables and energy efficiency became important issues. With the current political atmosphere regarding sustainable energy supply and climate change, Aachen is working to keep their city ahead of the energy goals of the EU and Germany. They work extensively to help the city meet the 20/20/20 goals of the EU and meet ever increasing emissions regulations.

To keep Aachen attractive to the energy industry they have been pioneers in new energy policy. The city had the first solar subsidy program in Germany in 1996 in a project called “1000 Roofs” to get photovoltaic units on the roofs of 1000 houses in Aachen. Aachen also worked to get some of the first wind parks in Germany installed on the outskirts of the city. When other cities in Germany sold their electrical grid infrastructures to large power companies such as RWE, the city of Aachen kept their own electrical grid so as to maintain a more flexible and innovative grid. This allows them to choose whom they purchase electrical power from and implement smart grid technology to manage a growing number of smaller power sources within Aachen.

More recently Aachen has been working to find financing in energy efficiency to help fund, for example, new and more efficient heating systems in homes. Aachen has incentives for a variety of consumers and offers up to 30% subsidy with access to low interest credit for the rest of the investment. Aachen has performed their own energy audit for the whole city, and is therefore aware of the consumption of energy throughout the city and has used this information to know which energy uses are more effective to address. For instance, they know that 65% of the city’s energy is devoted to heating, and so more efficient heating in the city is a primary concern.

Aachen uses the waste heat from the lignite power plant in Eschweiler to heat much of the center of the city to help address the heating needs of the city.

To address transportation needs in a clean and innovative way the city is working to implement an electric bicycle program with infrastructure for 1000 electrical bicycles for the inner city with RWTH. E-mobility is another concern for Aachen, and is investigating options for energy efficient and environmentally friendly ways for people to get around the city.

Aachen is unique in its pioneering of new energy policies and subsidies, having been the first in Germany to do so. Aachen is uniquely situated to address energy issues with one of the best technical universities in Europe within the city, and utilizes this think tank to devise innovative and sustainable energy solutions for Aachen. With RWTH Aachen has an attitude of innovation and research which is a very unique feature that the city of Aachen is utilizing.

www.aachen.de
+49 (0) 241 / 432-7610
Aureliusstraße 2, 52062 Aachen
Germany

9.3.8 Limburg Development Company LIOF

After closing of the coal mines in 1974 the region European funds in the Netherlands were used to initiate new industry in place of the closed coal industry

LIOF is a regional development company working for the Chamber of Commerce in Limberg to investigate international competition and create and execute investment strategies to develop a value chain for sustainable business in the region. They have a large knowledge base on subsidies in other countries which local businesses must compete with and find value chains which are locally feasible and profitable, and therefore worth investing in. LIOF then helps direct investors, both public and private, to the right channels to help start new businesses and projects that also promote growth and development of the region. LIOF has access to funds for investment in four key areas:

23. Venture Capitalist – access to 45 million euro in venture capital
24. Innovation and Development – access to 20 million euro innovation fund in Limberg province
25. Business & Industrial Estates
26. Inward business developments – LPC housing for start ups (like AGIT)

There are seven major subjects that LIOF has identified as particularly valuable and strong within the region:

27. Agro-food
28. Contact Centers
29. High Tech Systems
30. Life Sciences
31. Logistics
32. Performance Materials
33. Renewable Energy

In the area of Renewable Energy LIOF has a great deal of experience with photovoltaic value chains: from silicon production to wafer production to module production LIOF has helped with the establishing and investment in PV companies. They have worked with the AVANTIS Science and Business Park and companies within it, such as Solland Solar which is manufacturing PV cells in the AVANTIS Park. They have also worked with DSM, a local coal and chemical processing company, in themes such as CO2 capture and storage in abandoned coal mines, waste heat to electrical production, and industrial hydrogen production and utilization, just to name a few. LIOF is constantly trying to network innovative ideas with the means to realize them in the sustainable energy theme.

The network that LIOF has developed is filled with world leading competence in sustainable energy, as well as in the other subjects LIOF has identified in the Limberg region.

www.liof.com
Boschstraat 76, 6201 BH Maastricht
Netherlands

9.3.9 Stichting Voortgezet Onderwijs Parkstad Limburg (SVOPL)

The SVOPL was initially involved in tailoring education to the agriculture and coal mining that was the dominant industry in the region when it was formed in 1920. So related to educating people in the coal industry, SVOPL has been in the energy industry since its inception. In the last 3-4 years they have become heavily focused on sustainable energy and related projects.

SVOPL is a foundation of educational program developers and teachers for secondary education. It is their goal with education to stimulate the sciences and social aspects of sustainable energy. Regarding energy they have projects with their school facilities to analyze the building for energy efficiency and raise the student's awareness to sustainability issues. They are also working with the Hogeschool nearby to reduce their energy costs. Within the SVOPL's school they have 65% of their students have a technical studies profile which has been developed to prepare them for technical studies after secondary school.

Giving students in secondary education a solid grounding in sustainable energy and its technical and social aspects is very important to the energy industry with regard to creating general awareness, but also preparing students for work in energy related fields.

www.svopl.nl
+31 (0) 45-5712597
Akerstraat 85-87, 6417 BK Heerlen
The Netherlands

9.3.10 Gemeente Houthalen

Since the coal mining started in 1901 the municipality of Houthalen has been involved in providing public services catering to a coal centered economy. After the closure of the coalmine in 1968, the reconversion greatly depended on the growth of the waste management sector.

The Houthalen-Helchteren municipality has a great deal of interest in the energy industry due to the nature of the industry in Houthalen-Helchteren. As the first municipality in the Limburg region to close the local coalmine, it quickly became a waste dumping site for all of Belgium. From the transportation and processing of this waste, a certain amount of business sprung up in the otherwise dying coal mining town. It pioneering methods of waste management and recycling. Four hundred companies started up in the region making money on innovative ways of disposing of the waste or recycling it. A waste incineration plant was built to process combustible waste, and within the last 8 years a 20MW power plant was started that utilizes biogas emitted from a 250 ha big dump site. Companies also sprang up that were utilizing the waste material that could be recycled into useful products.
The municipality's role in this has been trying to manage policy that keeps pollution levels low enough to keep the population safe and happy, but still encourage the economic growth due to the "wealth" of waste.
More recently in Houthalen-Helchteren is under development a new project of 'Enhanced Landfill Mining' called "Closing the Circle", which implies that waste can be turned into new products again so that the old dumpsite can be reused completely. Waste would either be recycled into new usable materials or incinerated for energy production in new plasma techniques. This project aims to utilize all of the waste in the 250 hectares of waste sites in the region and reclaim the land for use as nature parks in the future.
The municipality is also promotes waste heat from agricultural and industrial sources in the heating for a tourist park and other public buildings.
They are currently renovating an old coal mining industrial site for a Cleantech Campus: incubator and visitor centre for the green economy.

The Closing the Circle project is unique in being the first of its kind in the world to convert old waste sites into new materials and energy. The Houthalen-Helchteren region pioneered this concept since the 1970's and has a great deal of competence in waste management for energy production and recycled materials processing.

www. houthalen-helchteren.be
+ 32 11 600 511
Grote Baan 112, 3530 Houthalen-Helchteren
Belgium

9.3.11 Kamer van Koophandel Limberg

.

Kamer van Koophandel Limburg, or the Limburg Chamber of Commerse, has been monitoring and promoting regional development in Limburg for 150 years. They have been an observer of the energy industry starting in Limburg in the form of coal industry and the reforming of the energy industry after the coal mines closed in the 1960's. Within the last 10 years there has been a significant increase in sustainable energy businesses and related projects in Limburg which KvK has been involved with to contribute to the regional development of Limburg. The Limburg Chamber of Commerce has three main obligations:

34. The first main task of the Chamber of Commerce is to implement economic legislation, including the Trade Register Act and the Establishment of Businesses Act. These laws have been introduced to enable businesses to benefit from reliable information recorded by an impartial organization. Currently the Chamber has about 60,000 organizations registered in Limburg.
35. Information is the second main task of the Chamber of Commerce. The Chamber gives general and specific information to all entrepreneurs and existing businesses operating in the Netherlands. The core package of information services is grouped into five specializations, namely:

    - Starting entrepreneurs
    - Growing companies
    - Import and export
    - Company termination and transfer
    - Legislation and Regulations

36. The Chamber's third main task is to stimulate the regional economy. They do this by undertaking initiatives to inform entrepreneurs and member organizations of what it takes to be successful in the Limburg region. This includes market analysis, educational programs, and connecting similar organizations with each other.

In regard to energy, the Chamber is involved in a number of projects which aim at promoting sustainable and energy efficient practices. Their largest project like this is "Save and Earn", a project which promotes energy savings with organizing energy audits for companies and subsidies for energy bills. Other projects are the "Cradle-to-Cradle" project which concerns sustainable materials reuse, waste heat utilization projects with DSM, and other smaller sustainability projects.

The Limburg Chamber of Commerce is unique to the Netherlands in being the largest former coal region of the Netherlands and saw a whole change of the energy industry from local coal to other sources and the change in what businesses were successful in a post energy-rich region. The Chamber is unique in that the region they oversee has been the first European coal region to have to adapt to new businesses in the wake of resource depletion.

www.kvk.nl
+31 (0)88 9876 200
info@limburg.kvk.nl
Pierre de Coubertinweg 5, 6225 XT, Maastricht
The Netherlands

9.4 Educational Institutes

9.4.1 Open Universiteit Nederland

The Open Universiteit Nederland (further on named Open Universiteit) enrolled its first students in September 1984. The University is an independent government-funded institute for distance learning at university level with 750 full time employees.
The Dutch government's purpose in founding the Dutch Open Universiteit was to make higher education accessible to anyone with the necessary aptitudes and interests, regardless of formal qualifications.
The University has six Bachelor and ten Master accredited programs in seven different disciplines: Humanities, Management Science, Environmental and Natural Sciences, Psychology, Law, Education and Information Science. In addition, students can also choose from approximately three hundred academic courses and sixteen short programs, three programs at a professional or graduate level, and one MBA program. The University also offers businesses tailor-made programs and in-company courses. Recently the University extended its catalogue by adding Open Educational Resources, i.e. free Internet-based courses.
Involvement in the energy sector:

- Environmental science program which discusses energy focus policy and health including water management.
- Energy Analysis course in collaboration with ECOFYS via e-learning (120 students).
- Sustainable Business course in collaboration with Avantis.

What makes the Open Universiteit Nederland unique:

- Interdisciplinary approach
- Academic Methodology that involves dialog between experts and society by surveying public interests to help scientists understand societies needs. This is used to more effectively influence public view in the application and policy of science and new technology.
- Open distance learning to students worldwide regardless of qualifications.
- New Green Campus with the focus on sustainable energy management under construction, in tandem with University research on environmental impact of educational systems and sustainable renewable energy technologies

specializing in solar but including wind, biomass, and geothermal (in collaboration with the Heerlen Mine Water project).

The University has enrollment of students from all around the world. The majority of the students come from the region. The University has shown growth of 2% during the past few years. Its concept of e-learning and sustainable topics are strengths that insure that the university remains valuable and competitive in the education industry.

www.ou.nl
communicatie@ou.nl
+31(0) 455 762 888
Valkenburgerweg 177 6419 AT Heerlen
The Netherlands

9.4.2 RWTH Aachen

RWTH is a technical university offering bachelor, master, and PhD degrees in a wide variety of scientific subjects. It was founded in 1870 and has 7200 employees.
RWTH's educational goal in the sciences is based on Humbolt's principal of "learn by doing", and so they focus applied learning in laboratories and close connections with industry.

There are nine Faculties within the University:

1. Faculty of Mathematics, Computer Sciences, and Natural Sciences
2. Faculty of Architecture
3. Faculty of Civil Engineering
4. Faculty of Mechanical Engineering
5. Faculty of Geo-resources and Materials Engineering
6. Faculty of Electrical Engineering and Information Technology
7. Faculty of Arts and Humanities
8. Faculty of Business and Economics
9. Faculty of Medicine

Within these faculties there are 260 Institutes, 66 of which are involved with energy related research. Four of these institutes are members within Energy Hills and have their own entries in this Appendix. The other 62 institutes have descriptions of their activities in the Energy Industry in the following Appendix.

What makes RWTH Aachen unique:

- RWTH Aachen University is the largest university of technology in Germany and one of the most renowned technical universities in Europe, being one of the nine Excellence Universities of Germany.
- Leaders in automotive, mechanical, and material science fields.
- Most third party funding from industry of any university in Germany
- Aachen's unique location in the "Euregio" border region is apt to enhance and accelerate research activities and technology transfer between Germany, the neighboring states of Belgium and the Netherlands and Europe at large.
- Special law which allows professors to form a company institute (un-institute) still connected to the University, but working on private projects earning money was pioneered at RWTH, and remains a source of competence for the

University by keeping successful professors at the university while also exposing the university to cutting edge work in industry.

- RWTH is part of the Idea League Network which includes such universities as Imperial College, Delft, Zurich, and Paris Tech. Not only are students at RWTH able to cross register with them, but this Idea League Network has a lot of influence on EU policy, and one of the core areas of influence is sustainable energy.

- An institute of RWTH runs the Frauenhofer Institute, which is an EU-wide federal institute doing research in almost all areas of science.

RWTH has grown in the number of employees and in number of students, including 100 more professor shifts. By being a large public university makes RWTH very secure as seen in the last 140 years.

www.rwth-aachen.de
+49(0) 241 80 94023 / 94566
Templergraben 55 52062 Aachen
Germany

9.4.3 Hogeschool Zuyd

Hogeschool Zuyd is a university of applied sciences that has existed in its present form since 2000, but has existed previously within the educational institutes of the Heerlen region. With approximately 40 bachelor and 10 master programs, 13,200 students and 1,550 staff, Zuyd University is one of the largest universities of applied sciences in the Netherlands. Students can choose from both Bachelor's and Master's degrees in the field of:

- Economics, Languages and Communication
- Behaviour and Society
- Health Care
- Fine Arts, Music and Drama
- Education
- Technology and Engineering

Regarding energy, Hogeschool Zuyd bundles all of their relevant fields of study into a group initiated in 2007 called the Center of Research New Energy. They combine themes of life sciences, technology and engineering, economics, and management into their energy research in an effort to make the energy technologies practical and economical. There are four groups in the Center, with a variety of topics within each:

1. New energy in the built environment
    - The District of Tomorrow at Avantis
2. Solar Energy
    - PV systems and Solar Cell Technology
3. Future Power Systems
    - E-traction, electric vehicles, storage systems, hydrogen research, distributed energy/smart grids
4. Energy Management
    - Power (Industrial Engineering Learning Company)
    - Energy conservation within the HSZ)
    - Planning (decentralized, hybrid, Ontario is planning pilot in European energy project)
    - Strategic decision models and business plans

The Hogeschool Zuyd is the #1 technical school in the Netherlands. They are leading in their work with transitions between technology, application, and business models, and their connection with other universities like Technical University Eindhoven

(most notably the world leading organic solar cells they collaborate on testing with TUE)

www.hszuyd.nl/nieuweenergie
+31 45 400 6275
Nieuw Eyckholt 300 6400 AN Heerlen
Netherlands

9.4.4 Continium Discovery Center

In 1995 the organization was started as Industrion which was a coal mining museum that opened to the public in 1998. In 2003 it was changed to a Discovery Center to include more energy related themes than simply the coal mining that had existed in the region for the past 100 years.

Continium Discovery Center is an educational organization that has a facility that they use to educate on different aspects of life and society. They have five areas that they shape their exhibits, displays, teaching, and forums around:

Live and Work – exhibits on efficiency in daily life and sustainable housing. This includes the geothermal heating for the Center's building displayed to show how it works and a house exhibit game illustrating how much power is used in a home and how to save energy.
Me & Body – life sciences
Eat & Drink – food science and agriculture
I Invent – solving problems
I Produce – sustainability in manufacturing

The Discovery Center also has an exhibit on solar energy and what factors affect solar energy potential. The Discovery Center also uses its connections with regional industry and research to hold educational forums for the public, school workshops for children, and even uses their access to the public to find volunteers for large sampling test surveys on different products from industry. The Discovery Center receives 90,000-100,000 visitors per year with 30,000 of them students, and of those students, 8,000 come from Germany.

The Discovery Center is not merely a science museum, but a facility to educate the public on issues facing society with regard to the science and technology available to help with these issues. The Discovery Center is a unique platform for the energy industry to educate the public about energy solutions for society, especially with as many as 100,000 people visiting the center per year. The Discovery Center's closeness to industry is another outstanding feature: industry and its associated research institutes can exhibit and explain new and cutting edge technologies to a large cross-section of the population.

www.continium.nl
+31 (0) 455676021
Museumplein 2 6461 MA Kerkrade
The Netherlands

9.4.5 Technische Universiteit Eindhoven - Faculteit Electrical Engineering

Capacity groups: Electrical Power Systems, Control Systems, and Electromechanics and Power Electronics

Technical University Eindhoven (TUE) is a university committed to using their research results to make successful innovations. In 1956 the University was founded to boost the economy in the south east Netherlands. As of 2007, enrollment at the university was 6927 students with an increasing number of international students. There are eight departments at TUE offering Bachelor and Master programs and conducting research within their eight fields of study:

- Applied Physics

37. Architecture, Building, and Planning
38. Biomedical Engineering
39. Chemical Engineering and Chemistry
40. Electrical Engineering
41. Industrial Design
42. Mathematics and Computer Science
43. Technology Management

Since its inception the electrical engineering department has been involved in energy related topics. Regarding energy, TUE has a Master's program in Sustainable Energy Technology which utilizes the Mechanical Engineering, Electrical Engineering, and Technology Management departments to educate students on the latest developments in Sustainable Energy Technology and the opportunities and limitations of the application of these technologies. This program, among others at TUE, is part of the 3TU Federation with Delft University of Technology and the University of Twente to collaborate in research, education, and technology transfer.

Furthermore the normal master on Electrical Engineering has many energy related topics and thesis variants.
There are many subjects with the Electrical Engineering department that are directly involved with energy, most notably the Electrical Power Systems group and the Control Systems group. Also the Electromechanics and Power Electronics group is of interest. Key energy research areas:

- Electrical grid management, optimization and control technologies

- Plasma technology in plasma physics, pulsed power technology, and chemical process technology for high power switching and grid control, as well as tar removal from biogas and syngas.
- Automotive energy management and guided vehicles
- Automated machinery controls, including pick-and-place machines

Among these departments the Electrical Engineering department has formed a strategic research area in Smart and Sustainable Energy which encompasses the following projects and facilities:

- 400m^2 facility for power quality for integrating renewable sources to test smartgrid concepts and control strategies
- 1200m^2 laboratory for post power processing
- Integrated Circuit Board production facilities
- Innovative research projects with the Dutch IOP EMVT (around 10-15)
- Government funded energy research projects regarding power quality, grid design and price based power system control
- Power electronic energy management of a small electricity generation system based on biomass and fuel cells

Within the EU, TUE has achieved the third best science citation impact score overall, after Cambridge and Oxford. TUE's work in electrical grid control and management is very extensive and highly appreciated, especially within the close collaboration with industrial partners.

University: http://w3.tue.nl/en/
Electrical Engineering: http://w3.ele.tue.nl/en/
+31 (0) 40-2474442
P.O. Box 513, Building Corona 1.17 5600 MB Eindhoven
The Netherlands

9.4.6 Katholieke Hogeschool Limburg – KHLim

KHLim
www.khlim.be

Katholieke Hogeschool Limberg (KHLim) is a university of professional education geared towards practical training of students. They are part of University Association Catholic University Leuven, a larger network of similar universities in Belgium. The first institute that later became part of the founding of KHLim in 1995 was a teacher training and education institute which was founded in 1920. In 1954, in the university proceeding KHLim, an engineering institute was founded and offered degrees in Chemistry, Electromechanics, Manufacturing, and Automation which did support local energy industry in some capacity. In 1978 there became a greater energy focus in the engineering programs. All of these institutes, as well as other institutes in the Limburg area, were combined in 1995 to form the present day KHLim. The subjects currently addressed at KHLim are:

44. Industrial Science and Technology
45. Education
46. Economic Science and Business
47. Health
48. Social Work
49. Media and Design Academy

The Industrial Science and Technology department is the most relevant to the Energy Industry with a variety of engineering and technology based subjects. They offer the following types of degrees or certifications within the Industrial Science and Technology department:

i. Professional Bachelors
   1. Biomedical Laboratory Technology
   2. Chemistry
   3. Electro-Mechanics
   4. Electronics - ICT
   5. Electrical
   6. Environmental

ii. Academic Bachelors
   1. Science in Industrial Chemistry
   2. Industrial Science in Electro Mechanics
   3. Industrial Science in Electronics-ICT

iii. Masters
   1. Automation
   2. Biochemistry
   3. Chemistry
   4. Electro-Mechanics
   5. Electronics – ICT
   6. Electrical Engineering

iv. Continuing Education

1. Certificate of proficiency in the cooling
2. Profibus - diagnosis
3. Siemens S7-Service
4. (Cooling Techniques) Cooling Mechanic - Refrigeration Mechanic Experience Proof
5. Supplement Coordinator for prevention consultants
6. Analytical Troubleshooting
7. Basic Electricity
8. Basic Electricity 2
9. Basic Ergonomics
10. Knots in the building energy regulation from 2010
11. Clean Mobility: Renewable energy secures the future
12. Cover-it: active maintenance technicians!
13. Crossroads
14. Inverters
15. Industrial Ethernet
16. Info Session Cover-it
17. Cool Techniques - brazing (Brazing)
18. Refrigerant Cooling Techniques Acts
19. Cooling Techniques for troubleshooting cooling
20. Cooling Techniques Basic
21. Cooling Techniques Blended learning process refrigeration technician
22. Cooling Techniques Refresh
23. Cooling Techniques: distance learning heating, cooling and climatization
24. Management School
25. Oxidation Technology Networking Event
26. Production of versatile products, plastic
27. Profibus - basic
28. Profibus PA
29. PROFINET
30. PROFIsafe
31. Project work
32. Siemens 300F
33. Siemens S7 Sys1/prac1
34. Siemens S7 Sys2/prac2
35. Siemens S7 Sys3/prac3
36. SMED
37. Improve Study Methods
38. TIG Welding
39. Safe working with electricity BA4
40. Safe working with electricity BA5
41. A Safety Coordinator for temporary or mobile construction sites
42. Security Studies - Level 1 prevention
43. Hydrogen Flemish Region - South Netherlands
44. Win CC Flex

v. Bridging Programs
   1. Linking to Prof. Ba. Master (IWT)

vi. Postgraduate
   1. Energy Coordinator: FULL
   2. Postgraduate Intelligent New Energy Technologies
   3. Additional Specific Safety Training Coordinator A Level

Regarding Energy related research KHLim has consolidated all of its sustainable energy research into one network entitled “I-NET Research Group”. This group involved in a variety of subjects, namely:

- Microgrid design and control
- Hydrogen and Fuel Cells
- Solar (photovoltaics)
- Wind

- Absorption cooling – including a certified cooling laboratory
- CO2 cooling and storage

KHLim has constructed their own micro-grid test unit with multiple sustainable energy sources to target solutions for households and small companies and organizations. This test stand for smart grid technology also addresses the problem of producing heat and cooling to customers, as well as providing an overall electrical grid.

KHLim is pioneering the connection between high schools and universities by developing stronger connections with both institutions. The projects in conjunction with Hogeschool Zuyd in the Netherlands, the EON research center in RWTH, and other educational institutions is unique in Belgium.

www.khlim.be
+32 (0) 11 23 07 70
Agoralaan gebouw 5B1 3590 Diepenbeek
Belgium

9.4.7 Arcus College Heerlen, Unit Technieke

Arcus College is a vocational education and training institution offering professional education for students starting at 16 years old to help them develop skills needed in the workforce and increase their value in the labor market. The technical school was formed in 1999, but has existed and been involved in the energy industry since 1913 when its proceeding institute was founded to train people for the coal industry, namely DSM, a large local coal company. This included the electrical, mechanical, and process technical training that the coal industry needed in new employees. They added other themes in energy in the 1970's with the closing of the coal mines such as electrical grid and other chemical industry subjects. Arcus College is part of a network of 71 educational institutes comprising 625,000 students across the Netherlands, 475,000 of which are in vocational schools like Arcus College.

Arcus College has programs that can be full time student oriented or in a work and study arrangement so that people can still work and take courses. They offer a variety of programs to students within five units:

50. Administration and Commerce (Business and Management)
51. Health, Welfare, and Services
52. Entertainment and Tourism (Art, Theatre, and Media)
53. Technical
54. Education

The technical unit is the most relevant to the energy industry, as it was this unit that was formed in part by the coal industry in the 1900's. Currently there are 2000 students enrolled in the technical unit. They offer programs in three different levels in the following topics:

- Protection and Finishing of Materials
- Architecture
- Automotive Body Repair
- Electrical Engineering
- Building Engineering/Technology of Infrastructure
- Woodworking and Furnishings
- Installation of new chemical plants
- Metal / Mechanical Engineering
- Automotive Engineering

- Process Engineering
- Transport and Logistics

They have an energy track to the Electrical and Mechanical Engineering programs that discuss power production and topics like solar, wind, and coal power. They have extensive energy efficiency training in the Insulation program, and also discuss energy efficiency in their Architecture and Building program. They also have an automotive repair shop and an electric car which they use to attract students to technical studies.

The most relevant task for Arcus College to the Energy Industry, both overall and in the Technical Unit, is to motivate young students to pursue careers in local industry. To meet this end Arcus College collaborates as much as possible with local industry in form of field trips, contacts with industry to find jobs for graduates, and develops their curriculums with knowledge from industry.

The College's contact with local industry and the fact that 40% of the Dutch population has taken vocational courses in the Dutch system that Arcus College is part of make it a very large platform for education.

www.arcuscollege.nl
+31-45-5606700
Benzenraderweg 1 6400 AC Heerlen
Netherlands

10 Appendix 5: Institutes in RWTH Aachen Involved in Energy-Related Topics

There are 66 institutes within Aachen University of Applied Sciences that are actively doing research or work in energy related fields

1. **EON Energy Research Center** (Energy Hills member: see their full entry)
   a. Applied Geophysics and Geothermal Energy (GGE)
   b. Automation of Complex Power Systems
   c. Power Generation and Storage Systems (PGS)
   d. Energy Efficient Buildings and Indoor Climate (EBC)
   e. Future Consumer Energy Needs and Behavior (FCN)
2. **Lehstuhl für Verbrennungskraftmaschinen (VKA)** (Energy Hills member: see their full entry)
3. **Institut für Biologie 1** (Energy Hills member: see their full entry)
4. **Forschungsgemeinschaft für Elektrische Anlagen und Stromwirtschaft e.V. (FGH)** (Energy Hills member: see their full entry)
5. **Lehrstuhl für Festkörper und Quantenchemie und Institut für Anorganische Chemie (Department of solid state and quantum chemistry and the institute of inorganic chemistry):**
   a. Theoretical electron total energy calculations and atomistic simulations for materials and processes important energy technology.
   b. Superconductor gas separation membranes
6. **Lehrstuhl für Molekulare Biotechnologie (Department of Molecular Biotechnology):**
   a. working with Fraunhofer IME on biotechnology in plants for biofuel production
7. **Institut für Biologie 1 – Spezielle Botanik (Special Botany):**
   a. Vegetable oils as renewable energy, biofuels
8. **Lehrstuhl für Technische Chemie und heterogene Katalyse und Institute für Brennstoffchemie und physikalische chemische Verfahrenstechnik (Institute of Chemical Technology and Heterogeneous Catalysis and Institutes of fuel chemistry and physical/chemical engineering):**
   a. Developing tribosystems in mechanical engineering for more efficient machines – bearing and lubrication technology.
9. **Lehrstuhl für Physikalische Chemie 1 (Department of Physical Chemistry 1):**
   a. Basic research on properties and long-term stability of functional materials for energy conversion processes such as high-temperature

fuel cells and oxygen permeation membranes for OXYCOAL processes (CO2 capture)

10. **Institut für Anorganische Chemie (Institute of Inorganic Chemistry):**
    a. Organometallic chemistry for the development of new catalysts and materials for hydrogen storage.
11. **Fraunhofer Institut für Molekularbiologie und Angewandte Oekologie (Fraunhofer Institute for Molecular Biology and Applied Ecology):**
    a. Metabolic Pathway Engineering: new plant transformation methods, nano-biotechnology, and biotic and abiotic stress resistance in plants.
12. **Institut für Umweltforschung (Biology V) (Institute for Environmental Research):**
    a. Alternative sources of biomass for bioenergy
    b. Developing plants for the cleaning of polluted soils (pollutants, salination) and erosion protection (Phyoremediation)
13. **LuFG Informatik 4 – Verteile Systeme (Computer Science 4 – Distributed Systems):**
    a. Energy-efficient communication mechanisms, in particular for autonomous sensor-based systems in: environmental monitoring, medical surveillance, and energy custom applications like intelligent roads.
14. **Physikalisches Institut, Lehrstuhl für Physik neuer Materialien (Institute of Physics, Department of Physics of new materials):**
    a. Development of transparent electrodes for photovoltaics
    b. searching for alternatives to expensive ITO
    c. alternative organic and inorganic materials for photovoltaics
15. **Lehrstuhl für Baubetrieb und Gebäudetechnik (Department of Construction and Building):**
    a. Energy rating tables
    b. monitoring and operational optimization of buildings
    c. energy and plant concepts
    d. numerical building and plant simulation
    e. evaluation of climate change on the building's energy needs
16. **Institut für Wasserbau und Wasserwirtschaft (Institute for Hydraulic Engineering and Water Management):**
    a. Support the planning and assessment of hydropower (running of hydroelectric plants, dams, pumped storage) in energetic, hydraulic, and constructive context
    b. Investigation of special issues on the basis of mathematical, numerical, and physical models

c. Automatic optimization of hydraulic system parts, numerical modeling of flow processes, and safety and risk of hydraulic systems (including parts of hydroelectric plants)

17. Institut für Regelungstechnik (Institute of Automatic Control):

a. Modeling and Control of CO2-free oxyfuel power plant factory processes
b. solar tower power plant controls
c. regulatory processes in unstable combustion in combustion chambers(gas turbines) and engines(petrol, diesel)
d. minimization of fuel consumption in automobiles
e. optimization of cement production

18. Institut für Eisenhüttenkunde (Institute of Ferrous Metallurgy):

a. Materials for pipes to transport and store crude oil, gases, liquefied gases, etc.,
b. materials for power plant construction and the construction of internal combustion engines
c. High temperature corrosion
d. Metal Foam for turbine combustors

19. Lehrstuhl für Oberflächentechnik im Maschinenbau (Institute for Surface Engineering in Mechanical Engineering)

a. Thermal barrier coatings on turbine blades and combustion chamber layers measured correction of all components
b. Repair coatings by brazing
c. Corrosion and oxidation protective coatings for all components in the hot gas
d. Grazing and sealing surfaces of housing, blades, discs, and shafts Erosion protection layers on compressor blades
e. Titanium fire protective coatings in compressor housings
f. Tool coatings for the machining of high-alloy materials in the turbine (eg Ni-base alloys, TiAl, NiAl materials)

20. Institut für Dampf und Gasturbinen (Institute of Steam and Gas Turbines):

a. Steam and gas turbines
b. Power plant technology

21. Institute für Getriebetechnik und Maschinendynamik (Institutes of gear technology and machine dynamics):

a. Energy-efficient design of motion processing and packaging machines with facilities in lightweight and optimized motion presets
b. System components for energy-efficient internal combustion engines
c. Motion and automation equipment for exploration of primary energy sources (mining)
d. Energy-efficient machinery for the hollow glass industry

22. **Institut für Maschinenelemente und Maschinengestaltung (Institute for Machine Elements and Machine Design):**
    a. Wind Turbine Gears
23. **Lehrstuhl für Textilmaschinenbau und Institut für Textiltechnik (Department of Textile Engineering and Institute of Textile Technology)**:
    a. Materials for energy conversion and energy storage
    b. Increase energy efficiency in the production process
24. **Institut für Luft und Raumfahrt (Institute of Aeronautics and Astronautics):**
    a. Use of wind energy
    b. Reduce fuel demand from commercial aircraft by reducing the frictional resistance
    c. Reduce the fuel needed for transport aircraft, variable adaptation of the higher profile of the wing to the flight conditions (adaptive wing)
25. **Institut für Bildsame Formgebung (Institute of Metal Forming)**:
    a. Forming manufacturing components for large-scale power generation
    b. Ring rolling process for economic production of wind turbines required for bearing rings and rings made of super alloys (turbines)
    c. Setting the material properties of turbine runners and large crankshafts by process of interpretation of the free-form forging process (key for the know-how advantage)
    d. Semi-intelligent investigation for their applicability to the next generation of turbines, for example, for improved cooling thermally highly stressed parts
    e. Use of simulation programs developed at the IBF and experimental development on the trial, partly on a 1:1 scale
    f. Material characterization (input data for numerical simulation) in the material testing laboratory and experimental voting on the forming
26. **Werkzeugmaschinenlabor WZL, Lehrstuhl für Technologie der Fertigungsverfahren (Machine tools laboratory WZL, Department of Manufacturing Technology)**:
    a. New production technologies and process chains as an enabler for energy-efficient production, transport and storage:
        i. stationary turbines and aircraft turbines
        ii. Wind Energy
        iii. Solar Energy
        iv. Bio-Fuels
27. **Lehrstuhl für Wärme und Stoffübertragung (Department of Heat and Mass Transfer):**
    a. Coal combustion, atmospheric and pressurized with air and CO2
    b. Two-phase flow

c. Numerical Modeling
d. Motorized injection
e. Film currents
f. Contact heat transfer

28. Lehrstuhl für Technische Thermodynamik (Department of Technical Thermodynamics):

a. Predictive models of material data for renewable fuel
b. Spectroscopic measurements of mixture formation and combustion processes
c. Analysis and optimization of energy systems
d. Technology Review
e. CO2 allocation procedures
f. solar cooling
g. Adsorption heat pumps
h. Adsorption heat storage

29. Aachener Verfahrenstechnik Prozesstechnik (Process Engineering in Aachen):

a. Modeling and Simulation Engineering Process
b. Dynamic Process
c. Design of intensified chemical processes
d. Separation process design for multi-component mixtures in refinery processes
e. Model-based Experimental Analysis (SFB 540)

30. AVT- Mechanische Verfahrenstechnik (AVT-Mechanical Process):

a. Renewable Energy
b. Hydrogen Economy
c. Thermal Biomass Conversion
d. CO2 emission power plant technology
e. Process optimization

31. Lehrstuhl für Reaktorsicherheit und technik (Department of Nuclear Safety and Technology):

a. Security of radioactive waste
b. Material development and material characterization
c. Disposal relevant properties

32. Institut für Technische Verbrennung (Institute for Combustion Technology):

a. Modeling of combustion processes in engines and combustion chambers
b. Experimental investigations of turbulent mixing and combustion

33. AVT – Thermische Verfahrenstechnik (AVT - Thermal Process):

a. Materially procedural aspects of the production and conversion of energy (distillation, extraction, phase separation) with superimposed response:
    i. Biodiesel production, separation problems
    ii. Recycling of secondary components of bio-energy production
    iii. Establishment of local and global budgets, to assess the feasibility and evaluation of technology and energy scenarios (life cycle assessment) derivation of normative standards for Society and Politics
    iv. energy and material use of biomass

34. Lehrstuhl und Institut für Dampf und Gasturbinen RWTH; Lehr und Forschungsgebiet Solartechnik DLR („Jülicher Modell“) (Chair and Institute for steam and gas turbines, RWTH, teaching and research solar technology DLR (Jülich model "))

a. DLR leader in the field of Concentrating Solar Power (CSP) for the production of heat / cold, electricity, and fuels

35. Lehrstuhl für Lasertechnik der RWTH Aachen (LLT) und Fraunhofer Institut Lasertechnik (ILT) (Institute for Laser Technology at RWTH Aachen (LLT) and the Fraunhofer Institute of Laser Technology (ILT))

a. Application (Basic) research and development of laser-based manufacturing processes for parts and components from the energy sector such as:
    i. Generative Procedure: 3D laser beam welding (Laser Metal Deposition, LMD), Selective Laser Melting (SLM)
    ii. Thin film, pulsed laser deposition (PLD)
    iii. Drilling
    iv. Removal and Texturing
    v. Cutting and joining (macro and micro-cutting and welding)

36. Institut für Schweißtechnik und Fügetechnik (Institute of Welding and Joining Technology)

a. Complete technical joining expertise through joint utilization of resources of the ZAT the Forschungszentrum Jülich and the ISF RWTH Aachen University in Aachen-Jülich Alliance:
    i. Arc welding process
    ii. Resistance welding method
    iii. Laser and electron beam welding process
    iv. High temperature and arc soldering process
    v. Welding procedures
    vi. Friction and diffusion welding method
    vii. Micro Joining
    viii. Welding Modeling and Simulation

ix. Automation and robotics in welding technology
x. Bonding

37. Aerodynamisches Institut (Institute of Aerodynamics):

a. Basic research in fluid mechanics: focusing on the turbulence, which is on all energy issues, where there are fluid mechanical processes of vital interest

38. Lehrstuhl für Werkstoffe der Energietechnik (Institute for Materials in Energy Systems):

a. Materials Structure and Properties of Materials in Power Plant Technology
b. High temperature fuel cells and thermally highly stressed components of future fusion devices (Department employs up to 50% with the properties of materials used in power plant technology, to about 35% for high temperature fuel cell with material matters, the rest of the far future in materials research is directed to studies of materials for fusion technology .)

39. Lehrstuhl für Brennstoffzellen (FZ Jülich) (Department of Fuel Cells (FZ Jülich)):

a. Energy conversion technologies:
    i. Realization of high temperature and low temperature fuel cells
    ii. Autonomous energy systems with hydrogen as a storage
    iii. Stacks for stationary, portable or mobile applications
    iv. Complete systems with fuel cells
    v. Developments in the provision of appliances for the fuel gas

40. Institut für Kraftfahrwesen (Automotive Institute):

a. Energy efficiency of vehicles:
    i. Reduce fuel consumption through optimization of propulsion components and driving resistance to conventional vehicle propulsion
    ii. Development of unconventional powertrains to optimize consumption (eg hybrid)
    iii. Further measures to reduce CO2 emissions from vehicles such as through optimized energy management in the electrical system and traffic flow simulation and derivation of innovative traffic management strategies

41. Lehrstuhl und Institut für Eisenhüttenkunde (Chair and Institute of Ferrous Metallurgy):

a. Energy conservation in the iron and steel production
b. Research in the areas of CO2 emissions and particulate matter emissions

42. **Institut für Bergwerks und Hüttenmaschinenkunde (Institute of Mining and Metallurgical Machinery):**
    a. Calculation and monitoring of machines and equipment for the extraction and transportation of fossil fuels
    b. Development of new methods and systems for condition monitoring of large-scale
43. **Geißerei Institut:**
    a. Single-crystal turbine blades (material and process)
    b. High Temperature Materials (automotive and power plant)
    c. Hybrid components and graded materials
    d. Lightweight automotive construction
    e. Blades and turbocharger in TiAl
44. **Lehrstuhl für Applied Geophysics and Geothermal Energy:**
    a. Geothermal Energy: Measurement of thermal and hydraulic rock properties, development of numerical simulation programs for geothermal reservoir engineering, design calculations of geothermal systems for heat and electricity.
    b. CO2 storage in geological reservoirs: Measurement of thermal and hydraulic rock properties, development of numerical simulation programs for the suitability of reactive transport in the geologic CO2 storage reservoirs; simulations to conduct long-term underground storage of CO2 and farming and long-term safety of stored CO2
45. **Lehr und Forschungsgebiet Berg und Umweltrecht (Mining and Environmental Law Education and Research):**
    a. Aid, competition, emissions trading, investment authorization law
    b. Sustainable Development
46. **Lehrstuhl für Wirtschaftsgeographie (Department of Economic Geography):**
    a. Economic analysis of the dynamics of industrial development with respect to Renewable Energy
    b. Research projects on Economic Development, site structure of the photovoltaic industry in Germany
    c. Analysis and design of the systemic approach linking different actors in the energy sector, establishing cooperation based synergies
47. **Institut für Metallkunde und Metallphysik (Institute of Metallurgy and Metal Physics):**
    a. High temperature materials (eg for use in gas turbine)
48. **Lehr- und Forschungsgebiet Kokereiwesen, Brikettierung und Thermische Abfallbehandlung (Coking, Briquetting and Thermal Waste Treatment Education and Research)**
    a. Characterization of energy resources (oil, gas, coal, and biomass):

b. Combustion, pyrolysis and gasification of solid fuels
c. Agglomeration (in briquette, pellet, and built agglomeration forms)

49. Oel-Waerme Institut GmbH und Lehr und Forschungsgebiet Energie und Umweltprozesstechnik in der Materialtechnik (Oil Heat Institute Ltd. and Energy and Environment Process in Materials Technology Education and Research):

a. Research and development of combustion and gasification of liquid fossil and biogenic fuels regarding the budget, transport, and industry
b. Reforming of fuels
c. Properties of fuels and gasoline

50. Geologisches Institut (Geological Institute):

a. Fossil fuels:
    i. Reservoir Geology - Seismic - sedimentology, salt dynamics, "tight gas' reservoirs, natural gas and CO2 storage, seam gas (CM), geothermal
b. Nuclear:
    i. Repository in salt
    ii. Properties of the host rock

51. Geographisches Institut Lehrstuhl für Physische Geographie und Geoökologie (Geographic Instutute Department of Physical Geography and Geoecology):

a. Biomass and its impact on material flows, water and landscape function

52. Lehrstuhl für Geologie, Geochemie und Lagerstätten des Eröls und der Kohle (Department of Geology, geochemistry and mineral deposits of petroleum and coal):

a. Fossil fuels:
    i. Numerical simulation of the geological development of oil / natural gas systems;
    ii. Sealing properties of geological layers;
    iii. Education, transport and storage of Erdgassen in sedimentary basins, coal geology and geochemistry
    iv. Underground storage of carbon dioxide
b. Nuclear:
    i. Repository in shales - sealing properties of rocks

53. Institut und Lehrstuhl für Rohstoffgewinnung über Tage und Bohrtechnik (Institute and Department of Surface Mining and Drilling):

a. Selective extraction of coal to increase the calorific value and reduce greenhouse gases
b. Pretreatment of coal to increase power plant efficiency and CO2 reduction

c. Deep wells for the extraction of geothermal energy
d. Deep wells for sequestration of CO2 from industrial combustion plants in the subsurface

54. Institut für Industrieofenbau und Wärmetechnik im Hüttenwesen (Institute for Industrial Furnaces and Heat Engineering in Metallurgy):

a. Implementation and conversion of energy in industry (about 1 / 4 of energy in Germany)
b. Electric Steel
c. Thermal Processes

55. Institut für aufbereitung, Kokerei und Brikettierung (Institute for Treatment of Coke and Briquettes):

a. Mechanical Process for solid waste material
b. Aerobic and anaerobic biological treatment process for solid waste
c. Sensor-based sorting technology
d. Simulation of processes of waste recycling production of substitute fuels from waste mixtures

56. Institut für Markscheidewesen (Institute of Mine Surveying):

a. Mine Surveying and reservoir management for the extraction of raw materials for:
    i. classical mining
    ii. Use of unworked seam gas (from mining) not accessible areas
    iii. Use of coal mine gas from abandoned mines and workings
    iv. deep geothermal

57. Lehr- und Forschungsgebiet Physische Geographie und Klimatologie (Physical Geography and Climatology Education and Research):

a. Impacts of climate variability on ecology and economics, etc. Aspects of energy supply or energy production

58. Lehrstuhl für Metallurgie von Eisen und Stahl (Metallurgy of Iron and Steel Department):

a. Energy conservation in the iron and steel production
b. Research in the areas of CO2 emissions and particulate matter emissions

59. Institut für Gesteinhüttenkunde (Department of Mineral Engineering):

a. Development and testing of high-temperature ceramic materials and ion conductors
b. Mastery of the entire process from raw materials through design for sintering and testing in the laboratory and pilot plant scale (corrosion due to gases, ash, and slag in contact with metal)
c. HT-creep under load, creep tests in extreme atmospheres
d. Experience in the field of:
    i. Pulverized coal firing

ii. Incineration
iii. Coal Gasification
iv. Low-POX reformer

60. Lehr- und Forschungsgebiet Geologie – Endogene Dynamik (Geology - Internal Dynamics Education and Research):

a. Fossil fuels:
   i. Structural Geology
   ii. Tectonics
   iii. Geomechanics
   iv. Top and fault seals
   v. Salt tectonics
   vi. Tight gas reservoirs
   vii. Oil shale
   viii. CO2 storage
b. Nuclear:
   i. Repository in salt
   ii. Properties of the host rock

61. Institut für Stromrichertechnik und Elektrische Antriebe (Institute for Power Electronics and Electric Drives):

a. Theory, analysis, implementation of functional models and prototypes:
   i. Power Electronics:
      1. Transformation of electrical energy
      2. Control and regulation systems to improve efficiency
      3. Development of inverters for photovoltaic systems
   ii. Electric actuators:
      1. Hybrid Vehicles
      2. Electric Vehicles
      3. Efficiency of household appliances with innovative propulsion concepts (eg reluctance machine)
   iii. Electrochemical energy storage:
      1. Characterization and analysis of battery storage systems for conventional vehicles and hybrid vehicles
      2. Study of aging phenomena

62. Institut für Elektrische Maschinen (Institute of Electrical Machines):

a. Design of efficient electromechanical energy converters
b. Numerical calculation and modeling of losses
c. Modeling of production-related influences aof the loss behavior of the energy converter
d. Efficiency optimization

e. Energy saving concepts for the operation of electromechanical transducers

63. Institut für Elektrische Anlagen und Energiewirtschaft (Institute of Power Systems and Energy):

a. Planning and operation of electricity and gas networks
b. Maintenance quality and safety of electricity and gas networks
c. Asset management and regulation
d. Power generation and trading

64. Institut für Halbleitertechnik (Institute of Semiconductor Technology):

a. Research on silicon-based photovoltaic solar cells of the 1st and 3rd generation:
    i. 1st Generation production-process development to improve efficiency and reduce costs
    ii. 3rd Generation demonstrated highly efficient silicon solar cells using Quantenstrikturen by nanotechnology (the world's first solar cell with SiQWs!)

65. Institut für Hochspannungstechnik (Institute of High Voltage Engineering):

a. Electrical Power
b. Sustainable energy supply, especially scenarios of future supply systems, including technology-roadmapping
c. Asset management in distribution and transmission networks
d. Equipment of high voltage technology (diagnostics, insulation systems, circuit breakers)
e. Life cycle assessment of energy systems, taking account of supply of hybrid structures (electricity / gas / heat)

66. Lehrstuhl für Praktische Philosophie (Chair of Practical Philosophy):

a. Research on the problem of "climate justice", with three occupied interdisciplinarily Junior Research Groups:
    i. Model development for Bilansierung use of resources for various energy and technology options and identify the associated shift in the trade-offs (Prof. Pfenning, TVT)
    ii. Systematic analysis of alternative forms of energy supply ("generation and distribution," Prof Schnettler, IFHT)
    iii. Intergenerational, international and deferred equity (Prof. Hinsch, Practical Philosophy)

11 Appendix 6: Unique facilities and equipment in Energy Hills

- Most efficient lignite fired coal power plants in the world at 43% efficient with two plants under construction to be 47% efficient (RWE)
- Pilot public grid in Heinsberg, Germany for smart grid research and development (NUON Energie & Service)
- Solar Tower Power Plant in Jülich (Solar Institute FH)
- Minewater Project untilizing local abandoned coal mines for geothermal energy (Heerlen Muni.)
- Internal Combustion Engine test facility (VKA)
- Lighting research facility (Philips Research Labs)
- Photovoltaic cell manufacturing facility (Solland Solar)
- 450MW power plant with 90% carbon capture (RWE)
- Largest technical university in Germany (RWTH)
- One of the top four leading solar PV Institute facilities (ECN)
- Facilities for over 500 start up technology companies (AGIT)
- Four industrial parks (NUON Energie & Service)
- Custom software (SOPTIM, Solar Institute FH, NOWUM Institute FH, BET, liNear, EUTech, Econcern, Consentec, Philips Research Laboratories)
- One of the largest supercomputers in the world for simulation research and the Ernst-Ruska-Centre for Electron Microscopy (FZ)
- Discovery Center with 100,000 visitors per year (Continium)

- Only science and business park where the third supplementary protocol between Germany and the Netherlands concerning double taxation applies (AVANTIS GOB)