# The Federal Programme for Heating Systems Optimisation in Germany – evaluation methods and intermediate results

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## ABSTRACT

In 2016, the German government established the "Directive Governing the Promotion of Heating Optimisation through Highly Efficient Pumps and Hydraulic Balancing": a programme giving financial support for heating optimisation measures in buildings. It is open to private building owners, organisations, municipalities and businesses. The overall aim of the programme is to increase energy efficiency and reduce $CO_2$ emissions in the buildings sector.

This paper describes the results of an evaluation of the programme for the years 2016 to 2020. It presents the initial results, the evaluation approach and methodology. This covers: the programme's achievement of implementation targets, its effectiveness and cost-effectiveness. The evaluation makes use of theory-based evaluation methods, market and stakeholder analysis and a barrier analysis.

The initial results of the evaluation suggest that the support programme can be considered very efficient. The programme is triggering investments and behaviour change that save energy and reduce GHG emissions that are cost-effective for programme beneficiaries and society. The programme's structure limits free-rider effect payments but also administrative red tape.

## Introduction

### Background

In 2016, the German Federal Ministry for Economic Affairs and Energy (BMWi) established the "Directive Governing the Promotion of Heating Optimisation through Highly Efficient Pumps and Hydraulic Balancing" (HZO-programme). The programme provides subsidies to building-owners to replace their old heating system circulators and warm water circulation pumps with highly efficient pumps and to carry out hydraulic optimisation of heating systems. These are one-off subsidies of 30 % of the net investment costs which includes professional installation and material costs (max. 25,000 euro per location) (BAFA. N.d.). The target group of the subsidy is broad in scope: private building owners as well as organisations, municipalities and companies are all eligible to apply. The overall aim of the programme is to increase energy efficiency and reduce $CO_2$ emissions in the buildings sector. The programme thus supports the achievement of Germany's sectoral target of an almost climate neutral building stock by 2050 (BMWi 2016a).

Arepo Consult in partnership with the Wuppertal Institute have been commissioned by the Federal Energy Efficiency Center (BfEE) to carry out a formative and summative ex-post evaluation of the directive according to the requirements of the Federal Budget Code (BHO § 7)[1] (BMJV 2019) for the programme duration from 2016 to 2020. This paper presents the initial results of the evaluation (the main results achieved during the first three programme years) as well as the evaluation approach and methodology.

### Scope of the paper

The content of the paper is structured as follows: The first section gives an overview of the aim and approach of the evaluation. This includes its objectives, the development of the programme theory, main indicators and methods applied as well as the main data collection methods. The second section then presents the methodological approach in more detail as well as the evaluation results to the end of June 2019. The section is structured into three sections in accordance with the Federal Budget Code´s evaluation criteria: the achievement of programme targets (e.g. number of (approved) applications, subsidies provided, etc.), impact evaluation (with regard to final energy savings and $CO_2$ reduction adjusted for free-rider effects and according to target group and geographic distribution) and cost-effectiveness (in terms of administration costs, programme-induced investments, $CO_2$ emission reductions achieved and cost-effectiveness from a societal and investor perspective). The results are derived by using a "Theory of No Change" (TONC) (Wörlen 2011) approach: a barrier analysis identifies the main restraints towards a more effective outcome. The paper concludes with a reflection on the evaluation implementation challenges and the lessons learned from this process leading over into final summarising thoughts on the evaluation.

## Aim and approach of the evaluation

### Evaluation scope and objectives

The overall aim of the formative and summative ex-post evaluation of the HZO-programme is to assess the programme for the duration from 2016 to 2020 according to three criteria: programme achievements, impacts and cost-effectiveness. The assessment of 'programme achievements' considers the level of energy savings and $CO_2$ reductions achieved by the supported measures. The impact evaluation reviews the interaction between the subsidised actions and the achievement of objectives and is guided by three key questions: (i) whether the programme was suitable to induce additional energy savings and $CO_2$ reductions; (ii) whether there is a causal relationship between subsidised actions and observed outcome; and (iii) whether there are unintentional positive or negative effects influencing the programme achievements. The evaluation of the programme's cost-effectiveness investigates the relationship between programme achievements and funds used; it considers whether the measure was cost-efficient with respect to its achievements and examines the cost-effectiveness of the programmes´ execution. It also considers the barriers to programme effectiveness.

### Programme theory

In order to operationalise the evaluation objectives, the evaluation team developed a programme theory to describe the cause-effect-chain through which the programme works from input to output, outcome and longer-term impact level.

The programme theory (cf. Figure 1) assumes that subsidies aimed at reducing energy consumption trigger efficiency measures not only directly, among the subsidy-recipients, but also - beyond the programme -

[1] The Federal Budget Code (BHO § 7) is standard for all funding programme evaluations of the German Federal Ministry for Economic Affairs and Energy.

by triggering further market development. It represents the interaction of the activities and the resulting effects among the most relevant actors for the implementation of the programme. These actors are: decision-makers (i.e. programme beneficiaries), the BMWi and the Federal Office for Economic Affairs and Export Control (BAFA), as well as heating, ventilation and air conditioning (HVAC) contractors. The programme theory also considers the way that HZO interacts with other subsidy programmes. The causal chain begins with decision-makers being both aware of the problem of inefficient heating systems and motivated to act on it, which then translates into the planning of improvement measures. It is assumed that decision-makers are either already aware and motivated and thus entering an information search process in which they come across the HZO programme or awareness and motivation is triggered by the HZO programmes public relations work across the subsidy programme. However, there are also other information channels: in case of urgent measures, e.g. a broken heating valve or a pipe break, HVAC contractors could draw the decision-makers' attention to the measures that the HZO-programme supports in the longer term. When the HZO-programme is noticed, the decision-makers register on the BAFA website and submit a subsidy application to BAFA. BAFA will process this application and approve or reject it. Energy savings will be achieved upon completion of the measure either from saved thermal energy (due to hydraulic balancing and accompanying measures) and / or from saved electricity for pump operation.

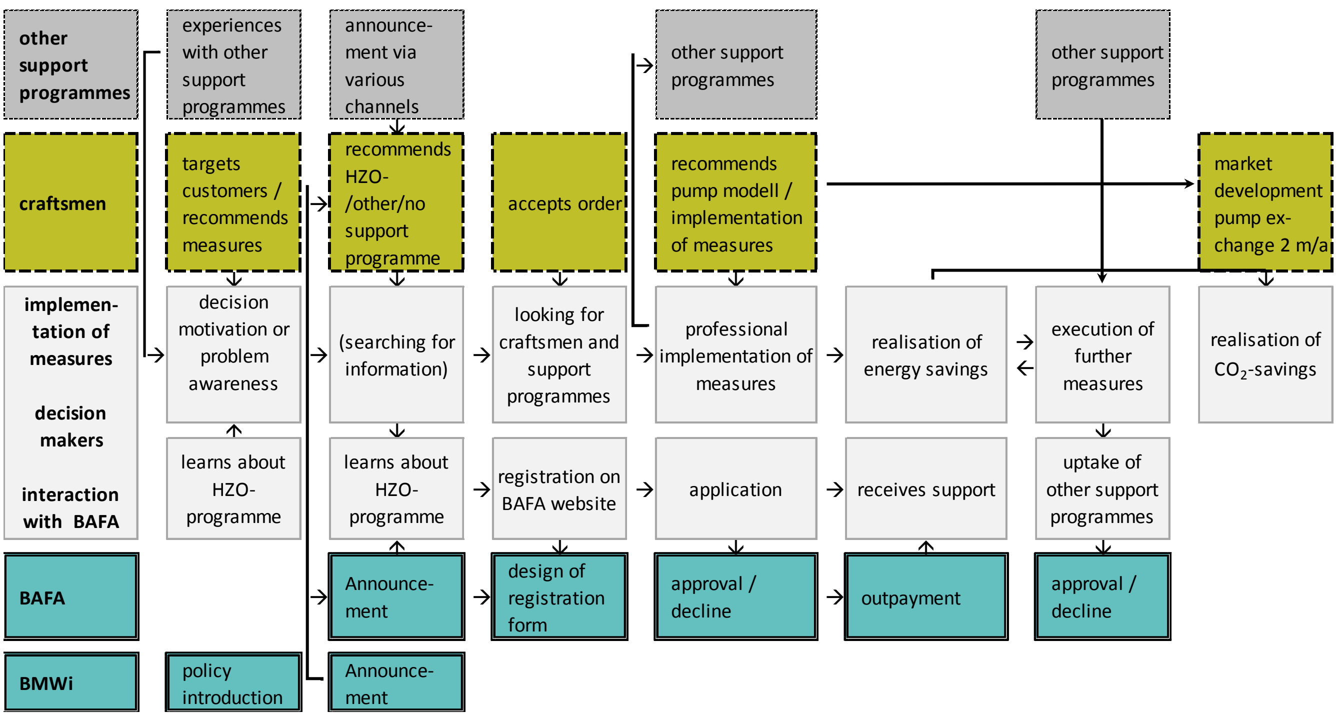


Figure 1. Programme Theory. *Source*: own graph.

## Main indicators evaluated and methods applied

On the basis of the evaluation questions of the evaluation mandate and the programme theory several cause-effect hypotheses (such as `the subsidy triggers further efficiency measures´) were derived describing the different steps of the causal chain of the programme. These evaluation questions and hypotheses were tested with the help of indicators. For the data analysis and verification of hypotheses a mix of methods was used. These include calculations based on standard indicators frequently used in energy evaluations (e.g.

average heated area; energy source mix of heating energy), theory based qualitative data collection and analyses (e.g. focus groups on programme barriers based on the Theory of No Change), calculation based on quantitative data collection and testing hypothesis based on indicators. The methodological approaches applied are described in detail in the respective following sections, presenting the evaluation results.

The indicators were clustered in eight thematic groups: 1) public relations / awareness of the programme, 2) number of registrations, 3) reaching the target groups, 4) impact including $CO_2$ reduction achieved, 5) multiplier effect, 6) economic effects, 7) implementation efficiency and 8) effectiveness of subsidies provided. At the time of this paper, the evaluation was based on 29 indicators. These include amongst others: number of website visitors, awareness of the programme among private building owners, number of registrations, share of subsidies per target group, energy savings (electricity / heat), $CO_2$ emission reduction, share of administrative expenses per application and lastly induced investments.

### Data sources

In order to test the hypotheses developed, the following primary and secondary data collection and analysis was conducted (dates in parentheses indicate the year the data was collected and analysed):

- A comprehensive literature review (i.e. scientific papers and grey literature, governmental documents, comparable evaluations), among other things, as a basis for the market analysis and for the determination of input variables of calculations (2017),
- The preparation of an initial market analysis in 2017 and a more in-depth analysis in 2018,
- The semi-annual evaluation of the programme statistics (micro data) over time (2017 – now),
- Interviews with HVAC contractors, chimney sweepers and the real estate industry (June 2017 to April 2019),
- Interviews with other key stakeholders of the programme (June 2017 to April 2019),
- An annual debriefing with BAFA (with a query on administrative costs) and BMWi (2017 – now),
- The analysis of other support programmes (first time in 2017 with update in 2018),
- Three focus groups with private building owners from different regions of Germany who have not taken advantage of the HZO-programme, as part of the barrier analysis (March 2018),
- An online survey of the recipients of subsidies (sent to 66,748 e-mail addresses, response rate 21 % or 13,911 respondents) (2018),
- An online survey of all persons registered at that time (sent to 31,836 email addresses, response rate 9 %) (2018).

The data collection for this paper was partly on-going and partly at certain points in time between June 2017 and January 2020.

## Intermediate evaluation results

### Programme achievements

The application procedure for subsidies is a two-step process. First, applicants need to register within the programme database *before* heating optimisation measures are implemented. Afterwards there is a six months window in which measures can be implemented and subsidy applications submitted. This proceeding aims to reduce free riding. To apply for subsidies, invoices have to be submitted via the online portal.

Until June 2019, 180,545 subsidy applications had been submitted of which 179,069 had been processed.[2] Out of these processed applications, 168,633 or 94 % had been approved and 10,436 or 6 % had been rejected. This suggests a well-designed application procedure, in which a majority of applicants apparently had little problems to understand and adhere to the formal programme requirements. This has also been corroborated by the results of the programme user survey.

The statistics on programme use over time show spikes in registrations and applications within the heating periods (i.e. September to March) (cf. Figure 2) which suggests increased utilization of the programme on the occasion of pump failure. This is a plausible assumption, considering that few private building owners (which represent the majority of applicants) would deliberately suffer the inconvenience of heating system disruption during this time of the year.

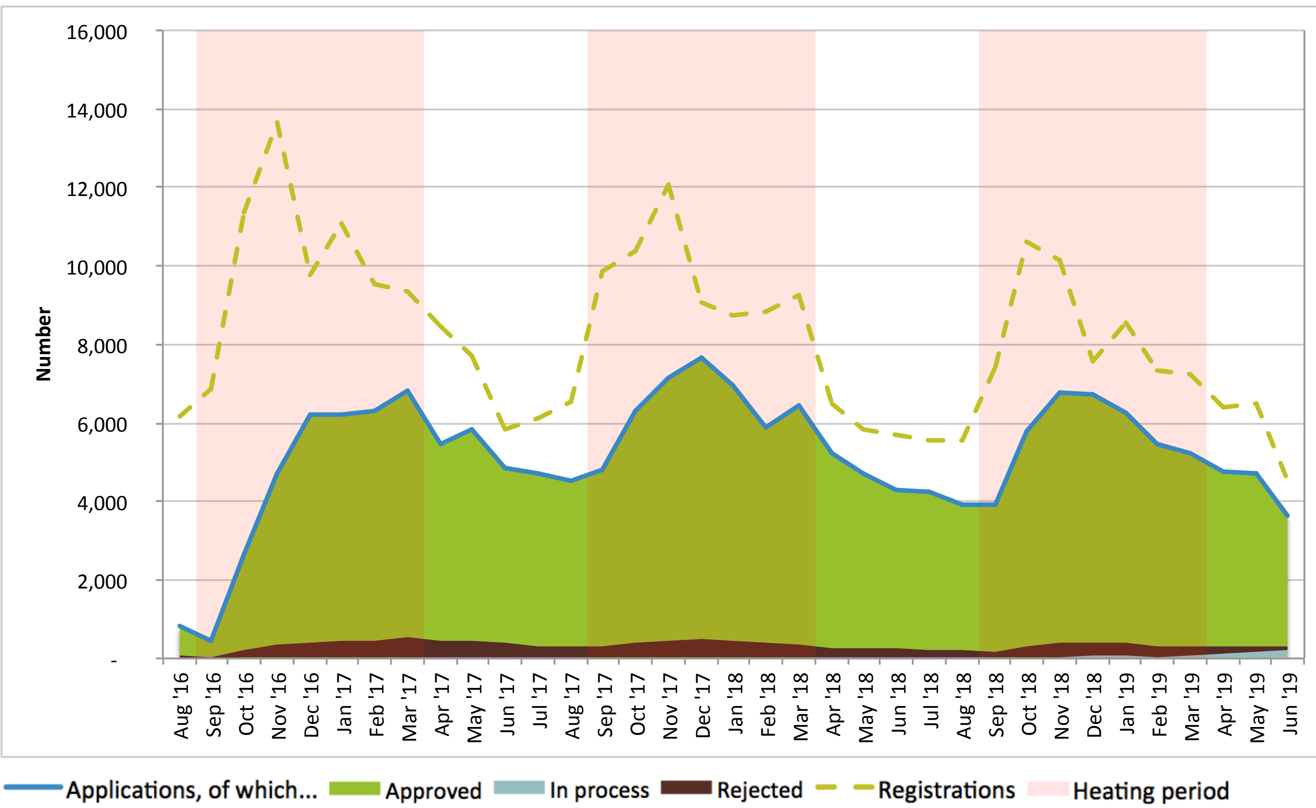


Figure 2. Monthly numbers of registrations and applications including their status (approved, rejected, pending decision) between August 2016 and June 2019. *Source:* own graph based on the programme statistics.

Based on approved applications, HZO had supported 394,620 energy efficiency measures by June 2019. These consisted of 249,288 pump replacements (207,300 glandless circulation pumps, 41,178 warm water circulation pumps and 810 dry running circulation pumps), 50,367 hydraulic balancing and 94,965

[2] All results shown in this section are based on the analysis of the programme statistics.

accompanying measures.[3] To support these measures, subsidies amounting to almost 79.9 m euro were provided to the applicants.[4]

Looking at the distribution of approved applications across the programme target groups shows that private building owners account for the major share of the 168,633 successful applications (84 %), followed by businesses and freelancers (7 %) and homeowners' associations and property management companies (6 %) (cf. Figure 3). This is in line with the programme rationale, which defined private building owners as the central target group for heating optimisation measures. Other applicant groups (including public institutions as well as associations and foundations) only submitted a small share of the approved applications (3 %). The distribution of subsidies shows a corresponding pattern although the shares deviate due to cost differences of the respectively implemented measures.[5] Accordingly, private building owners - though still leading the ranking - received a comparatively lower share of total paid subsidies (65 %), followed by enterprises and freelancers (18 %), homeowners' associations and property management companies (10 %) and other target groups (7 %) (cf. Figure 3).

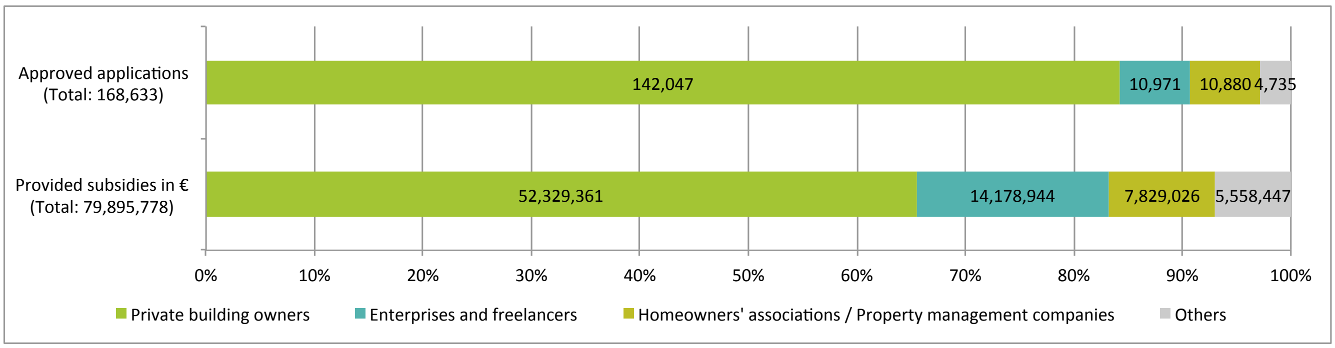


Figure 3. Distribution of approved applications and provided subsidies across programme target groups in absolute and relative terms. *Source*: own graph based on the programme statistics.

The geographical distribution of approved applications shows that a majority (105,200 or 62 %) originates from the populous states of Bavaria, North Rhine-Westphalia and Baden-Wuerttemberg in southern and western Germany, in which correspondingly also the majority of subsidised measures have been implemented. Lowest numbers of approved applications were found for the city states of Hamburg, Bremen and Berlin as well as the north-eastern state of Mecklenburg-Vorpommern. When set into proportion with the

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3 Accompanying measures are only subsidised in combination with hydraulic balancing and comprise installation of measuring and control technology user interfaces, buffer storage, sectioning valves, technology for flow rate control and thermostatic valves.

4 The extent to which predefined targets (of HZO) were achieved are not presented in this paper because they do not provide meaningful insights. The market analysis carried out at the start of the project has shown that the targets set in the directive are based on the assumptions of a too large reference market and a too high stock of inefficient pumps eligible for programme support (e.g. substantial numbers of pumps in the stock are integrated into the boilers and cannot be replaced in a simple manner, and thus also not be addressed by the programme). The unrealistic high programme targets can therefore not be achieved.

5 While private building owners usually install one or few small scale glandless circulation pumps or warm water circulation pumps, applicants from different target groups operate larger facilities and thus often apply for support for the purchase and installations of multiple and / or larger scale pumps, which translates into higher subsidies per application. The same applies for other heating optimisation measures (e.g. hydraulic balancing), whose costs correlate with the size of the heated floor area. Respective differences across target groups have been collected in the beneficiary survey (n=13,911) and found on average to range between factor 3 to 10 (ca. 196 $m^2$ for private building owners and ca. 1,961 $m^2$ for public institutions).

number of households living in the different states, the order at the upper and bottom tail slightly changes. Without in-depth inquiry into the reasons of this geographical distribution, it is plausible to assume disposable household incomes, general attitudes towards subsidy programmes, the amount of nearby energy advice offers (e.g. via regional energy agencies), availability of HVAC contractors and home ownership structures in the different states to be additional factors besides absolute household numbers. For instance, home ownership rates in those states with the lowest absolute and relative numbers of applications are with 37.8 % (Bremen), 23.9 % (Hamburg) und 17.4 % (Berlin) partly well below the national average (46.5 %).[6]

## Impact evaluation

Based upon a bottom-up calculation of theoretical savings resulting from the implementation of supported measures, the programme has been estimated to deliver yearly net final energy savings of 147.32 GWh (gross 307.15 GWh) (cf. Figure 4). Total final energy savings consist of heat energy savings attributed to hydraulic balancing (ca. 61 % of total savings) as well as electricity savings due to the replacement of inefficient pumps (ca. 39 %). In order to calculate the respective final energy savings, different methodological approaches were applied. With regard to heating energy savings, the number of hydraulic balancing measures was multiplied with an assumed 10 kWh final energy saving per $m^2$ and year (Wolff et al. 2014) and the weighted average heated floor area across all applications (342 $m^2$) and adjusted for free-rider effect (see following section). In order to determine the weighted average heated floor area, the results of a survey among programme beneficiaries comprising the average heated floor area per target group as well as the number of approved applications comprising hydraulic balancing per target group from the programme statistics have been used (for an overview see Table 1).

Table 1: Input factors to determine the energy savings attributed to hydraulic balancing

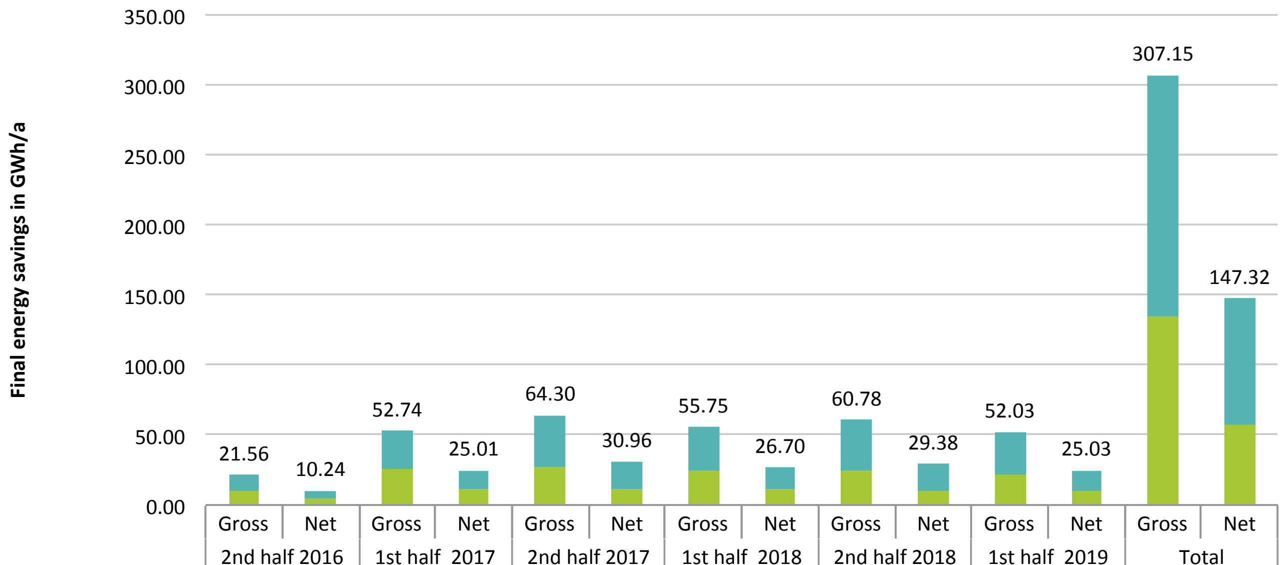
| **Target group** | **Private building owners** | **Homeowners' associations and property management companies** | **Enterprises and freelancers** | **Public institutions*** | **Associations and Foundations** | **All** |
|---|---|---|---|---|---|---|
| **Ø heated floor area (in $m^2$)** | **196.3** | **672** | **1,843.9** | **1,960.7** | **1,113.4** | **342[1]** |
| **Number of approved applications (by June 2019)** | n = 44,528 | n = 1,834 | n = 2,614 | n = 1,048 | n = 343 | n = 50,367 |

[1] *Weighted average across all target groups.* *Definition of Public institutions: municipalities, public corporations, special purpose associations and local administration union. *Source*: Programme statistics and beneficiary survey (n=13,911).

In order to calculate the electricity saved by replacing inefficient pumps, we calculated the difference between the average consumption of efficient pumps eligible for programme support and that of the existing stock by performance class. We did this by assuming yearly operating hours of 5,000 hours for glandless circulation pumps, 5,840 hours for warm water circulation pumps and 6,500 hours for dry running circulation pumps. Weighted average final energy savings were calculated per pump type, differentiated into small pumps (i.e. glandless circulation and warm water circulation pumps → 537 kWh) and big pumps (i.e. dry running circulation pumps → 1,631 kWh). This figure was, multiplied with the number of subsidised pumps and adjusted for free-rider effect. To account for the additional saving effect of an applicant with a broken pump choosing a very efficient pump over one with an Eco-design standard due to the subsidy offer, the small

[6] Figures are for 2018, cf. https://www.destatis.de/DE/Themen/Gesellschaft-Umwelt/Wohnen/_Grafik/_Interaktiv/eigentuemerquote.html

difference between the respective average consumption levels (small pumps: 20 kWh; big pumps: 435 kWh) has been multiplied with the number of free-rider effect cases and added to the overall programme result.




| | Gross | Net | Gross | Net | Gross | Net | Gross | Net | Gross | Net | Gross | Net | Gross | Net |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2nd half 2016 | | 1st half 2017 | | 2nd half 2017 | | 1st half 2018 | | 2nd half 2018 | | 1st half 2019 | | Total | |
| Total | 21.56 | 10.24 | 52.74 | 25.01 | 64.30 | 30.96 | 55.75 | 26.70 | 60.78 | 29.38 | 52.03 | 25.03 | 307.15 | 147.32 |
| Heat energy savings | 11.13 | 5.79 | 26.57 | 13.82 | 37.21 | 19.35 | 30.88 | 16.06 | 36.49 | 18.97 | 30.02 | 15.61 | 172.30 | 89.60 |
| Electricity savings | 10.43 | 4.46 | 26.17 | 11.19 | 27.09 | 11.61 | 24.87 | 10.64 | 24.29 | 10.40 | 22.01 | 9.42 | 134.85 | 57.73 |

Figure 4. Calculated yearly gross and net final energy savings disaggregated by heat energy and electricity by half year. *Source*: own graph based on the programme statistics.

Overall, the programme so far has supported the replacement of 248,478 small and 810 big pumps as well as 50,367 hydraulic balancing interventions. In terms of $CO_2$ reductions, the above-mentioned final energy savings translate into 57,587 t $CO_2$ savings per year. An overview of the distribution to the different measures is presented in Figure 5. To transform final energy savings into $CO_2$ reductions, different emission factors have been used for electricity and heating energy. For the former, the official emission factor for the German power mix (600 g $CO_2$ / kWh) has been used. For the heating energy, an average weighted emission factor has been calculated (256 g $CO_2$ / kWh) based on the distribution of heating systems among beneficiaries (as collected within the survey) and the corresponding emission factors as summarised by *Schüwer et al. (2015).*

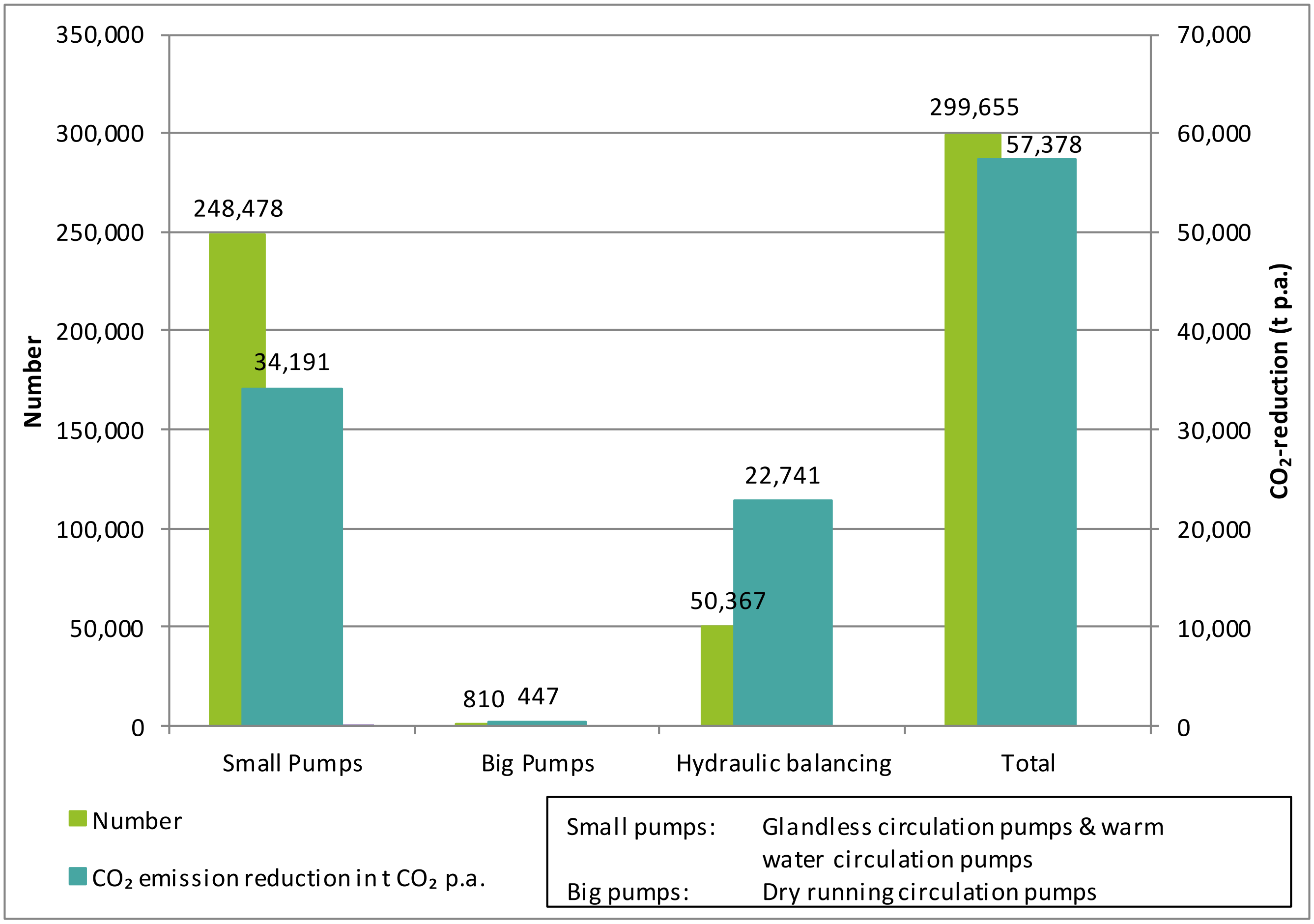



Figure 5. Number of supported measures by type and associated $CO_2$ reductions by June 2019. *Source*: own graph based on the programme statistics.

The extent to which predefined targets (of HZO) were achieved are not presented in this paper because they do not provide meaningful insights. The market analysis carried out at the start of the project has shown that the targets set in the directive are based on the assumptions of a too large reference market and a too high stock of inefficient pumps eligible for programme support (e.g. substantial numbers of pumps in the stock are integrated into the boilers and cannot be replaced in a simple manner, and thus also not be addressed by the programme). The unrealistic high programme targets can therefore not be achieved.

## Causality Analysis

In order to determine the additionality of the HZO-programme, again the results of the beneficiary survey were used. Within the survey, data on the types of measures (i.e. heating pump replacement, warm water circulation pump replacement, hydraulic balancing or accompanying measures) implemented by the respondents was collected. To identify whether these measures were attributable to the programme, beneficiaries were asked:

*Would you have also implemented the measure(s) without the subsidy?*

*Yes.*

*Yes, but at a later point in time.*

*Yes, but only a part of the measures.*
*No.*
*Don't know / No answer*

Each response type was then coded. Those answering "No" were coded as having implemented measures that were **fully attributable** to the programme. Those answering "Yes" were marked as creating a **free-rider effect**. Respondents answering "Yes, but at a later point in time" were considered to be demonstrative of the programme's **pull effect** (and the effects also attributable to the programme). To assess how "Yes, but only a part of the measures" should be coded, a follow up question was asked as to which of the measures would not have been implemented without the subsidy. While this approach holds the risk of introducing bias via self-reporting (e.g. through social desirability bias), the subject is sufficiently impersonal to assume no significant bias. With regard to pump replacements, 5,507 out of 13,608 respondents were considered to have implemented measures due to the programme ("No" n=1,893; "Yes, but at a later point in time." n=3,104 and "Yes, but only a part of the measures." n=510). Accordingly, a significant part of the programme impact can be attributed to its pull effect. With regard to hydraulic balancing measures, 1,739 out of 3,375 respondents were considered to have implemented measures due to the programme ("No" n=465; "Yes, but at a later point in time." n=730 and "Yes, but only a part of the measures." n=544). This again points to a pull effect as well as to the programme providing a decisive incentive to implement hydraulic balancing in addition to pump replacements.

In summary, causality factors of 0.40 for pump replacements and 0.52 for hydraulic balancing were determined. While these in combination with the programme utilization patterns (see under Programme Achievements) underline the creation of significant free-rider effect, these are in line with the expectations at the outset of the programme set-up.

## Barrier analysis

At various points in the cause-effect-chain there may be obstacles that prevent the HZO-programme achieving its intended effect. To validate the barriers identified in the literature review, the evaluators consulted three sets of stakeholders who did not benefit from, or otherwise could provide information on how heating optimisations could happen without HZO subsidies: interviews were carried out with chimney sweepers, HVAC contractors and other relevant stakeholders; three focus groups with home owners that have not utilized the HZO-programme yet were conducted; and a survey of private building owners that registered for the programme, but did not submit an application was conducted. A barrier analysis was undertaken based on hypotheses developed using the `Theory of No Change´ (TONC) (Wörlen 2011).

The TONC assumes that there are four relevant stakeholder groups: potential programme beneficiaries, supply chain actors (including HVAC contractors), local financiers, and political / administrative decision-makers including subsidy programmes, regulations and laws (policy makers). These stakeholders are faced with six types of barriers: 1) lack of awareness; 2) lack of interest / motivation; 3) lack of practical knowledge; 4) lack of access to technology / HVAC contractors; 5) lack of profitability and 6) lack of affordability. Having this in mind, the barriers identified by the evaluation team can be clustered into two main categories: 1) barriers that hamper the implementation of the eligible measures of the HZO-programme and 2) barriers hampering the utilization of the HZO-programme itself.

The most significant barrier for the implementation of heating optimisation measures in Germany is a lack of HVAC contractor availability / interest in implementing them. The current capacity constraints and workload within the HVAC contractors in Germany is very high resulting in little interest in new orders with low margins. It is precisely these low-threshold, cost-effective efficiency measures (hydraulic balancing, pump replacement) that the HZO programme focuses on in order to motivate larger investments beyond the scope of the programme. HVAC contractors often fail to inform private building owners about the possibility of low-investment measures. When asked about the reasons why they had not carried out a measure after registering on the BAFA website, 21 % of the (potential) programme beneficiaries stated that they had not found a HVAC contractor to carry out the measure. Both private building owners and HVAC contractors conveyed the impression of mutual expectations and responsibility that heating optimisation measures had to be actively requested and offered. While the private building owners justified the lack of implementation by saying that the HVAC contractors had not adequately informed them about energy savings potential of heating optimisation, they on the other hand complained that the private building owners were not interested in such information. Apart from this, both the HVAC contractors themselves and other interviewees stated that many HVAC workers are not sufficiently qualified to carry out hydraulic balancing. The measure is basically unpopular in the professional field. About half the (potential) programme beneficiaries who registered with the HZO-programme but ultimately did not carry out a measure considered the measure too expensive or technically impossible to implement with the existing heating system. The profitability of the pump replacement was not questioned. However, the hydraulic balancing in existing buildings was often, without a valid data basis, considered uneconomical, even for final customers owning their heating system. This was justified by the effort involved where a large number of valves would have to be replaced and sometimes a complete pipe plan would have to be drawn up.

The availability of financial resources played a subordinate role in the eyes of most interviewees. Only groups with very low disposable income, such as pensioners, were not considered able to raise the necessary financial resources by other stakeholders.

Beyond general obstacles to the implementation of heating optimisation measures, there are additional obstacles to the use of subsidies in general and the HZO-programme in particular. On the basis of a representative survey, interviews with experts and several focus groups with private building owners, the evaluators found that awareness of the HZO-programme was low. All the surveys on the topic `awareness of subsidy programmes for heating systems´ showed that the households surveyed often have difficulties in differentiating between different subsidy programmes and operating entities. For example, the HZO-programme was only occasionally perceived as a separate programme from the offers of the Kreditanstalt für Wiederaufbau (KfW). The investigation of several other public subsidy programmes showed that the HZO-programme offers the best support for almost all target groups. However, the HZO-programme is not the most attractive programme for larger or more complex measures. For these cases the KfW-programme includes a number of financial incentives that affect the entire heating system that are not included in the HZO-programme. For the real estate industry and other target groups with more complex buildings, KfW-programme support may therefore be more appropriate if they wish to receive financial incentives for advisory, planning and construction support services. However, the HZO-programme also loses potential applicants to KfW-programmes due to other reasons. KfW, for instance, with a generally longer tradition in the field of building refurbishment, is the first point of contact for many of the target groups when looking for financial support. The HZO-programme also suffers from the fact that the multipliers are also more familiar with KfW-programmes and are thus more likely to recommend these.

Apart from the lower awareness of the BAFA-programmes compared to the KfW-programmes in general, there are significant prejudices about the supposedly high bureaucratic effort involved in subsidies - which are, however, unjustified in relation to the HZO-programme: 98 % of the subsidy recipients stated that they were satisfied with the application procedure and would recommend it to others.

## Results of cost-effectiveness evaluation

Five economic indicators were analysed in this programme evaluation: 1) programme administration costs to assess the implementation efficiency; 2) programme induced investments / demand effect; 3) cost-effectiveness from the perspective of programme beneficiaries; 4) cost-effectiveness from a societal perspective; and 5) subsidy effectiveness in terms of programme costs compared to energy savings and $CO_2$ emissions reductions.

**Programme administration costs**

In order to examine implementation efficiency, i.e. administrative costs and the proportion of total programme budget these made up, a cost-effectiveness calculation was implemented. The total administrative costs result from the combined administrative costs at the BAFA and the BMWi.

Compared to other subsidy programmes[7], the administrative cost quota of the HZO-programme is within the usual range. The share of administrative costs in the total budget of the subsidy programme is 10.58 % (as of 31.12.2018). It has decreased over time. By the end of 2017 it was 15.25 %. This is partly due to learning effects in the administration and partly since the absolute subsidy sum per application has increased from 391 euro by the end of 2017 to 461 euro by the end of 2018.

**Programme induced investments / demand effect**

The induced investments (excluding VAT) of the programme correspond to the additional macroeconomic demand effect and can also be interpreted as additional sales revenue of the HVAC contractors. Programme investments comprise the costs of the HVAC contractors and the costs of the measures implemented by the end-users. The analysis distinguishes between investments made in any case, i.e. also without the programme, and investments induced by the financial support provided under the HZO-programme.

The net investments per target group are calculated from the programme statistics. In order to calculate the additional investments induced by the HZO-programme, target group-specific causality factors are determined, which are based on the results of the online survey conducted among programme beneficiaries.[8] By multiplying the total investments per target group with the target group-specific causality factors, the additional investments induced by the HZO-programme are obtained.

The total gross investments (incl. VAT) amounted to 308,911,787 euro from programme start until 30.06.2019. They comprise the investments induced by the HZO-programme amounting to 108,184,168 euro, investments of 160,942,049 euro that would have been made anyway and VAT payments of 39,785,570 euro.

**Cost-effectiveness for programme beneficiaries**

Subsidies were paid out at 30 % of the total cost (excluding VAT) of optimising the heating system for the grant recipient. The cost-effectiveness from the end-user's perspective indicates whether the measures supported by the programme are economically attractive for the target groups and what effect the financial support has in this respect. The benefit-cost-ratio is calculated by dividing the present value of the energy cost savings over the measure lifetime by the investment costs (including and excluding the subsidies provided). The present value was calculated using an interest rate of 1.5 % for both private building owners and homeowners' associations and property management companies and 8 % for enterprises, and by assuming the following measure lifetimes: 10 years for hydraulic balancing, 15 years for glandless and warm water circulation pumps

[7] The HZO programme was benchmarked against several comparable national subsidy programmes. These include: BAFA: Umweltprämie (environmental bonus), BMWi: Investitionszuschüsse zum Einsatz hocheffizienter Querschnitts-technologien im Mittelstand (Investment grants for use of highly efficient cross-sectional technologies in middle class), BMWi: Energiesparberatung vor Ort, Förderjahr 2012 (Energy saving advice on site, funding year 2012), BMWi: Beratungs-förderung für KMU und freie Berufe (Consulting support for SMEs and liberal professions), KfW: Energieberatung im Mittelstand(Förderperiode 2012-2013) (Energy consulting for medium-sized companies (funding period 2012-2013)

[8] The following causality factors are applied for the target groups: private building owners: 0.44, enterprises and freelancers: 0.36, homeowners' associations and property management companies: 0.31, other: public institutions (municipalities, public corporations, special purpose associations and local administration union), associations and foundations: 0.32.

and 30 years for dry running circulation pumps. Energy cost savings are calculated with 2018 final energy prices for electricity and heat.[9] The calculation is done for different typical use cases for the target groups. A benefit-cost ratio > 1 shows that a measure implementation is cost-effective for programme beneficiaries.

The results of the analysis for pumps show that most of the supported measures are cost-effective even without the subsidies, but that the financial incentives can provide a decisive impulse, in particular in the case of dry running circulation pumps (cf. Table 2).

Table 2: Results of the cost-effectiveness analysis from the perspective of programme beneficiaries

| **Measure type** | **Dry running circulation pumps** | **Warm water circulation pumps** | | **Glandless circulation pumps** | | | |
|---|---|---|---|---|---|---|---|
| **Target group analysed** | Enterprises | Home-owners' associations and property manage-ment companies | Private building owners | Home-owners' associations and property manage-ment companies | Home-owners' associations and property manage-ment companies | Private building owners | Private building owners |
| **Watt of pumps analysed** | whole range | whole range | whole range | 100-199 W | ≤ 30 W | 100-199 W | ≤ 30 W |
| **Benefit-Cost-Ratio excl. subsidies** | **0.81** | **3.00** | **2.30** | **3.23** | **2.02** | **3.87** | **2.46** |
| **Benefit-Cost-Ratio incl. subsidies** | **1.16** | **4.08** | **3.08** | **4.39** | **2.74** | **5.17** | **3.29** |

The analysis has also shown that hydraulic balancing is cost-effective in connection with the financial incentives as an individually supported measure for the three analysed target groups, although the benefit-cost ratio for homeowners' associations and property management companies (1.03) and private building owners (1.01) is only slightly positive. The benefit-cost ratio for enterprises is with 1.99 significantly higher, meaning that future energy cost savings will almost outweigh twice the investment costs. Without subsidies hydraulic balancing is, however, as an individual measure not very attractive for the two other target groups investigated (benefit-cost ratios of 0.76 and 0.75). Also, in view of the high proportionate $CO_2$ reductions of hydraulic balancing, it is important to keep hydraulic balancing in the focus of financial support and possibly to incentivise the measure more strongly.

**Cost-effectiveness from a societal perspective**

The indicator reflects whether the energy system cost savings that result from the programme induced energy savings outweigh the investment costs (excl. VAT) of the measures implemented. The benefit-cost ratio

[9] Electricity: 28.19 ct / kWh (BMWi 2018); heat: 7.8 ct / kWh (BMWi 2018; C.A.R.M.E.N. E.V. 2018).

is calculated by dividing the present value of avoided energy system costs over the lifetime of the measures by the investment costs (excl. VAT). A benefit-cost ratio > 1 shows that the promotion of the HZO measures is beneficial from a societal perspective.

The net investment costs are directly calculated from the programme statistics. The avoidable long-run electricity system costs are based on the results of Prognos and IAEW (2014). A lower value of 11.87 ct and an upper value of 15.53 ct per kWh of electricity saved by heating and warm water circulation pumps is used in the calculations. As there is no comparable study for savings of thermal energy carriers in Germany, the avoidable energy system costs for gas and heating oil are approximated based on energy market prices, taxes, network tariffs and $CO_2$-prices. Taking into account the proportionate savings of gas and heating oil through hydraulic balancing, the average values for savings of thermal energy sources amount to 4.87 ct and 9.87 ct per saved kWh, depending on the $CO_2$ price applied.[10] The two limit values are applied to the achieved savings of hydraulic balancing. As the future development of the capital market interest rate cannot be predicted, the present value was calculated using an interest rate of both 4 % and 0 %. Moreover, the same measure lifetimes have been assumed as in the above analysis from the investor perspective. Further multiple impacts of energy efficiency such as employment or GDP effects, increased energy security or avoided environmental damage costs have not been considered in the calculations.

The results show that the benefits of the programme, i.e. the avoided energy system costs, substantially exceed the investment costs. This is also true if a capital market interest rate of 4 %, which is high from today's perspective, is assumed, if low avoided energy system costs are assumed and despite neglecting the other multiple benefits for the national economy. Depending on the interest rate and energy system cost scenario considered, the benefits of the HZO-programme exceed the costs by more than 1.5 to almost 3 times (cf. Table 3). Each euro invested thus leads to savings higher than one euro. The promotion of the HZO measures is therefore beneficial from a societal perspective.

Table 3: Results of cost-effectiveness analysis from a societal perspective

| | **Sensitivity analysis A:** Interest rate: 4 % Avoided energy system costs: low | **Sensitivity analysis B:** Interest rate: 4 % Avoided energy system costs: high | **Sensitivity analysis C:** Interest rate: 0 % Avoided energy system costs: low | **Sensitivity analysis D:** Interest rate: 0 % Avoided energy system costs: high |
|---|---|---|---|---|
| Present value (€) | 160 | 222 | 214 | 296 |
| Investment costs (€) | 101 | 101 | 101 | 101 |
| **Benefit-Cost-Ratio** | **1.58** | **2.20** | **2.12** | **2.93** |

**Effectiveness of subsidies provided**

The effectiveness of subsidies provided represents the relationship between the programme costs and either the energy savings or the $CO_2$ emission reductions. It is an additional indicator enabling the comparison of different financial incentive programmes to support economical housekeeping on the federal budget. The effectiveness of subsidies as the ratio between the programme costs and the absolute $CO_2$ reduction resulted in 37.29 euro / t $CO_2$ (gross) and 87.69 euro / t $CO_2$ (net) across all applications except accompanying measures.[11] The leverage effect of the programme was 0.32 euro in programme costs per euro invested (gross).

[10] A lower value of 25 euro / t $CO_2$ reflecting the current price in the EU-ETS is assumed and an upper value of 180 euro / t $CO_2$ reflecting the external damage cost of climate change (UBA 2019).

[11] Accompanying measures are those investments that are only subsidised in connection with the performance of hydraulic balancing, including buffer storage tanks and line valves. These measures are not differentiated in the statistics, thus no $CO_2$ emission reduction can be calculated for these cases.

## Evaluation implementation challenges and lessons learned

The evaluation was conducted without any implementation challenges. However, whilst the monitoring of the programme provided a broader set of data, and the scope of the evaluation requested by the authorities was broader too, during the implementation of the evaluation, the evaluation team encountered a range of challenges that related to the programme and evaluation framework, the evaluation methodology as well as to data collection / availability.

From a methodological point of view, the calculated savings as well as some cost-effectiveness indicators have been structurally underestimated due to the fact that there is no scientifically sound / reliable estimation of savings attributable to (in parts quite) costly accompanying measures. Furthermore, with hydraulic balancing accounting for a major share of the calculated programme savings, there is a strong dependency of the evaluation results on the assumed average final energy savings per year and $m^2$. This parameter is however strongly dependent on a building's insulation level (Wolff et al. 2014) and would thus require more detailed information on the building stock of programme beneficiaries for an accurate determination.

Lastly, with regard to data, the team encountered difficulties to engage HVAC contractors and the circulator industry for expert interviews. Access to and appointment coordination with the former was hampered by the described capacity constraints and a certain mistrust towards the evaluation team thought by some to represent industry interests. Furthermore, also with regard to the programme statistics there were some monitoring gaps that undermined the accuracy of the impact estimates. For instance, data on hydraulic balancing and accompanying measures were only collected in a binary manner, i.e. whether the measure had been implemented or not but not how often / many were installed. Accordingly, this represented another source of systematic underestimation of impacts.

The listed challenges provided for some valuable lessons with regard to future evaluations of comparable support programmes.

## Conclusions

In economic terms, the HZO Programme is cost-effective and worthwhile for both end-users and the economy as a whole. From the end-user's point of view, it is unbureaucratic and recommendable. However, the outreach of the programme differed significantly across target groups and regions. The main beneficiaries of the programme so far are private building owners situated in the two most populous states of Germany. The two aspects, target group and regional distribution, need further investigation to understand why this is the case. The use of the HZO Programme is limited by several factors such as the currently high capacity constraints in the HVAC sector, significant prejudices about the supposedly high level of bureaucracy involved in the application for funding and confusion about the numerous subsidising options for energy efficiency measures. The evaluation team expects further findings from the empirical review of the qualitative barrier analysis, particularly on the weighting of these barriers.

Based on the evaluation performed so far, a series of recommendations to increase programme effectiveness have been formulated. These include: 1) An explicit target group-specific communication strategy for the promotion of pump replacement and heating optimisation and corresponding advertising measures to increase the awareness of the HZO Programme; 2) Motivation offers, training and further education for the HVAC workforce on technical and subsidy-related questions and the qualification of energy consultants and workers, especially for the planning and implementation of hydraulic balancing in apartment buildings and non-residential buildings and 3) Merging the HZO Programme with the programmes of the KfW in a modular system in the sense of a 'one-stop shop'. The first three recommendations would also require a significant increase in the share of the overall budget used for these supportive actions, by at least a factor of two or three.

However, it has to be noted that these recommendations are based on the evaluation findings until June 2019. Since then the political framework conditions (such as the new climate protection law) have changed. Such contextual factors may have an effect on programme results / progress. Furthermore, the data collection process is not completed yet. Both of these factors impact upon the final recommendations the evaluation team will formulate in its final report.

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