New Energy = New Noise?

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ABSTRACT

The German public strongly demands for a sustainable energy production and consumption. Thus our government broadly enables funds to develop and exploit renewable energy sources. Especially private households have the choice to independently generating heat, cold and electricity with an appropriate financial and technical effort. This well-functioning funding system has boosted the market for small block-heating power plants, air conditioners and heat pumps. Roughly guessed there will be more than ten million of these new private energy generators in Germany in 2030. Concerning our densely population, we face a new quality and quantity of noise sources. The noise quality is moving towards a more complex disposition than today. We do not only face high noise levels, but also low frequencies and problems with low noise levels in former quiet areas. Our existing law for noise abatement is ineffective with the new noise situation. Lots of complaints about this let our ministers of environment enforce a task to customize our existing law. That is why we studied the impact and noise quality of energy-related noise sources. We developed options for a common regulation for effective noise abatement of the new noise sources. One first milestone was the publication of a code of practice for installation and operation of small stationary equipment in sensible areas. This paper is a progress report of our work.

INTRODUCTION

Today Germany generates a 23.5 % share of electricity consumption (ELC) and a 12.7 % share of final energy consumption (FEC - electricity, heat and fuel) from renewable sources. The goal of our government is to generate shares of ELC/FEC of about 50/30 % in 2030 and 80/60 % in 2050 (FME 2013). That is why we have been intensively promoting the exploitation of new energy technology for years. This process is called ‘Energiewende’ (energy system transformation) in Germany.

This has lead to kind of a paradox public situation. The transformation process shifts the power supply into sensitive areas. But the inevitable new technology also generates noise. On one hand the public sees a high effort in both generating own energy and being environmental friendly. On the other hand many people do not want the many new noise sources in their living environment. Furthermore the noise is assumedly qualified by more low-frequency components than common noise sources. Additionally there are other attributes of new technologies like disfigurement of sites or a fear of infrasound which concern the people.

German public law should protect sensitive areas from environmental noise. But we are now facing a gap between the principle of the 1960s ordinances and the present noise situation. You have to go to a civil court if you want to change something in your new noise situation. But the chances of success are small due to insufficient law. So people often feel helpless and alone with their problems and fears.

ASSIGNMENT

By official order (UMK 2011) the Federal Government has been asked to make federal regulations for the protection against noise from stationary equipment in sensitive areas. The regulations shall provide a higher level of protection than valid law. Out of this order we have been assigned by the Federal Ministry for Environment to suggest solutions for the protection against new noise from new energy. Thus the results and suggestions in this paper might have a more governmental - or administrative - than a strictly scientific point of view.

NEW NOISE SOURCES

We figured out block heating power plants (BHPP), air heat pumps (AHP) and air conditioners (AC) to be the main private new noise sources. We investigated on the typical use, technical noise sources, noise emission levels and the market relevance of available technology. Table 1 summarizes the basics of our findings. We estimate more than 10 million new noise sources in private households in 2030. Unlike in other countries Germany has not been used to these kinds of machinery until about 10 years ago. Because of the quick exploitation this could be a significant environmental noise problem in sensitive areas. We noticed a high amount of complaints and reports about poor health. More of these equipment types in sensitive areas in the near future let us expect more complaints. Especially low-frequency noise (LFN) is a very popular new fear. LFN appearance from new noise sources can be ascribed to equipment rpm depending on the mains frequency. We are currently funding two studies both on LFN scenarios in sensitive areas and on LFN impact on health and well-being.

Table 1: New Noise Sources

	Small Block Heating Power Plants	**Air Heat Pumps**	**Air Conditioners**
Principle	CI engine generator and heat recovery	refrigerator (split heat exchangers)	refrigerator (compact mobile; split systems)
Input	fossil fuels	electricity, ambient heat	electricity, ambient heat
Output	electricity, hot water	hot water	ambient cold
Typical Equipment Location	basement	indoor unit: basement outdoor unit: near adjoining property	indoor unit: living/sleeping room outdoor unit: outside wall
Main Noise Source	exhaust, structure-borne	fan, compressor, (structure-borne)	fan, compressor
Low-Frequency Noise	usually in the same building when BHPP is rigidly coupled to the masonry can occur when operated without exhaust silencer	usual noise from the compressor extra disturbing when compressor is part of the AHP outdoor unit	unusual
2013 Stock	27,000 [1]	235,000 [3]	2,700,000 [4]
2013 Sales	5,400 [2]	39,000 [3]	200,000 [4]

[1] Newly built small BHPP from 2002 to 2013 (VDI 2013). Former numbers not available.
[2] BHPP with maximum electrical power of 50 kW, (BAFA 2014)
[3] (OBS 2013) and (BWP 2014)
[4] (VDMA 2009) and (JARN 2013) - estimation

NEW NOISE ABATEMENT

To protecting against the noise of any equipment we always try to find a way to abate the noise emission level in the first place. It can be done by information, regulation or benefit – best solution is a combination of all three measures.

Regulation

The European market is harmonized. No member state of the European Union shall regulate any product attribute like noise emission on its own. Product attributes are generally regulated in European Directives or European Regulations. Directives bind the member states to nationally approximate the Directives' regulative content. Regulations bind the product manufacturers directly. The noise emission of both AC and AHP are limited by European Regulations (R206 2012, R813 2013, R814 2013). The Regulations also include benchmarks for the lowest noise levels on the market when the Regulations came into force. These limits and benchmarks are a first step to solve the new noise problem in Germany. Table 2 shows the European noise emission level limits and benchmarks of BHPP, AHP and AC in comparison with ambitious noise emission levels from our investigations.

Table 2: Noise Level Limits and Benchmarks vs. Ambitious Noise Levels

	Small Block Heating Power Plants	**Air Heat Pumps**[1]	**Air Conditioners**[2]
Power Range (private use)	P_{el} = 0 … 50 kW (electrical power)	P_h = 0 … 20 kW (heating power)	P_c = 0 … 12 kW (cooling power)
Average Noise Emission[3]	20 + 25 * log (P_{el} + 15) dB	39 + 25 * log (P_h + 5) dB	25 + 40 * log (P_c + 5) dB
European Outdoor Noise Emission Level Limit	-	$P_h \leq 6$ kW…65 dB $6 < P_h \leq 12$ kW…70 dB $12 < P_h \leq 30$ kW…78 dB $30 < P_h \leq 70$ kW…88 dB	$P_c \leq 6$ kW…65 dB $6 < P_c \leq 12$ kW…70 dB
European Outdoor Noise Emission Level Benchmark[4]	-	$P_h \leq 6$ kW…39 dB $6 < P_h \leq 12$ kW…40 dB $12 < P_h \leq 30$ kW…41 dB $30 < P_h \leq 70$ kW…67 dB	-
Ambitious Noise Emission Levels[5]	$P_{el} \leq 20$ kW…55 dB $20 < P_h \leq 50$ kW…60 dB	$P_h \leq 6$ kW…55 dB $6 < P_h \leq 12$ kW…60 dB $12 < P_h \leq 20$ kW…65 dB	$P_c \leq 6$ kW…55 dB $6 < P_c \leq 12$ kW…60 dB

[1] AHP are regulated by European Regulations (R813 2013) and (R814 2013). The noise limits become valid on 26/9/2015.
[2] AC are regulated by European Regulation (R206 2012). The noise limits became valid on 1/1/2013.
[3] In 2012 we collected data (noise levels, nominal power) of 67 BHPP, 1226 AHP and 1574 AC. The noise levels of BHPP are sound pressure levels in the distance of 1 m from exhaust. The noise levels both of AHP and AC are sound power levels. Both the louder and quieter 50 % of the equipment noise emission levels in the database lie above and below these average noise emission curves.
[4] The benchmarks are the lowest sound power levels on the market at the time of entry into force of European Regulations (R813 2013) and (R814 2013).
[5] In 2012 we had the ministerial order to find ambitious values for the lowest noise emission levels of BHPP, AHP and AC. We decided on 5 % of the equipment in our database should comply with this state of the art. We have unconfirmed information from industry representatives that more than 20 % of new equipment in 2014 has noise emission levels below these values.

Operators of industry sites in Germany need an administrative decision for operation in compliance with the requirements of the Federal Immission Control Act (BImSchG 1974). Therefore the noise exposure by an industry site is rated by the Technical Instructions on Noise Abatement (TA Laerm 1998). The rating procedure basically consists of a sound propagation model derived from (ISO 9613-2 1996), overheads for tonality, impulsiveness, etc. and Binding Immission Values.

Private operators of BHPP, AHP or AC do not need approval for operation. Nevertheless the operation must not lead to harmful environmental effect if avoidable by state of the technology (§ 22 of BImSchG 1974). If one of this equipment has an ambitious noise emission level (see Table 2) and is operated in concordance with the Technical Instructions on Noise Abatement (TA Laerm 1998) this would be state of the technology.

Information

Starting from this point we need assured the information on noise emission levels of the new noise sources and a code of practice for the state of the technology.

Fortunately there are European Regulations for the energy labeling of both AC and AHP (R626 2011, R811 2013, R812 2013). These Regulations force the manufacturers to place an energy label onto every product. Besides the energy efficiency classification, the specific A-rated sound power levels for outdoor and indoor units have to be labeled, too (see Figure 2).

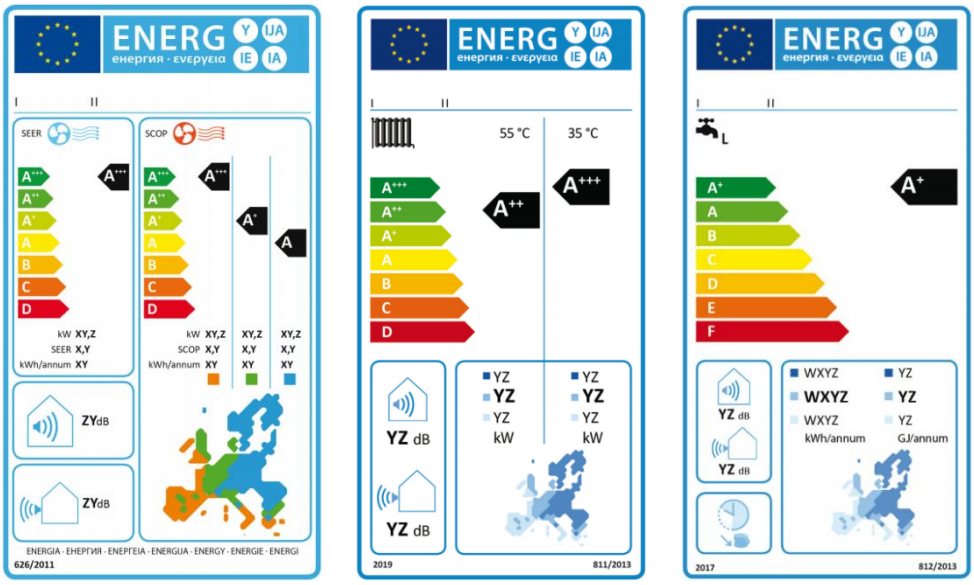

Figure 1: Labeling schemes for reversible AC and AHP space heaters and AHP water heaters according to European Regulations (R626 2011, R811 2013, R812 2013). As you can see, the labeling of the indoor and outdoor sound power levels are integral parts of the schemes.

We created a code of best practice to find the best (noise proof) location, installation and operation of new noise sources in sensitive areas. This code has been developed by a working team delegated by the Federal and State Ministries of Environment and subordinate agencies. It is now available for anyone (LAI 2013). It describes a simple method to find a proper distance to the neighbor, using the common standards for sound propagation (TA Laerm 1998) (see Figure 3). In the code you can further find a library with state of the technology noise abatement measures.

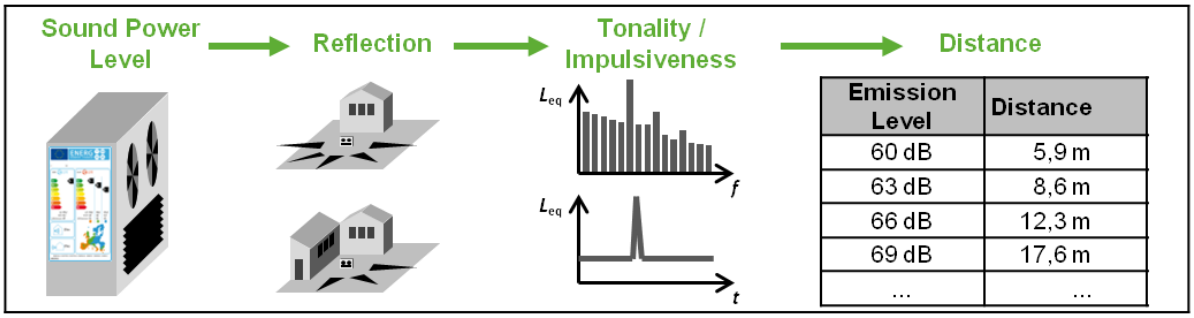

Figure 2: Code of best practice: simple method for finding the proper distance of a new noise source (e.g. an outdoor unit of an AHP) to your neighbor. First step is to find out the sound power level of the equipment. This will be labeled. Next two steps are to choosing the reflection, tonality and/or impulsiveness overheads from a list of common possible situations. In the last step you compare your calculated emission level value with a prepared table (according to TA Laerm 1998), which shows the proper distance you need to ensure between your new noise source and the next neighbor.

Benefit

By act (EEG 2011) any producer of energy out of renewable sources is granted with public funds. The granting depends on requirements like energy efficiency, size of the site, technology of the equipment. Due to unscientific political decisions in the past the noise abatement departments were not involved into the legislation process of this act. That is why there are no requirements concerning the noise emission of new noise sources. It is possibly the main reason for the evolution of the whole problem. Today it is nearly impossible to make up for noise requirements in this act.

It seems to be hard to benefitting the purchasing of low-noise technology. But we are now trying to benefit the operation of low-noise technology. German federal legislation on noise exposure of the new noise sources can generally only lay down provisions for the operator and not for the manufacturer. Thus we drafted a reasonable order of new noise sources in sensible areas. According to the draft a new noise source shall only be operated at night if it fulfills the state of the technology. This would be a benefit for low-noise technology. The state of the technology shall be approved by an authorized noise consultant. At this moment, the draft order is being interdepartmentally coordinated. Figure 1 shows the content of the draft order from the point of view of an operator.

Figure 3: The draft order for the protection against noise from stationary equipment in sensible areas from the point of view of an operator. If you want to operate a new noise source in a sensible area, you need advice by an authorized noise consultant in the first place. He shall find both the best product and location on your property. He will also recommend the best noise abatement measures for your situation. You will get a certificate for your files. Only then you will be allowed to operate your new noise source. If your new noise source meets the state of the technology you are benefitted to unrestricted operating. If not you are only allowed to operating from 7 a.m. to 8 p.m.

Figure 4: The Blue Angel environmental endorsement label.
This special type is awarded for low-noise products.

Low-noise technologies in Germany have traditionally been awarded by the environmental endorsement label Blue Angel (see Figure 4). It was the first environmental label worldwide and has set the standard for environmental-friendly products in Germany for more than 35 years. Only the most environment-friendly products can meet the requirements of the Blue Angel (20…30 % on the market). A Blue Angel labeled product has lower environmental impact, better health protection and usability than any other product. Besides requirements for any other environmental concern there are also noise-related requirements in the Blue Angel criteria documents. There are criteria documents for BHPP (UZ108 2012) and AHP (UZ118 2012) which include noise requirements. These requirements could support the noise consulting.

Another indirect instrument for the implementation of low-noise technology into the society is a European order for public procurement. This helps public agencies, ministries, big companies to find the best available technology. One new aspect of the public procurement is to integrate ‘green’ requirements into the product-related criteria documents. With respect to the Blue Angel experts’ experience most of the criteria are transferred from or derived by Blue Angel criteria documents. So our work in this field is quite simple. For the success of public procurement we just have to harmonize between European and national working groups.

CONCLUSION AND OUTLOOK

We found block heating power plants, air heat pumps and air conditioners to be the new noise sources. Our research on these kinds of equipment lead to ambitious noise levels we proposed to be state of the technology. We developed a code of best practice for the compliance with present law. We drafted an order to benefitting the operation of state-of-the-technology new noise sources.

We have started a working item to harmonize requirements for the nomination of authorized noise consultants. We have to raise awareness for noise among craftspeople, especially heating engineers. Due to noise is not part of their apprenticeship often noise problems can be traced back to disadvantageous installation of this kind of equipment. It is inevitable to solve this task for the smooth functioning of all other components of the strategy.

There is always the question of standardization. If there is no measurement standard, any limit or labeling is obsolete. Thus we keep linked to the processes on standardization of acoustical measurement and rating in national and international panels.

Due to we could not fully estimate future developments of other equipment, it was initially excluded from this strategy. But we could forecast a fast development of new technologies, especially energy storage systems. Some of them could be relevant for noise issues if they particularly base on pumping, rotating or combustion principles. Nevertheless the strategy will be expandable with newer technology.

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