Evolutions of energy labelling: lessons from German energy labels for air-conditioning and ventilation

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Abstract

EU product efficiency policy plays an important role in buildings through ecodesign and labelling of space and water heaters, ventilation units, air-conditioning and more. However, long-term climate and energy objectives require that product efficiency policies tackle even more energy savings. We can identify three areas that are not fully addressed by the existing EU energy label: first, products and systems already in use; secondly, the performance of products or systems in their operational context (e.g. dimensioning); and thirdly, planning and quality control of systems during their installation. A broader understanding of the possible functions of labels reveals that labels could be a helpful instrument in all three areas, and could be used by national governments to complement the EU Energy label.

This paper illustrates the case by way of examples from new German labelling approaches for air conditioning and ventilation: a "non-label" (a so-called QuickCheck with graphical display of results for systems in use), and a more detailed label for systems in use or new systems under planning and up to installation. The QuickCheck delivers an initial assessment that should motivate users to get a more detailed inspection. The system label largely follows the lines of the EU energy label, with the difference that it evaluates efficiency in the operational context: beyond component efficiency, it includes dimensioning and operation.

We show these are promising developments for energy labels with considerable savings potential. We analyse in which ways these labels expand the traditional understanding of labels by addressing new phases in the product/system life cycle and involving new actors, and discuss implications and challenges, e.g. with respect to broad penetration of the voluntary labels or market surveillance and verification. Due to their voluntary status, actual market penetration of the labels remains to be seen. However, the labels have the potential to shed light on significant areas of energy consumption, which are today mostly opaque to their owners. We thus consider it worthwhile to explore adaptations to the European context. Finally, bringing product policy closer to complex systems in buildings may also be a way to support long-term targets in the buildings sector.

Introduction

European product policy, namely ecodesign and labelling, has proven to be an effective policy instrument for energy and climate targets (Wierda and Kemna, 2017; IEA, 2016). While there are still savings to be tapped, ecodesign and labelling regulations, in force or being prepared, cover the most significant product groups in terms of energy consumption. Meanwhile, energy savings and emissions reductions must soar to achieve long-term targets.

The buildings sector remains one of the major concerns of efficiency policy as its evolution in terms of energy consumption is far from aligned with long-term objectives. While most regulations focus on new buildings, the existing stock of buildings accounts for the bulk of energy consumption and greenhouse gas emissions – and renovation rates throughout Europe lag far behind necessary levels. It must also be emphasised that non-residential buildings are significant energy consumers: while non-residential buildings make up about 25 % of the European buildings stock, they account for 32 % of its total energy consumption (ENTRANZE 2014)[1].

Additional, effective instruments are therefore necessary for existing buildings. One must remember that almost all major energy consumers in buildings work in systems, namely for heating, ventilation, and air conditioning (HVAC). "The whole is greater than the sum of its parts" (Aristotle) – and potential energy savings at system level are usually significantly greater than at component or subsystem level. Furthermore, the actual operational context of the systems plays a major role in buildings. This applies both to the dimensioning of the systems and their actual operational settings. Only taken together, the three elements (1) component efficiency (i.e. the efficiency of built-in components such as fans, pumps or compressors), (2) accuracy of dimensioning, and (3) operating efficiency (corresponding to correct settings and adaptation to actual needs) can leverage the entire savings potential. The same principle should apply when planning new installations, which are often oversized and when installed, rarely operate at optimum efficiency.

Lastly, HVAC systems are often opaque as to their functioning. Owners and operators lack basic information about how much the installations consume and whether operational settings are energy efficient. There is also a lack of awareness of the problem, such that few operators seek energy counselling. Digital solutions could support the implementation of labels in the sector: digital tools could link labelling approaches to systems in their operational context, while giving individualised information.

This paper's thesis is that energy labelling could and should be transferred to more complex systems in buildings, both for the existing stock and for planning of new installations. We consider that such extended labelling approaches could be helpful instruments, and that national governments could use them to complement the EU Energy label. The paper illustrates the case through examples from new German labelling approaches for air conditioning and ventilation. These are "non-labels" (so-called QuickChecks with graphical display of results for systems in use), and a more detailed label for systems in use or during planning and installation. The QuickCheck delivers an initial assessment of energy consumption, unused savings potential, and the need for action that should motivate users to get a more detailed inspection. Regarding the system label, it resembles the EU energy label's appearance and evaluates efficiency in the operational context: beyond component efficiency, it includes dimensioning and operation.

After an overview of the project background concerning system approaches in product policy and the field of air conditioning and ventilation, we describe the labelling tools developed. We then discuss their implications for evolutions of energy labelling and finally present conclusions.

Background

ADDRESSING THE BUILDINGS SECTOR FROM A PRODUCT POLICY PERSPECTIVE

A range of regulations addresses energy consumption in the building sector: the European Energy Performance of Building Directive (EPBD), the Renewable Energy Directive (RED) and the corresponding national regulations. In addition, ecodesign and in some cases labelling regulations cover major HVAC components. From a product policy perspective, the buildings sector is complex for two reasons:

First, the fact that energy savings potentials are greater for systems than for sub-systems or components is easy to grasp – e.g., optimising air conditioning as opposed to fans and pumps – but hard to translate into product policy. In principle, the energy labelling framework regulation (2017/1369) also applies to systems, which it defines as follows: "'system' means a combination of several goods which when put together perform a specific function in an expected environment and of which the energy efficiency can then be determined as a single entity". However, multiple methodological challenges remain when working with systems, not least defining tangible system boundaries. Unsurprisingly, a system approach has rarely been applied in ecodesign and labelling: only motors (ecodesign only) and the upcoming lighting systems are true system approaches under the existing regulations. Ecodesign and labelling approaches related to buildings have been so far more product-oriented. Systemic aspects have also been included in labelling of residential ventilation (Reg. (EU) 1254/2014), ecodesign of air heating and cooling products (Reg. (EU) 2016/2281) and ecodesign of fans, which includes other components including motors (Reg. (EU) 327/2011). Ecodesign of ventilation units includes a larger system consisting of a range of components including motors, fans, filters, heat recovery systems, speed drives, casings (EU) 1254/2014. An interim solution is labelling of water and space heaters, where an extended product approach applies: the so-called installer label for combinations including water heaters or space heaters (Reg. (EU) 011/2013, 812/2013, and 1187/2015) (Calero-Pastor et al., 2017).

Second, while the buildings stock is central to energy consumption, product policy works with standardised rules for new products placed on the market or put into service. Systems in the building stock come with a complete spectrum of ages. Consequently, one has to define trigger events for regulation, comparable with the placing on the market for new products. EU ecodesign and labelling regulations exclude products and systems in use; requirements from the European Building Directive EPBD or, in Germany, the national energy savings ordinance (EnEV) only apply to a limited extent to existing installations. The area is therefore particularly relevant for national measures and some solutions of the kind already exist, like the German national label for old heating installations[2]. However, large areas of energy related products in existing buildings remain untapped, especially in non-residential buildings, which

1. Excluding industrial buildings, non-residential buildings in the ENTRANZE data tool essentially comprehend buildings in the service sector (ENTRANZE 2014).

2. https://www.bmwi.de/Redaktion/EN/Artikel/Energy/energy-efficiency-labelling-of-products-01-framework-regulation.html, see also Schlomann et al. (2016).

consume on average 40 % more energy per square meter than residential buildings (European Commission, 2016).

In addition, the more complex plants and systems are, the more their operational context affects their energy consumption. Difficulties to address real usage patterns in regulations have already been discussed for a number of products, e.g., household electrical appliances (Spiliotopoulos, Stamminger and Siderius, 2018) and televisions (Baton et al., 2017). For heat pumps, Nolting, Steiger and Praktiknjo (2018) pointed out large deviations of label values from real working conditions. An investigation of a thousand condensing boilers, done by the Federation of Consumer Centers (vzbv) revealed that only one third of them actually operated in condensing mode (Verbraucherzentrale Energieberatung 2011). In air conditioning and ventilation systems in particular, real need of air conditioning and actual settings and usage patterns sometimes differ widely (Schiller, Mai and Händel, 2014). Common discrepancies can be unnecessarily high air exchange rates unnoticed by users, or air conditioning of office buildings outside of hours of use. By adjusting the systems precisely, large amounts of energy can be saved: the operational context of systems is highly relevant for their energy consumption.

RELEVANCE OF AIR CONDITIONING AND VENTILATION SYSTEMS

Air conditioning and ventilation systems are relevant product groups for the application of more advanced instruments because they are large energy consumers in buildings, especially in non-residential buildings. They are closely linked to technical building equipment and are difficult to replace en bloc – hence, they tend to have very long lifespans. A pure product approach would therefore not make much sense for central systems. Schiller, Mai and Händel (2014) estimate that around 400,000 air conditioning and ventilation systems are installed in Germany, with older systems in particular showing potential savings of up to 50 % of energy consumption. It should be noted that in Germany, there is much greater potential for energy savings in ventilation systems than in cooling. At the national level, Thamling et al. (2014) assess an electricity consumption for air conditioning and ventilation (including auxiliary energy consumption) of 42 TWh/a.

In this paper, we define air conditioning systems as systems that deliver all or part of the following thermodynamic functions to the air of an occupied space: heating, cooling, humidifying and de-humidifying. Usually, air conditioning systems will include a cooling system with a refrigeration process. The air conditioning can function as air-based system only, or as combined air/water system, e.g., with cold-water circuits and ventilation. In some cases, cold transmission of the cooling system takes place separately from air supply, e.g., via cooling ceilings. We define ventilation systems as systems that by means of fans mechanically drive the flow of air into or through the building.

In the context of EU ecodesign and labelling, there is already labelling of air conditioners with an output of up to 12 kW (reg. 626/2011) and residential ventilation units (reg. 1254/2014). However, labelling is currently limited to the smaller units. Ecodesign regulation also comprehends larger installations (reg. (EU) 206/2012 for air conditioners with an output of up to 12 kW, (EU) 2016/2281 for air heating and cooling products and (EU) 1253/2014 for ventilation units).

In the following, we will focus primarily on medium-sized and large installations as they are typically used in non-residential buildings. This also applies to air conditioning systems with a cooling output of more than 12 kW, which were subject to the energy inspection obligation under the previous Buildings Directive 2010/31/EU. With entry into force of the new EPBD 2018/844, the threshold has been increased to 70 kW. Conversely, in Germany, the upcoming buildings energy law ("Gebäudeenergiegesetz") is expected to maintain the inspection obligation for systems above 12 kW. Unfortunately, energy inspections of air conditioning systems have never really penetrated the German market, in spite of the efficiency gains they could have brought (Schiller, Mai and Händel, 2014; Mai 2016). In the absence of comprehensive building data, market surveillance authorities did not have the means to determine which buildings are subject to inspection obligations and monitor them accordingly (Weiß et al., 2018).

The following voluntary tools are an attempt to take a different, more successful path to tapping energy savings potentials in air conditioning and ventilation systems by using product policy methods. Two sets of tools were developed: so-called QuickChecks with graphical display of results for systems in use and more detailed system labels for systems in use or during planning and installation[3].

"Non-labels": QuickChecks for cooling and ventilation

Air conditioning energy assessors estimate that many building operators in Germany are very little aware of the energy consumption of air conditioning, cooling and ventilation systems. This is because usually, the energy consumption and the associated costs appear unrelated to these systems: most lack necessary meters and sensors to follow outputs and energy consumption. With rented buildings, the German Heating Costs Ordinance (HeizkostenV) does not oblige building owners to draw up consumption-based billing for these systems. As a rule, lessors allocate air conditioning and cooling costs based on the rented area. Consequently, tenants view these costs as virtually unchangeable. Even building energy certificates do not assess the actual energy quality of the systems, since operating settings and dimensioning of the systems are not considered. Moreover, air conditioning and ventilation systems can have surprisingly long life spans: Schiller et al. (2014) describe inspections of air conditioning and ventilation systems in use between 2009 and 2014, the

3. Central to the tools' technical development were the project "Investigation of the potential of air-conditioning and ventilation technology as a contribution to the implementation of a climate-neutral building stock 2050", commissioned by the German Federal Ministry of Economic Affairs and Energy (BMWi) and the Federal Office of Economic Affairs and Export Control (BAFA) in 2016 and realised by Ecofys Germany, ILK Dresden and schiller engineering, and the subsequent project commissioned by BAFA in 2018, "Development and technical support of an online tool for the evaluation of air conditioning and cooling systems", realised by Schiller engineering and ILK Dresden. Preliminary research on possible efficiency instrumentation in the field and accompanying texts, conceptions of the visual assessments and layouts were mostly developed within two projects commissioned by BMWi, "Scientific analysis of the development of energy consumption and measures to improve product-related energy efficiency" (2015–2018) and the follow-up project "Scientific analysis to improve product-related energy efficiency" starting in 2018. For both projects, the main contractor is ifeu – Institute for Energy and Environmental Research Heidelberg, with Öko-Institut e.V. as a subcontractor and support from graphic designer suwadesign.

oldest system dating back to 1965 and the average age of the plants inspected being 25 years.

There is thus a need for simple evaluation methods that clarify the energy quality of air conditioning and ventilation systems and their potential for improvement at a glance for owners and operators. The so-called QuickCheck, a short assessment, answers this purpose. Technical details are described in Ecofys et al. (2018), graphic design and explanatory texts figure in Weiß et al. (2018). BMWi published the tools in November 2018 on the web pages of its energy efficiency campaign[4]; industry associations also communicate them during trainings.

The QuickCheck provides a preliminary estimate of the installation's energy costs. In addition, it gives an estimate for savings potentials and assesses the need for action. When there is need for action, the tool refers users to seek professional expertise in getting a detailed inspection of their plant. The QuickCheck relies on few, easily accessible and / or qualitative data.[5] As potential issuers of the QuickCheck, the tool targets auditors, energy consultants, and technically experienced employees and maintenance companies. Potential recipients are both technically experienced employees and recipients with a non-technical orientation.

The QuickCheck distinguishes between ventilation systems and cooling systems. For combined air conditioning systems, it runs through both areas separately and each receives its own results. Such a procedure makes sense for operators, since both areas usually have different energy consumption levels (ventilation is much more energy-intensive) and require different energy saving measures. A separate consideration is also necessary if a central cooling plant supplies several building areas with their own ventilation systems. For owners of several plants examined in parallel, an additional result can be a rough list of priorities given to plants for upcoming energy saving measures.

The QuickCheck software generates a short report on the preliminary assessment of the system. Text blocks are modular and vary depending on the system analysed, so that the text adapts to the weaknesses identified. However, there may be important information that is not included in the automated text, e.g., when the issuer discovers deficiencies or easy improvement options during his visit on site. In these cases, issuers may use a free, delimited field for their own comments. Since potential recipients also include those who are unfamiliar with technical details, emphasis was placed on comprehensibility of the explanations and a pleasant reading flow. Where necessary and useful, the report briefly explains technical backgrounds.

The core of the QuickCheck is the graphic evaluation shown in Figure 1. The rationale behind the graphic evaluation is to use the advantages of a label in the sense that it delivers a quick visualisation. At the same time, the QuickCheck should not convey the impression that it delivers a comprehensive analysis. On the contrary, it should motivate users to go further and commission an expert with a detailed inspection. The final result can be called a "non-label": a standardised visualisation that is integrated into an accompanying document.

Underlying focal points of the design were clarity, reader friendliness and easy comprehensibility. The visuals should allow gauging relevant aspects at a glance. The tonality of the QuickCheck should be high-quality, clear, open information at eye level that does not patronize recipients. The grey and black panels at the top evoke pressure keys; they refer to energy consumption ("Energieverbrauch") and unused savings potential ("ungenutztes Einsparpotenzial"). The keys are marked from "low" to "very high" and emphasize the qualitative approach. The traffic light for the need for action at the bottom provides an intuitively understandable result: a green, yellow or red light conveys the urgency of the action at a glance.

Figure 2 shows the QuickCheck with the accompanying report. Pictograms next to the text liven up, structure the paragraphs and guide the reader through the text. In the figure, the modular text blocks appear in full. In reality, the text will usually be shorter, as not all points will apply. On the last page, receivers will find references to funding programmes and expert lists for detailed inspections of their plants (not shown in the figure).

The (few) initial market reactions have been broadly positive: an interview partner of the trade journal CCI commended the QuickChecks for being a positive impulse and argumentation aid for investors. A point criticised was shortcomings of the printing function (cci Dialog GmbH, 2018; cci Zeitung, 2018).

System labels for air conditioning, cooling and ventilation

In contrast to the QuickCheck, the system label is a tool for detailed assessments. It is a voluntary label destined for experts, namely air conditioning energy assessors. Its role is to enhance energy inspections of air conditioning systems: through a label with an efficiency class, building owners and operators get a clear view of the energy quality of their system at a glance. It makes sense to draw up the system label in connection with an energy inspection, as the inspection provides the necessary, extensive data: a standardised procedure for energy inspections of air conditioning systems (German standard DIN SPEC 15240) guides assessors through the process.

As a result, clients will typically receive the inspection report – a long and rather technically complex assessment – and the label with its accompanying document, which can serve as a sort of executive summary. In addition to the energy efficiency of components, the label takes dimensioning and the mode of operation of the system into account and thus gives the client a concise statement on the efficiency of his system. Concerning the efficiency of components, the tool compares calculated efficiencies with thresholds of successive Energy Ordinances (EnEV), based on calculation methods of the German standard DIN 18599-7 for air conditioning. Dimensioning relies on an analysis of part-load levels for cooling and on a comparison of air volume flows with cooling loads and minimum fresh air

4. https://www.deutschland-machts-effizient.de/KAENEF/Redaktion/DE/Standardartikel/Dossier/dank-effizienter-klima-und-lueftungsanlagen-energie-sparen.html.

5. Instances of input data for ventilation systems are air volume flow, approximate year of construction, type of use of the building/rooms and cooling and humidification functions. For cooling systems, input data include nominal cooling output and design types of important elements, e.g., design type of the refrigerating plant, of refrigerant compressors, type of recooling and the cooling flow temperature at the refrigeration plant.

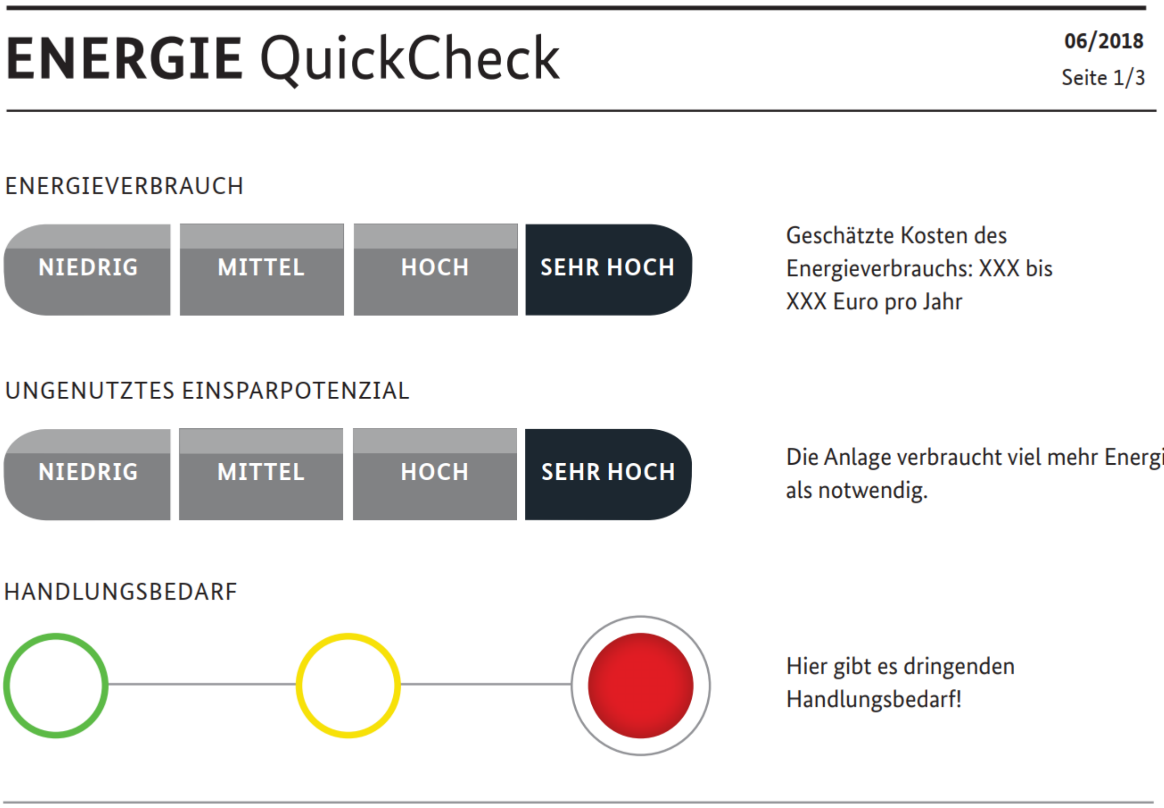
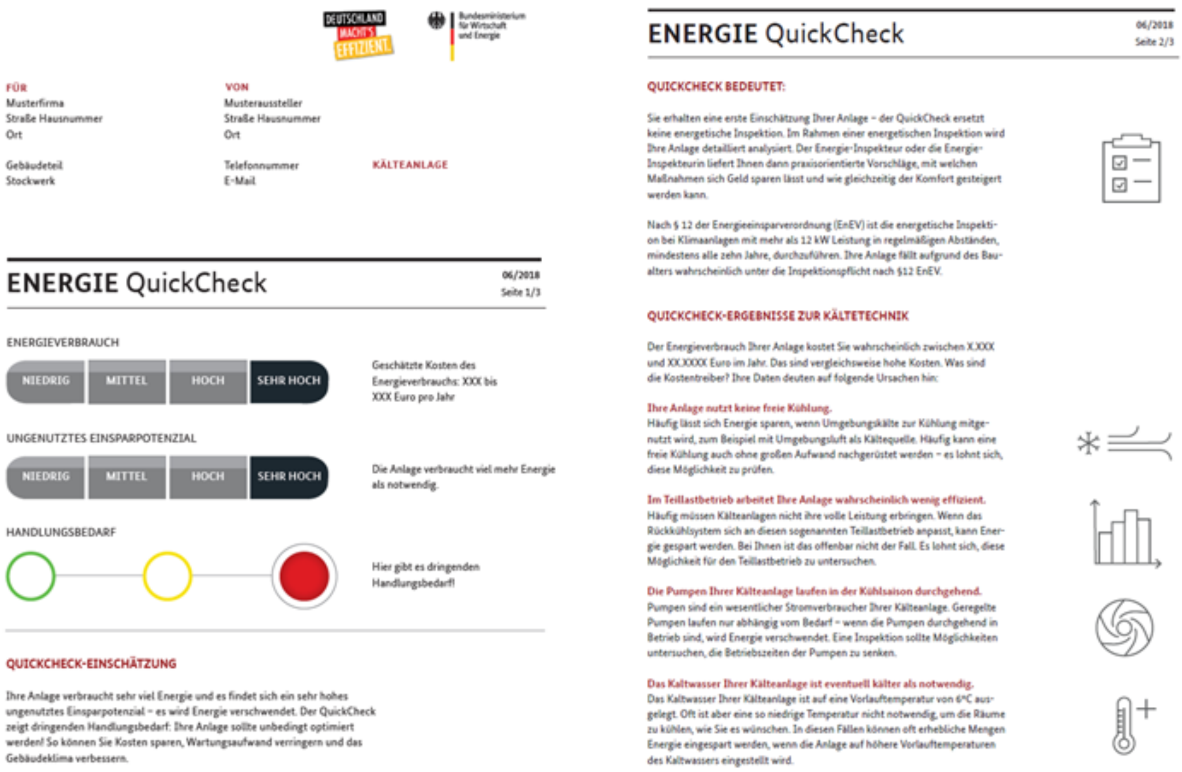


Figure 1. Graphical QuickCheck assessment (Weiß et al. 2018).



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ENERGIE QuickCheck — 06/2018, Seite 1/3

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Hier gibt es dringenden Handlungsbedarf!

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Ihre Anlage verbraucht sehr viel Energie und es findet sich ein sehr hohes ungenutztes Einsparpotenzial – es wird Energie verschwendet. Der QuickCheck zeigt dringenden Handlungsbedarf: Ihre Anlage sollte unbedingt optimiert werden! So können Sie Kosten sparen, Wartungsaufwand verringern und das Gebäudeklima verbessern.

ENERGIE QuickCheck — 06/2018, Seite 2/3

QUICKCHECK BEDEUTET:

Sie erhalten eine erste Einschätzung Ihrer Anlage – der QuickCheck ersetzt keine energetische Inspektion. Im Rahmen einer energetischen Inspektion wird Ihre Anlage detailliert analysiert. Der Energie-Inspekteur oder die Energie-Inspekteurin liefert Ihnen dann praxisorientierte Vorschläge, mit welchen Maßnahmen sich Geld sparen lässt und wie gleichzeitig der Komfort gesteigert werden kann.

Nach § 12 der Energieeinsparverordnung (EnEV) ist die energetische Inspektion bei Klimaanlagen mit mehr als 12 kW Leistung in regelmäßigen Abständen, mindestens alle zehn Jahre, durchzuführen. Ihre Anlage fällt aufgrund des Baualters wahrscheinlich unter die Inspektionspflicht nach §12 EnEV.

QUICKCHECK-ERGEBNISSE ZUR KÄLTETECHNIK

Der Energieverbrauch Ihrer Anlage kostet Sie wahrscheinlich zwischen X.XXX und XX.XXXX Euro im Jahr. Das sind vergleichsweise hohe Kosten. Was sind die Kostentreiber? Ihre Daten deuten auf folgende Ursachen hin:

Ihre Anlage nutzt keine freie Kühlung.
Häufig lässt sich Energie sparen, wenn Umgebungskälte zur Kühlung mitgenutzt wird, zum Beispiel mit Umgebungsluft als Kältequelle. Häufig kann eine freie Kühlung auch ohne großen Aufwand nachgerüstet werden – es lohnt sich, diese Möglichkeit zu prüfen.

Im Teillastbetrieb arbeitet Ihre Anlage wahrscheinlich wenig effizient.
Häufig müssen Kälteanlagen nicht ihre volle Leistung erbringen. Wenn das Rückkühlsystem sich an diesen sogenannten Teillastbetrieb anpasst, kann Energie gespart werden. Bei Ihnen ist das offenbar nicht der Fall. Es lohnt sich, diese Möglichkeit für den Teillastbetrieb zu untersuchen.

Die Pumpen Ihrer Kälteanlage laufen in der Kühlsaison durchgehend.
Pumpen sind ein wesentlicher Stromverbraucher Ihrer Kälteanlage. Geregelte Pumpen laufen nur abhängig vom Bedarf – wenn die Pumpen durchgehend in Betrieb sind, wird Energie verschwendet. Eine Inspektion sollte Möglichkeiten untersuchen, die Betriebszeiten der Pumpen zu senken.

Das Kaltwasser Ihrer Kälteanlage ist eventuell kälter als notwendig.
Das Kaltwasser Ihrer Kälteanlage ist auf eine Vorlauftemperatur von 6°C ausgelegt. Oft ist aber eine so niedrige Temperatur nicht notwendig, um die Räume zu kühlen, wie Sie es wünschen. In diesen Fällen können oft erhebliche Mengen Energie eingespart werden, wenn die Anlage auf höhere Vorlauftemperaturen des Kaltwassers eingestellt wird.

Figure 2. QuickCheck assessment in the context of the accompanying document (pages 1 and 2) (Weiß et al. 2018).

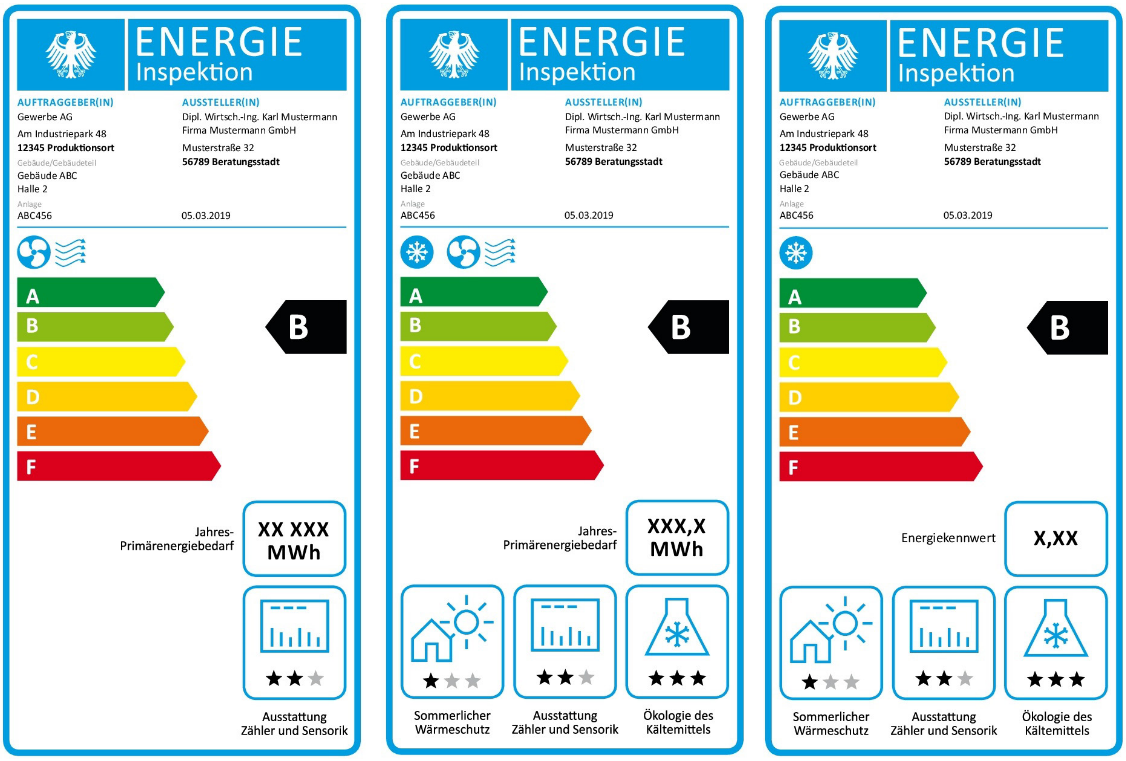

Figure 3. Labels developed for combined systems (air conditioning with integrated cooling) (left), ventilation systems (middle), and cooling systems (right) (source: ifeu/suwadesign).

flow rates.[6] The efficiency assessment of operation is mainly based on control technology and adaptation to users' needs.

The labels distinguish three cases: like the QuickChecks, they assess ventilation and cooling systems separately. Besides, there is a third version for combined systems, air conditioning systems with integrated cooling. For smaller systems, it may make sense to assess both parts together and use the label for combined systems. In that case however, the cooling's energy assessment will hardly affect the efficiency class compared to the ventilation system's bigger energy needs.

The starting point to develop the label was to follow the design of the existing EU energy label, whose effectiveness of the colour coding and the alphabetical energy classes has long been confirmed[7]. The current EU labelling framework regulation (EU) 2017/1369 prohibits suppliers and dealers to exhibit labels that mimic EU energy labels – but exempts Member States, which may create labels similar to EU labels, provided the products concerned are not already covered by a delegated act (Article 6). As the air conditioning systems targeted here are not subject to a relevant delegated act, they are considered to fall under said exception of Article 6.

6. As part of the research project by Ecofys, ILK Dresden and schiller engineering, the researchers involved have contributed to further develop the underlying German standard for energy inspections of air conditioning systems. Both calculation methods were newly integrated into the German standard for inspection of air-conditioning systems, draft version DIN SPEC 15240:2018-08. The new draft version is to enter into force in 2019 and reflects the principles of the system label.

7. See e.g. Brazil and Caulfield (2017) who conducted an eye-tracking experiment with an EU label for white goods and a similar label for cars, as well as numerous previous studies about effectiveness and consumer comprehension of the energy label, e.g. Waide and Watson (2013), Molenbroek et al. (2014), IEA (2016), Waechter et al. (2016).

The completed labelling tools will be made available at no charge on the Federal Office of Economic Affairs and Export Control (BAFA)'s website during the course of 2019. In addition, calculation methods and programming codes have been shared with software manufacturers, so that energy assessors will be able to access the new label and its accompanying document through their customary industry software.

The rating on the label is based on the colour scale from A to G in dark green to red, familiar from the EU energy efficiency labelling. To ensure that the classes sufficiently differentiate energy consumption, however, the number of classes for the system label was reduced to six. This results in a scale from A to F, also coloured from dark green to red. The efficiency classes were conceived along the lines of increasing standards of successive German Energy Saving Ordinance (EnEV)[8] versions; a modelling of possible systems according to the German calculation standard DIN 18599-7 for air conditioning helped adjust the exact class boundaries. For ventilation systems, class A corresponds to 25 % less primary energy consumption than stipulated in EnEV 2016; class F corresponds to roughly 1.75 times the primary energy consumption stipulated in EnEV 2007. For cooling systems, class A roughly amounts to 33 % less energy consumption than specified in EnEV 2016, class F corresponds to more than twice the requirement of EnEV 2013. For both cases, modelling suggests that class A will rarely be populated, leaving room to discern more efficient plants in the future (Ecofys et al., 2018).

8. EnEV's primary energy requirements rely on a reference building method – the reference building having the same size, shape and orientation as the real building. Thus, EnEV limits primary energy demand for buildings individually and does not give absolute numbers.

The graphic design is based on existing EU energy labels. As the label is only intended for the German market, it does not have to be language-neutral. In this sense, it follows the German label for old heating installations, which also mimics the EU energy label while displaying some German wording. Nevertheless, pictograms supplement additional information – a good comprehensibility of the pictograms is a core issue. Figure 3 shows the three label versions developed (see similar, previous stage in Weiß et al., 2018).

Pictograms are notably given for additional aspects that the standard air conditioning inspection does not cover. In fact, the system approach of the label was further extended by including the following aspects, each aspect being awarded zero to three stars, following a list of questions to the energy assessor:

- **Summer thermal insulation:** Reducing unnecessary heat input into the building leads to significant energy savings by lowering the cooling requirement and thus the energy consumption of the system.
- **Equipment with meters and sensors:** The majority of air conditioning and ventilation systems does not operate transparently, especially in the absence of a centralised building automation. Often, there are no separate meters to record electricity consumption, volume flows and heat or cold quantities are insufficiently measured, if at all, and target and operating temperatures are only recorded in part. In the absence of measured data, it is difficult to determine whether the system is working properly. In addition, experience shows that the more complex the system, the more susceptible it is to inefficient or faulty modes of operation. In extreme cases, this extends to simultaneous operation of heating and cooling. In this respect, adequate equipment with meters and sensors is a basic prerequisite for permanently energy-efficient operation.
- **Ecology of the refrigerant:** Many of the refrigerants commonly used in refrigeration systems have global warming potentials of several thousand, i.e. they are several thousand times more harmful to the climate than CO_2. Parts of the refrigerant are released into the atmosphere via leaks, where they contribute to climate change. Refrigerants are therefore a relevant factor for the climate-damaging properties of refrigeration systems. A glance at the refrigerant's climate effect is also helpful for operators of refrigeration systems with particularly harmful refrigerants, which are subject to restrictions under the EU F-Gas Regulation and subsequently a gradual phase-out of these refrigerants (Weiß et al., 2018).

Enclosed with the label, the client receives a standardised document with individual assessments. Besides explaining the label, the aim of the accompanying document is to help motivate the owner to undertake energy saving investments. Unlike energy labels for products regulated under the EU framework regulation, the label will not be attached to the air conditioning system. That would make little sense, as most components will be located in plant rooms or outside the building, and label recipients would not always have access to them – thus, the use of a printed label designed to be joined to the energy assessor's inspection report.

FURTHER EVOLUTION: LABELS FOR PLANNING AND INSTALLATION OF NEW PLANTS

In its present form, the label addresses existing plants. In a second step, however, the label should be transferred to new systems under planning, prior to and during installation. Ideally, building owners could then commission plants of a certain efficiency class; planners could align the planning process to the achievement of the target and, after commissioning, prove by means of an independent examination that the desired efficiency class has been achieved.

The independent examination is necessary because in most cases, planning moves from draft planning to detailed planning and undergoes many changes during the process. Only an independent party can make sure that the finalised system has been installed correctly and corresponds to the system planned at the beginning. Quality assurance for new plants would be thus improved; good planning performances would be visible.

This concept was discussed and specified at a workshop with planners in May 2018 in the BMWi and was generally welcomed by the participants. Its further development is in progress.

Discussion

The labelling tools presented are interesting from a number of points of view as they allow exploring some new areas and functions of energy labelling.

SETTING NEW STANDARDS FOR SYSTEM APPROACHES IN LABELLING

Both sets of tools are on a way of setting new standards for system approaches in labelling. They disseminate assessment systems that comprehend component efficiency aspects, dimensioning, and operating context through a package of pathways: the online tools, industry trainings, the official energy inspection standard DIN SPEC 15240, and integration in commercial industry software.

In doing so, they allow gaining further experiences about viability and possibilities of system labels for energy consumption and incidentally, contribute to tapping additional savings potentials at system level compared to component level.

VOLUNTARY LABELS

Both sets of tools are voluntary labels. What makes them easier to introduce in the market is also their drawback: it has yet to be seen how far they will penetrate the market. The label's "selling point" for issuers is that they facilitate giving clear assertions about the plants and, by delivering convincing arguments for customers, may generate new business for energy-oriented refurbishment.

A common problem of voluntary labels is that they tend to preferably label "good" products. This should not be a problem for QuickCheck and system label for existing plants: they are more oriented towards refurbishment; issuers can have no interest to limit labels to highly performing systems. It is different for the system label for planning and installation: in this case, the label is certainly more attractive for energy efficient systems. While it may thus not discriminate inefficient plants, it does exert a pull-effect on efficient systems which may be able to achieve better value.

ADDRESS NEW PHASES ON PRODUCTS/SYSTEM LIFE CYCLE FROM A USER PERSPECTIVE

Traditionally, energy labels give guidance for purchasing products. They help to compare products with similar functions. The QuickChecks and system labels show that labels can also evolve towards other product life phases (see Figure 4) and, thus, can have an effect on several levels:

- The label for planning and installation covers, in a more traditional way, the product choice and adaptation phase, with the planning element as a new addition. Here, it can support discussion between builder and planner by making transparent the impact of planning decisions, such as the efficiency of fans purchased, the impact of a heat recovery system or a control system that automatically adapts usage.
- Conversely, the QuickChecks and the system label for existing plants concern the phases operation and maintenance, retrofit and energy saving measures.

In doing so, the labels adapt a role rarely taken by product labels: their focus changes from the purchase decision to an assessment of equipment the user already owns (a similar role, but with a scope limited to products instead of systems, is found with the German label for old heating installations). In addition, the labels presented here sensitize owners and operators for the real performance of their plant and can ultimately influence investment decisions.

MORE TRANSPARENCY IN A B2B SECTOR

The existing energy labels address much more household consumers than business customers, the underlying assumption being that businesses take rational decisions based on economic criteria. In the field of air conditioning and ventilation however, the plants are often so opaque to their owners, that there is no basis for rational economic decision-making. That is, choice of a system may be difficult to make based on clear facts. The same holds true for investment decisions during operation of the systems. In addition, as the field usually is not the core competency of the businesses concerned, they lack time and personnel to delve deeper into the issue. Insofar, the labels bring much needed transparency into a B2B-sector and give the opportunity to further explore B2B-labels.

LINKING LABELLING AND ENERGY CONSULTING APPROACHES

A new aspect of the developed labelling tools is that through their individualised, explanatory texts and the fact that they are issued in the course of a personal, face to face contact, they interlink labelling and counselling approaches. This is because each of the tools delivers individual assessments of the plants and joins a customised accompanying text. Thus, there is a link to standardised and automated energy consulting offers, which become more frequent with increasing digitisation of processes.

Looking at counselling approaches in the buildings sector, we can describe energetic refurbishment in buildings as a process divided in five steps from a first contact over an initial counselling, a more detailed counselling, planning and execution, and evaluation and documentation (NABU, 2012). Looking at the process shows that the labelling tools developed can spring into action at three different steps in the process (see Figure 5).

The QuickCheck acts during an initial counselling phase: it acquaints operators with shortcomings of their installation and motivates to take further steps. At this phase, there are usually few data available about the systems. The QuickCheck's crucial

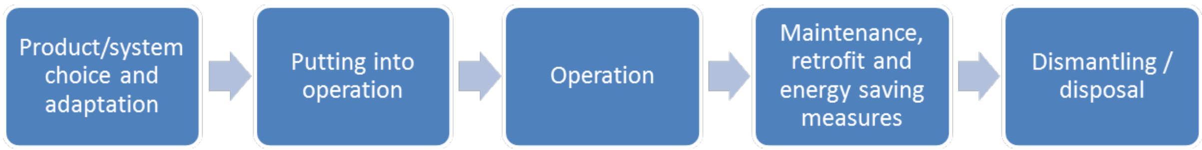

Figure 4. Product/systems life phases from a user perspective. (Source: own diagram.)

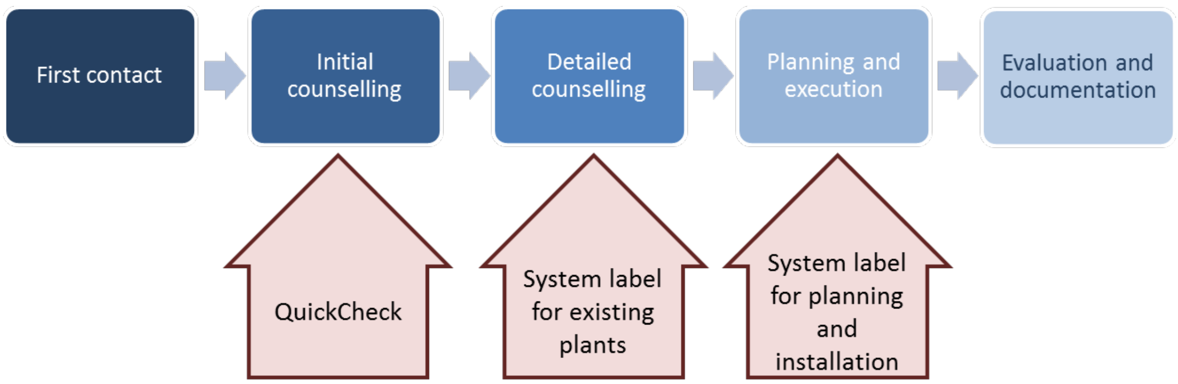

Figure 5. The new labelling approaches in the context of a building refurbishment process (following NABU 2012).

success factor is that it enables to make reliable assertions based on qualitative statements about air conditioning systems. The QuickCheck does of course not replace a thorough inspection – its strength is that it gives an assessment of urgency and a sense of priorities to clients.

The system label appears at two steps: for existing plants, it delivers detailed counselling – together with the underlying inspection report compiled by the assessor. In using labelling features, it enhances the informative value of the report. Thus, the label facilitates communication with decision-makers, e.g. on investment decisions. For the planning and installation of new plants, it guides client and planner in the planning and execution phase.

VERIFICATION AND LINKS TO QUALITY CONTROL

EU energy labels are issued by manufacturers or suppliers and are subject to sample inspections by market surveillance authorities in order to verify the accuracy of the label content. The **system labels** for installations in use follows a different approach in verification. All products and components used are already approved on the market. The label adds a standardised calculation path. It is therefore not possible for a market surveillance authority to verify that the results are correct. Instead, the recipient gets a transparent list of input data within the accompanying document. Calculation results are under the personal responsibility of the energy assessor, whose name also appears on the label and whose inspection report is subject to sample verifications by German authorities.

The **non-labels QuickChecks** are essentially protected in that the system (and the calculation path) is highly automated and in that users receive a transparent indication of input data.

Conversely, when the **labels** are used **in planning and quality assurance**, the inspection by an independent third party is required in every case and thus goes beyond current procedures. Thus, the expansion of the system label's scope to planning and installation delivers a new linkage to quality control. So far, EU energy labels do not foresee to be verified by independent third parties at the moment of issuance. Due to the particularities of the planning process, the many changes involved when moving from draft planning to detailed planning and the difficulties of finding the correct operational settings, independent examination at commissioning has the potential to significantly enhance efficiency and performance of the plants. The label could deliver support and help develop a market for such verifications, while highlighting good planning performances.

Conclusions

In this paper, we present two sets of new, voluntary German energy labels for air conditioning and ventilation systems. With the so-called QuickChecks, we explore a "smaller" form of label that uses graphic means to make a result clearer, but its design also points out that a final evaluation is not yet given as with a "complete" energy label. As to the system labels presented, they give a clear assertion of the energy quality of the plants, using a holistic assessment that covers not only component efficiency, but also dimensioning and operational efficiency. In a first step, the system label is designed for existing installations, a further evolution will cover planning and installation of new systems. Foremost aiming at large systems in non-residential buildings, the labels illuminate areas with considerable energy consumption, but that are today mostly opaque to their owners and operators.

In terms of product efficiency policy, the labels show that interesting evolutions are possible: they delve deeper in the realm of complex systems, expand labelling to systems already in use and, future novelty, they will transpose the labelling approach to planning and installation. They are thus a possibility to gain experiences with widening the scope of traditional labelling in order to tap new energy savings potentials.

In doing so, the labels set new standards in assessment of air conditioning; address new life phases of the systems concerned and bring additional experiences with B2B labelling. In addition, they fortify links to energy counselling and add clear assertions to refurbishment processes.

Further monitoring is needed to follow the dissemination of the labels in the market, as well as their actual impact. Considering their voluntary status, the extent to which the labels are used depends on how they benefit practitioners in the industry. In any case, as with energy efficiency measures in general, the effect of the labels also depends on price levels of energy carriers. For carbon-intensive energy carriers, their effect could increase considerably for when combined with significant carbon pricing. In the end, labels provide necessary transparency, but commercial viability of investments in energy savings measures depends on energy prices.

In all, we estimate it worthwhile to investigate possible adaptations to the European context. There is research to be done at the European level as to the establishment of suitable efficiency classes of this kind of new labels. In the exemplary cases presented, the energy classes were derived from the German Energy Ordinance (EnEV). That could provide a good starting point for adaptations in other European member states, even though national characteristics could require specific national solutions.

An adaptation to the European context should equally comprehend further investigation of labels for installations in use: potentially, they could bring more dynamics to the stagnant refurbishment in the buildings sector. There are major concerns that macro policies as the EPBD are not stringent enough to meet long term targets. Bringing product policy closer to existing installations in the buildings sector may be a way to tap more savings potentials and to get better visibility by aligning micro- and macro-policy levels.

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