HEAT PUMPS IN TRANSITION TO A RENEWABLE SOCIETY

W. Koppen, Director, Vos Duurzaam b.v. , Bergen
P. van Alphen, Director, Techneco, Delft
E. Burdorf, Consultant Manager, DWA, Bodegraven
R. Traversari, Manager Department Heating and Refrigeration TNO, Apeldoorn
P. Wagener, Director, BDH, Hardewijk
K. Braber, Director Area Development, Builddesk, Arnhem
O. Kleefkens, Senior Advisor, SenterNovem, Utrecht

Abstract: The Dutch energy policy has been stimulating the research and development on heat pumps for quite some years in order to support market implementation. Specific policy instruments, such as EPC/EPL (Energy Performance Coefficient/ Energy Performance on Location), stimulate low-energy building, thereby leaving it to the market players to make their own choices for the application of interchangeable energy conserving heat pumps concepts in (new) buildings. In recent years the heat pump has ultimately been able to gain a temporary unsteady market share of 6% (2007) in new residential buildings. However, its minor market position does by far not reflect the energy-conserving potential of this mature technology.

The heat pump concepts, both gas- and electricity-driven can now already save energy by the use of commercially available technologies, can substantially contribute to sustainability in both new and existing houses, and can play a predominant role in the construction of energy neutral buildings in the future. A higher degree of sustainability cannot be achieved in the building industry by other technologies.

For marketing reasons, the Transition Platform Renewable Electricity (TP-DEV) and SenterNovem recently have consulted a group of key stakeholders in the market to jointly draw up a status document in order to elucidate, how other energy conservation and sustainability options interrelate with heat pump systems, how heat pump concepts contribute to sustainability of the energy supply system, and what the necessary efforts should be to achieve a sound development of the heat pumps market.

Key words: heat pumps, future energy supply

1 INTRODUCTION

At present heat use is responsible for almost 80% of the energy use in houses and utility buildings, whereas the energy use for cooling is growing, year after year. To realize the general objective of 20% renewable energy in 2020, a market transition will have to be implemented in order to sustain this form of energy use. This requires a substantial acceleration and trend breach as regards developments in the past few years. For this acceleration the government does not have a transparent policy with objectives yet. The (supply) market is not big enough yet and has insufficient strength in terms of market power and strategic vision to realize this without help from other parties.

The largest part of houses and office buildings, and consequently of the energy demand, is in existing buildings to which about 70,000 new houses are added per annum. The efforts for the application of renewable energy have, during the past period of time, mainly been

focused on this segment. Today, it is imperative that the energy use in existing buildings must come from renewable energy generation in order to reach the objectives.

Heat pumps provide a form of renewable energy with a very great potential. Heat pumping technologies have adequately proven themselves, so that the technology scale up is imminent, even in a country like The Netherlands where gas boilers have been the dominant heating technology for the last 30-40 years. The application of heat pumps has, for some time, been "state of the art" in a number of European countries, such as Sweden and Switzerland.

2 VISION

Heat pumps are available in different types; dependent on the required capacity a choice can be made between electricity or gas driven types, and for different renewable heat sources. Their application contributes to a more renewable energy supply and to the objectives of the government in the area of energy, such as

- Security of energy supply; electric driven heat pumps can use electricity from any form of power generation: gas/coal power stations, cogeneration, biomass-cogeneration, wind, geothermal energy and solar photovoltaics. As a result of this versatility heat pumps contribute more to fuel diversity than any other heat generators;
- Sustainability of energy supply; the high efficiency and use of ambient energy contributes to the reduction in CO_2, lower primary energy use and to a more renewable energy supply;
- Simplicity of energy infrastructure; on new building sites the electric heat pump offers the opportunity of mono electricity infrastructure (gas infrastructure is no longer required);

In the market it may, for a number of reasons, be attractive for the end-user to invest in heat pumps, on the condition that these are properly used:

- Savings in cost
- Robustness against future rises in gas prices;
- Increase in the quality of the living environment and comfort.

The heat pump is an important option in a transition to a renewable energy supply and is inextricably bound with low energy houses and in combination with renewable electricity the only way forward towards energy neutral buildings and a CO_2-free society.

2.1 Simplifying Energy Infrastructure

The electric driven heat pump can be used without extensive infrastructural adaptations. On new construction sites only an electrical infrastructure is sufficient. Other forms of energy supply (district heating, high efficiency boilers or micro-cogeneration units) require additional expensive infrastructure such as heat- or gas networks next to the always needed electrical infrastructure. Energy-saving measures result in an ever-diminishing heat demand of future buildings. As a result, the exploitation of heat and gas networks is becoming less and less profitable in comparison with the relatively cheap alternative of the heat pump.

For a proper use of the potential of heat pumps, buildings have to meet with a number of physical constructional conditions, such as:

- Good insulation that sufficiently restricts the heat/cold demand because heat pumps energy performance is much better in situations without peaks in the heat demand. As a result, and with adequate insulation measures to the outer shell, the demand amplitude is restricted, at the same time avoiding peaks in the electricity demand and the network.
- Heat storage: a heat pump in combination with heat storage enables the supply of heat when the electricity supply (and price) is most favourable. This enables a smart drive of

the electricity demand, for instance by filling the heat storage during the night hours. In this way the heat pump may contribute to the reduction in the difference between the (high) electricity demand during the daytime and the (low) demand during the night. In this way electric heat pumps also reduce the ramp of powering up of power plants in the early morning hours, saving overall cost of power production.

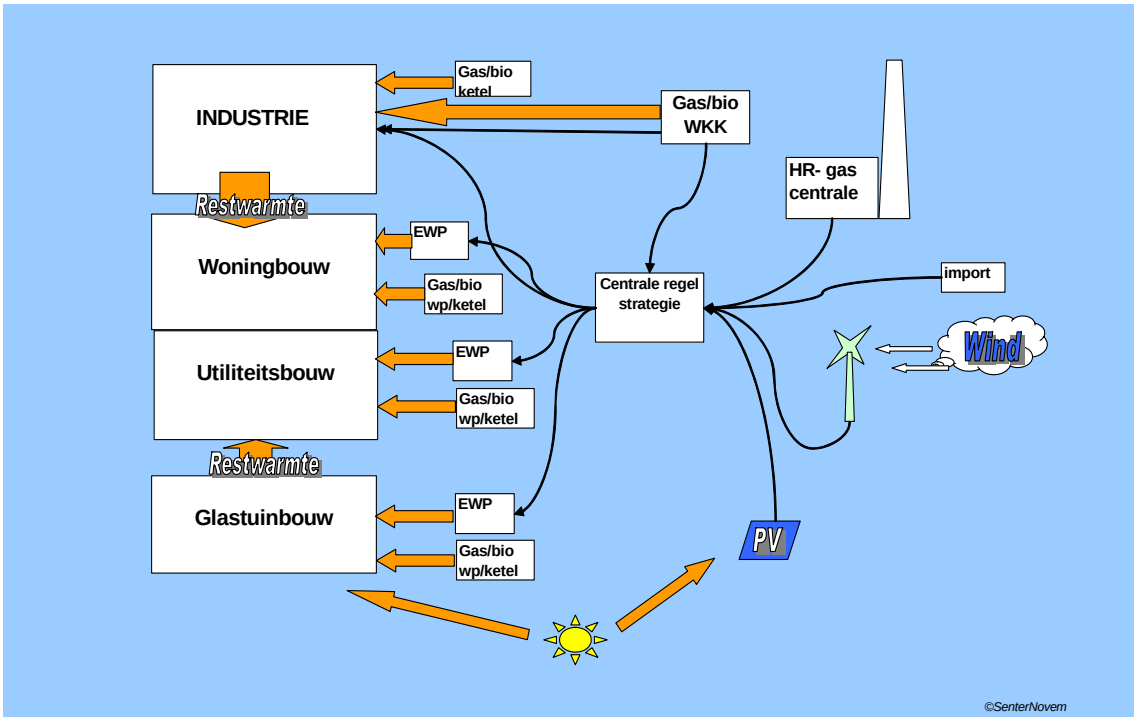

Figure 1: Future Energy Infrastructure

On the other side of the building scope are existing buildings. In The Netherlands the situation is different due to the situation of the omni-availability of gas networks (97% of Dutch households are connected to the gas grid) and the absence of low temperature systems. It is there that gas-driven heat pumps offer a good solution, or a combination of an electric heat pump with additional heat in the form of a gas boiler to meet peak demand, benefiting from the presence of the gas grid. Currently, we see a trend that heat pump suppliers active on the Dutch market (Inventum, Daalderop, Doorgeest, Daikin, Techneco) are developing these kind of concepts.

The same arguments as for households and domestic buildings can be given for commercial buildings and greenhouses with different larger scale solutions.

2.2 CO_2-reduction and a Contribution to Sustainability

The Energy Transition aims at a sizeable CO_2-reduction. For the different functionalities (in this case heating and domestic hot water) we may think of various technical concepts, each with its own effect on the energy consumption and CO_2-reduction. In most of the comparisons new systems are being put beside conventional generation, such as high efficiency gas boilers (standard in Dutch buildings) and the current efficiency of power generation. The discussion however, should be aimed at the question which savings can be achieved in the future energy supply or over the life time of the system. This comparison then has to be made for a completely different energy supply infrastructure with high efficiency electricity generation from new fossil STEG-power stations (or 'worst case" coal fired power plants with CO_2 storage) and a large part (>20%) generated by renewable energy sources.

The efficiency of a heat pump is expressed in a COP (coefficient of performance). The standard COP for electric driven heat pumps is at least 3.5 – 4.0. In order to establish the PER (Primary Energy Ratio), the efficiency of power generation must be included. Because the national power generation efficiency in the Netherlands currently amounts 40%, the PER will be larger than 1.4 (being 3.5*0.4). In the case of direct gas-driven heat pumps the PER is between 1.4 – 1.6. With this PER heat pumps can be compared with other heat generators, such as the reference, the High efficiency boiler, and micro-Cogeneration (see table below).

Table 1: Energy conservation of different heating technologies

	COP	PER	Energy savings
High efficiency gas boiler (reference)		1	0
Electrical heat pump	3.5	1.4 – 1.5	30 – 35%
Electrical heat pump next generation	5	2.5	60%
Gas driven heat pump		1.4 – 1.6	30 – 40%
Gas driven heat pump next generation		1.7 – 2.0	40 – 55%
Micro Cogeneration		1.1 – 1.3	11 – 22%

Transition is aiming at the future energy situation. A COP of 3.5 for electrical heat pumps is significantly lower than heat pumps with a momentary quality certification (like EPK and DACH-label). COPs from 5 and higher are now available for the “top-runners” on the market in various power classes. Gas driven heat pumps also show this upward trend. In the report “Technical energy- and CO_2 conservation potential for micro-cogeneration in the Netherlands (2010-2030)”, a power efficiency of 58% is used for the production in 2010, consistent with 55.7% at the end user. With an ultra efficient, gas-driven STEG and a COP of 5, the PER of the electrical heat pump reaches above 2.5 (250% heat efficiency in relation to primary energy use). The gas-driven heat pump gets at approximately 1.7 – 1.9.
The growth of the potential in CO_2-reduction of electrical heat pumps is substantial and, together with the development of the heat pumping technologies in both residential (existing and new), non residential buildings and greenhouse horticulture, goes hand in hand with the growth of the efficiency of electricity generation and the input of renewable electricity.

3 CHALLENGES AND BOTTLENECKS

The complaint most frequently heard from the market is that no good market strategy can be developed because of the discontinuity of government policy! The result is that in the market a stop-and-go situation is developing not conducive to a solid, qualitative strong market development. In an analysis in 2006 the challenges have been further mapped out; from this report stems a number of challenges for both the short and long term. These may be subdivided into three themes: policy, market and technology.

Policy:

- There is a need for a strong government policy with a mix of instruments, in which, in addition to fiscal stimulation, there is attention for the improvement of the preconditions in the market. Financial support or tightening of the rules and regulations alone is insufficient!
- Decision-makers/investors need to find a solution for sharing the investments and the operational burdens (energy cost), as a result of which decisions are made on the basis of investment levels only. Especially for housing corporations in the lower end of the housing market this has been and sometimes still is an enormous barrier.
- The performance and functionality of heat pumps exceed the existing requirements in the regulations (such as EPC). Tightening of the requirements leads to more applications of heat pumps, but in that case the market should be able (and willing) to do that. The

market of most project developers sees a further tightening of the requirements as threatening.
- Policy must be aimed at options in the construction industry for new buildings that enable the application of new technology in the future. Low temperature systems and qualitatively good insulation will have to become mandatory in the Building Code, hence in the case of future renovation (today's new buildings are tomorrow's existing buildings) heat pumps can be applied 'just like that'.
- The rules and regulations derived from current policy measurements in the Energy Performance Building Directive; EPC has a level of ambition which is too low and/or insufficiently organized!

Market:
- The overall building quality must be increased in day-to-day practice to meet the demands for quality of heat pump systems; although the building code seems to be sufficient it is insufficiently complied with/maintained in everyday practice. It is for that reason that an important precondition for the successful introduction of heat pumps is not guaranteed.
- The organization of the building sector today is fragmented, various disciplines do not work together and integral design according to basic quality principles for the processes is rare. This is the reason why the application of integral concepts like heat pumps remains limited as well.
- There is insufficient knowledge with parties like installers that should be working with heat pumps. The potential of the heat pump is insufficiently recognised.
- In the case of renovation not enough account is taken of future developments and consequently here, too, just as with new buildings there is no basis for future application of heat pumps.

Technology:
- Concepts for existing buildings are available but insufficiently known of while there is still not enough experience in the market with these systems.
- There is not enough connection in R&D and little connection to international knowledge in that area.

3.1 Savings in Cost

Heat pumps, ideally, are an essential part of a package of demand-restricting measures both in existing buildings and in new buildings, whereby the savings take place per individual object, and the end-user reduces his energy needs and thus has lower energy cost.
The investment decisions are often made at the level of investment only and not at the level of the overall exploitation period, because other parties than the end-user generally make these decisions, though it is the end-user who has the operational benefit (energy cost). This situation, which is found in the utility building industry and with housing corporations, but also with project developers for domestic housing areas, has a braking effect on the market development. Especially with housing corporations at the lower end of the market the investment costs cannot be translated in a higher rent as these rents are fixed at a certain level by legislation, although the rent is levelled by the lower costs for energy. In this situation some sort of flexibility is now being negotiated.

In these cases, where heat pumps may contribute to savings in energy cost, people mostly opt for seemingly (on the short term) more competitive options. Projects comply with the bottom legal obligations (such as EPC, etc.) and can be put into operation at the lowest cost (effort). Competitive options that economize more on cost and less on energy consumption use this regulatory market pull that may be at odds with the desired effect for the long term and for the environment.

Energy service companies (ESCOs) with different ways of financing enter this market with solutions in the various segments. Another way to solve these problems, as these are originating from the problems of a fragmented building sector under the various disciplines, is to introduce a turn key management responsibility under one designated person or company aiming at quality management of the building process.

3.2 Performance and Rules and Regulations

In addition to the requirements for energy performance, a sound building quality with well-applied insulation and a low temperature heating is a prerequisite for a successful introduction of the heat pump.
For new buildings the requirements for the energy performance apply in the form of EPC, EPL, etc., and building instructions apply in conformity with the building decree. Both the EPC and the building decree may be seen as the minimum requirements that a house/building must come up to.
A heat pump installation is usually dimensioned in view of the theoretical insulation values of the outer shell of the building. In the construction practice, however, many energy losses are caused by the inferior quality of the design and the construction; this is something people are not always aware of. The insulation quality of the house brought about is not guaranteed in the current rules and regulations. It is, therefore, recommended to aim at an integral building- and system quality for the entire building chain through a self-regulating quality system involving the market parties, tested by the local government.

The EPC may be tightened by the application of the heat pump when the technology and the market are up to it. Parties in the current market relations now see a further tightening as threatening, however. Many parties see the EPC, which is a “minimum” requirement for energy performance, as the limit.
Before the EPC can be tightened, a number of conditions must be met. For instance, the building code must be tightened. This approach paves the way to an energy-neutral construction, in which the heat pump is a corner stone. Heat pumps, because of their double functionality, provide an added value in the form of a renewable form of cooling.

3.3 Knowledge Management

There is enough knowledge with the individual parties (suppliers) and institutions. This knowledge, however, is fragmented and insufficiently broadly based with the parties having to work with it. This is the reason why the market cannot grow as big as it should.

Various professional groups are crucial for a sound market development. Important in this case is especially the grey segment between supply and demand, i.e. advisors, installers, engineers, project developers, building companies, architects, and so on. These professional groups often operate on a local level and have great influence on the decision-making of investors. In the area of installation technology and building physics more efforts must be made to install heat pumps. This is threatening for the areas within the existing market structures in which this grey segment is operating, whereas the consumer will buy the house offered to him anyway. Alternatives for gas boilers, such as micro cogeneration, which can be installed without any further fuss, do not face the same problems as heat pumps.

The formation of appropriate coalitions may be able to land the fragmented knowledge with those parties that are going to apply heat pumps. Important elements are:
- Specific training and courses for professional “intermediary” parties relevant to the market introduction (from architects to maintenance services)
- High profile examples of successful concepts in situ
- The creation of a win-win situation in which entrepreneurs within the different disciplines realise that the extra work of their services (their extra effort) also yields output and

efficiency. These parties may, as ambassadors and if the preconditions are met, contribute to the market penetration of heat pumps.

In an analysis of the competitive strength of technologies carried out in 2004 by SenterNovem, it appears that the heat pump, in contrast with other alternative options, may result in a win-win situation for almost all stakeholders in the market. Especially in a future market with a keen awareness of quality, the heat pump, able to supply (free) cooling in addition to heating, may increase the quality of the living environment and comfort in our homes. This may also be an important stimulus for renovation and upgrading of the housing stock of corporations (strategic stock management).

3.4 Research and Development

With the development of a supply structure in which, already now, Dutch manufacturers actively participate, it may be of economic interest to strengthen products for the home market by the further development of a product specific for the Dutch market. A heat pump cut out for the structure and economic environment of the Dutch market, dominated by a gas infrastructure, is a product that may create a distinct profile on the European market. This is why parties such as Itho, Inventum and Techneco and their products, today, are in a strong position as regards foreign competition.
The EOS (Energy Research Subsidy) status report by SenterNovem from 2006 clearly mentions the framework within which a research strategy can be formulated, using the knowledge from abroad. The strategy's elements are:

- The development of the add-on products and bivalent heat pumps, especially for existing buildings, and control strategies aimed at an optimal fit
- Optimisation of source systems
- Small, gas-driven heat pumps
- Desensitisation of the products for installation defects
- New technology for heat pumps (magneto-caloric, thermo-acoustic, etc.)

4 STATUS OF MARKET DEVELOPMENT

Over the past five to eight years over 120 projects with multiple heat pump applications have been implemented in new housing estates in the Netherlands (some of these projects were over 400 heat pumps per project). In new and larger commercial buildings the technology is even wider accepted. The novelty is no novelty anymore and the teething troubles seem to be over. In marketing terms, the market for heat pumps, however, is far from mature. For, an autonomously growing market in which standardized solutions are being offered is far from reality, whereas there are obstacles to be overcome in the market as well.

4.1 Domestic New Houses

About 50,000 – 70,000 new houses are annually added to the building stock. The government's policy on renewable energy and heat pumps has been primarily focused on this particular segment of the market. The market share, however, with an optimistic estimate for the number of heat pumps being 3,500 per annum, is still marginal (6%). The demand for heat pumps in residential buildings does show growth as a result of the tightening of the EPC (Energy Performance Factor) to 0.8. However, this tightening is insufficient to get the market really going.

Each and every self-respecting building contractor can now build houses with low-energy demands for space heating and domestic hot water. Minimum cost, but maximum quality is the first priority on the basis of the measures taken for the outer shell (quality of insulation and air tightness) and the heating systems (LTV - low temperature heating). In this concept the heat pump is a logical partner, able to meet the last bit of energy demand for space heating/cooling. Thus in any new housing development heat pumps can be applied as a standard solution, provided the houses meet with a number of minimum quality requirements as indicated in the Dutch directives and the system certification for heat pumps.

In the case of business-as-usual however the market for heat pumps will show a limited autonomous growth and therefore this market would greatly benefit from an additional stimulus. One of the most important conditions for acceptation by the market is that standard concepts of proven systems are used ("plug and play"). The gap between the innovators and the early majority has not been bridged yet, it is true. There is very little willingness to change within the installation world itself and the perception of the additional cost being too high are the most important hampering factors. If the application via fiscal measures is stimulated the number of applications will grow.

Figure 2: Low energy housing in Friesland

The objective for this part of the market is a 50%-penetration in 2010; it is to be realized by deploying quick scan heat pumps, standard concepts, recognised heat pump installers, system certification and goal-oriented communication.

On other hand it is possible to lower the energy demand further with the heat pump as logical partner in this process. The development of certified, renewable house concepts on the basis of "appropriate and sound insulation", crack sealing and integrated heat pump systems through tenders/competition. In addition heat pumps with a smaller capacity must be developed, integrated in domestic hot water- and ventilation systems.

As a result of new housing development and renovation the ratio of heat over power demand in domestic houses is shifting more and more towards power demand. At the same time the demand for space heating will relatively decrease compared to domestic hot water heating, whereas the demand for cooling and ventilation will increase. The heat pump is a bonus in this new demand pattern. With a market share in new house building of between 50-100%, the heat pump may add 0.25 – 0.5 PJ annually to energy-saving in this segment.

4.2 Existing Domestic Houses

In existing domestic houses well over 450,000 gas boilers are annually replaced individually and in large-scale corporative renovation projects. It is the largest potential market segment for heat pumps.
The electric driven ground source heat pump is very much favoured as a 'standard' and well proven solution for energy conservation and renewable energy in new larger domestic building projects. For the existing building stock there are a few barriers by which this solution is not as attractive as for new buildings. The degrees of freedom of design and economy are much more restricted. Thus, next to the demands for a high temperature solution the necessary investments for a ground source becomes the major obstacle and it seems fairly impossible to introduce heat pumps for retrofit on a large scale.

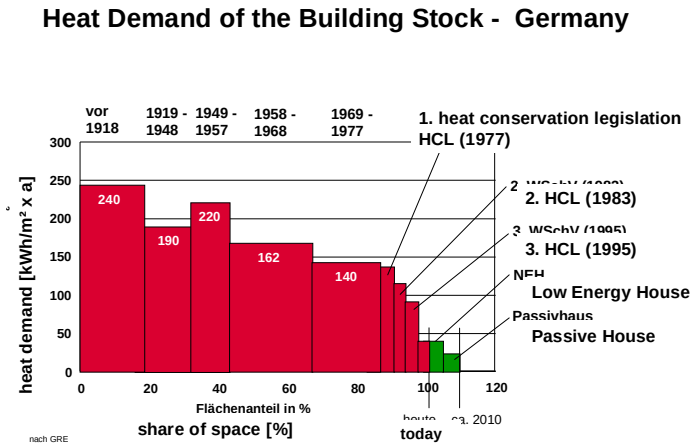

Figure 3: Existing building stock in Germany (ref Annex 30- Retrofit with heat pumps)

Only for large scale renovation in the collective sector the heat pump seems feasible. Several of these projects have already been built. The existing building stock in countries like Germany and the Netherlands is in the hands for almost 50% of collective ownership, i.e. building corporations, investment funds and Verenigingen van Eigenaren (VVE). The other 50% is privately owned. Large scale renovation as in the German example occurs mainly on collectively owned buildings. Four levels of renovation can be distinguished:

- Demolition and rebuilding
- Envelope and outer wall renovation up keeping the main skeleton and complete retrofit of the interior.
- Large scale replacement and renovation of the energy system with small renovation on the envelope, other than double glazing and crack-filling
- Replacement of the existing heating boiler at the end of its life time.

In the Netherlands and Germany several large scale renovation projects are already executed and new projects are under development. Corporations in their aim for strategic stock management will even go as far as deciding on demolition and renovation building, making great progress towards sustainability. Examples are Duindorp in The Hague and the Vegelin district in Leeuwarden (ref Annex 30).

Figure 4: Renovation project Veegelin in Leeuwarden

In privately owned buildings the main renovation is in measures which do not go further than the last two levels, being the replacement of existing heating boilers or hot water tanks and if well planned of the existing heating system towards floor and convector heating, offering better comfort. Also double glazing is favoured in these situations.

Several barriers which occur with ground source heat pumps can be overcome by choosing a heat pump with an air source. In areas with a relatively mild winter this type of heat pump has a sound potential and sometimes already gained some position.

In individual houses thus the absorption heat pump and the bi-valent heat pump are the potential to realize energy savings of 20-30%. It is important that this type of heat pump anticipates on the demand of peak capacity without burdening the existing network too much by a high electricity demand. By deploying such systems in large-scale renovation projects with corporations, experience will be gained and production can accelerate. The way knowledge is gathered in these "breeding places for innovation" will lead to a broader acceptance in the market and a development of concepts that will eventually find their way in the market for private, individual owners.

Figure 5: Bi-valent heat pump system with gas boiler

A target is set for 2015 to reach a penetration of 30% of the replacement market (= 150,000 heat pumps annually). These heat pumps can cause savings in this segment to grow by 2 PJ per annum. There are already various heat pump concepts available by Dutch heat pump manufacturers that may advance this perspective.

4.3 Commercial Buildings

In the commercial building market the heat pump has been further developed. In the segment "large offices" the penetration is about 50 - 60% of the total number of new buildings. Little information is available for the remaining part of the non-residential market; the penetration here, it is estimated, is about 30% of new buildings. Often there is an option for the application of heat pumps in the form of air conditioning, generally seen as a proven technology. For the more renewable systems, based on aquifers, the market penetration is not standard yet, although it is seen as a proven technology. To a small extent, the existing environmental legislation still stands in the way of these systems. Especially for smaller projects these existing procedures for the extension of licences are too time consuming and may lead to additional cost on the project budget.

The priority seems to be in embedding the knowledge from the bigger commercial buildings, and the transfer of the experience to smaller commercial building, through standardization of concepts, simplification of procedures and arithmetic methodology.
As a result of the great differences in proprietary structures, flexible financing possibilities and forms of process/organization can contribute to the further market development.

Figure 6: Large Commercial building project in Rotterdam

5 CONCLUSIONS AND RECOMMENDATIONS

How much more renewable would the situation be in 2020 without intervention of the government? Starting from the idea that the market pull is at odds with the effects on the environment, a new policy must be deployed to achieve a renewable energy management, or its current policy instruments must be adapted/organized to achieve this end.

At present heat demand determines almost 80% of the energy consumption in housing and utility buildings. This sector is responsible for approximately 40% of the ultimate Dutch energy consumption. To realise the general objective of 20% sustainability in 2020, a trajectory must be deployed to significantly reduce the heat demand and to increase its renewable generation. This will require a substantial step up and trend breach as regards the developments of the past years. In Transition a still higher objective is discussed, with a CO_2-reduction of 50% in 2030 and an energy-neutral building construction in 2050.

Given good preconditions, the heat pump already now works better than other heat supplying options such as High efficiency condensing boilers and micro cogeneration. In the future this will only be stronger. The heat pump, both the electricity- and the gas-driven types can also supply cooling, resulting in a technology which better suits the future energy needs in buildings. Heat pumps can thus play a valuable, if not crucial role in Transition.

At the present the market is in a transitional stage and the heat pump as well as the renewable energy community is not big enough to realise the desired changes in on its own. The market conditions for a broad application and introduction of the heat pump are as yet insufficiently present. Standardisation, quality guarantees, broadening of the supply structure, communicating these aspects, training, processing the knowledge in decision-making models and rules and regulations, etc. are the challenges for the period to come.
A policy with a mix of instruments within its own transition path will be necessary to take on these challenges. Policy should be focused on the achievement of large-scale dimensions without losing sight of the support of citizens. The motto being “finish by leaps and bounds”, the policy’s priority is large-scale application possibilities. This approach enables the use of this knowledge from large-scale implementation to be used for small-scale applications, these being far more intensive as far as implementation goes.

Only financial support or a tightening of the rules and regulations is not enough.

An accelerated introduction of the technology at more places, down from new buildings up to existing buildings, may lead to results already in the short term. It is, therefore, advisable

specifically for heat pumps in residential buildings, to proceed to remove the existing bottlenecks now in order to find solutions both in the area of market acceptation and of technology. A no-regret policy should be implemented as from now!

Continuity in policy in the form of a transition road map is necessary to break through the paradigm in the market and to achieve a system shift (= transition) in the market.

REFERENCES

Technical energy- and CO_2 conservation potential for micro-cogeneration in the Netherlands (2010-2030), march 2007.

EOS- State of the art document on Heat Pumping Technologies. O. Kleefkens et all (SenterNovem); december 2006

Competitive strength of renewable heating technologies, SenterNovem march 2004