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Article information

Article title

IMPRO – An Industrial Heat Demand Profile Tool: Multi-Temperature load profile generation for industrial heat demand modelling

Max. 20 words. The title should be unique.

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Keywords

Industrial Heat Demand; Heat Load Profiles; Process Heat; Excess Heat

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J. van der Geer, J.A.J. Hanraads, R.A. Lupton, The art of writing a scientific article, J. Sci. Commun. 163 (2010) 51–59. https://doi.org/10.1016/j.Sc.2010.00372

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Abstract

Accurate representation of industrial heat demand is essential for analysing decarbonization strategies and enabling cross-sectoral energy system integration. However, its variability across time, sectors, and temperature levels poses a significant modelling challenge. This work presents IMPRO (Industrial Heat Demand Profile Generator), a novel methodology for generating hourly, multi-temperature industrial heat load profiles. IMPRO builds on a cluster-based regression approach that links outdoor temperature to heat demand and extends it by integrating temperature level distributions and standardized operational patterns. The result is a flexible tool capable of producing realistic process heat profiles with high temporal resolution. In addition to accepting user-defined inputs, IMPRO includes a library of ready-to-use standard profiles for seven major industry sectors, allowing users to quickly generate and scale profiles based on outdoor temperature data. It also supports the estimation of excess heat availability across temperature levels to aid in heat recovery assessments.

Method highlights:
• Cluster blend to represent seasonal variations in heat demand.
• Integration of temperature level distributions to reflect sector-specific heat use.
• Increased temporal resolution through incorporation of hourly shift-based profiles.

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Specifications table

This table provides general information on your method.

Subject area	Energy
More specific subject area	Industrial Heat Demand Profile Generation
Name of your method	A tool that enables generation of multi-temperature level heat load profiles with hourly resolution for different industrial sectors based on ambient temperature profiles and total heat demand.
Name and reference of original method	Mateo Jesper, Felix Pag, Klaus Vajen, Ulrike Jordan, Annual Industrial and Commercial Heat Load Profiles: Modeling Based on k-Means clustering and Regression Analysis, Energy Conversion and Management: X, Volume 10, 2021, 100085, ISSN 2590-1745, https://doi.org/10.1016/j.ecmx.2021.100085 Fabian Bühler, Stefan Petrović, Fridolin Müller Holm, Kenneth Karlsson, Brian Elmegaard, Spatiotemporal and economic analysis of industrial excess heat as a resource for district heating,

	Energy, Volume 151, 2018, Pages 715-728, ISSN 0360-5442, https://doi.org/10.1016/j.energy.2018.03.059.
Resource availability	https://github.com/tillho/IMPRO *If applicable, include links to the resources necessary to reproduce your method (e.g., equipment, data, software, hardware, reagents).*

Background

Heating and cooling account for approximately 50% of the total energy demand in the European Union, with industrial process heating alone responsible for 32% of this heat consumption in 2015. [1] Given its significant role in total energy consumption, the industrial sector is a key component of integrated energy system models that assess questions related to decarbonization pathways in the heating sector. However, representing industrial heat demand in such models presents unique challenges due to its high degree of heterogeneity compared to space heating demand.

In residential and commercial buildings, heat demand primarily consists of space heating and domestic hot water, which occur at relatively uniform temperature levels and exhibit predictable seasonal variations. In contrast, industrial process heat demand is highly sector-specific, varying widely in terms of temperature requirements, operational schedules, and load patterns across different industries. This variability poses a challenge for energy system models, particularly those with high temporal resolution, as they aim to capture cross-sectoral synergies, energy balancing mechanisms, and interactions between different energy carriers. Additionally, the feasibility of various heat supply technologies is strongly influenced by the required temperature levels, making a detailed representation of process heat demand across multiple temperature ranges essential for analysing industrial decarbonization strategies.

A more accurate representation of industrial heat demand also enables a better assessment of excess heat availability, as the two are intrinsically linked. Many industrial processes generate surplus thermal energy, which, if properly accounted for, could significantly improve energy efficiency and contribute to sector coupling strategies. However, excess heat utilization remains an underrepresented aspect in integrated energy system modelling, despite its substantial potential for decarbonization. [2] By improving the way process heat demand is characterized - particularly in terms of temporal dynamics and temperature levels - the same challenge in modelling excess heat availability can also be addressed more effectively.

While several studies have attempted to integrate industrial heat demand into energy system models, most approaches face key limitations. Some fail to distinguish between different temperature levels [3], rely on low temporal resolutions [4], or focus on industries with constant demand profiles [5]. Others focus on individual industrial sites with detailed measurement data, which, while valuable, do not provide a scalable framework for sector-wide analysis. [6] An alternative approach is to assume flexible industrial heat demand, allowing for some degree of demand side management. [7] However, some energy system models explicitly aim to represent industrial heat demand as a fixed load rather than as a flexible component. As a result, a gap remains in the availability of standardized, sector-specific heat load profiles that can be used in large-scale energy system models. A robust methodology is needed to capture the complexities of process heat demand and excess heat utilization while maintaining a level of abstraction suitable for energy system analysis.

Please describe your motivation behind providing this methodology. This section should provide readers with context for why and how your methodology may be used. (Max. 500 words).

Method details

The proposed methodology builds upon the work of Jesper et al. [4], who analysed nearly 800 gas load profiles from German industrial sites using k-means clustering. Their approach identifies clusters based on the correlation between outdoor temperature and gas consumption, resulting in linear regression parameters that enable users to generate synthetic load profiles. Given an outdoor temperature profile, an appropriate cluster regression can be selected to produce a normalized daily heat load profile.

Additionally, Jesper et al. provide a sector-specific distribution of clusters, demonstrating that the heat demand of an industry sector is typically represented by a combination of multiple clusters rather than a single one. This arises partly due to the limited number of clusters, leading to some overlap between them. Practically, this also reflects the fact that most industries employ a variety of heat sinks, which are best represented by multiple clusters. They also suggest potential heat sinks that each cluster may represent within different industry sectors.

Daily heat demand for multiple temperature levels

The novelty of the method proposed in this work lies in its integration of the cluster-based approach from Jesper et al. with the temperature levels of the associated heat sinks. Instead of using a single cluster to represent an industry's heat load profile, we introduce *cluster blends*, which combine multiple clusters to better capture the diversity of heat sink portfolios within an industry. Furthermore, we propose a mathematical correlation between the cluster blends and the temperature level of the heat demand they represent.

As noted by Jesper et al., clusters with weak correlation between outdoor temperature and heat demand (e.g., cluster 0) likely represent high-temperature heat sinks, whereas clusters with strong correlation (e.g., cluster 3) are more representative of low-temperature processes. This assumption is supported by the fundamental principle that heat transfer losses are directly related to the temperature difference between the heat source and its surroundings. Given two processes operating at different temperatures, T_h (high temperature) and T_c (low temperature), the relative change in heat loss due to a change in outdoor temperature $(T_o \pm x)$ is greater for the lower-temperature process. This follows from the fact that heat transfer is proportional to the temperature difference between the process and the ambient environment:

$$\dot{Q} \propto \Delta T, \quad \text{where} \quad \Delta T = T_{process} - T_o$$

The relative change in temperature difference for each process can be expressed as:

$$\frac{T_h - (T_o \pm x)}{T_h - T_o} > \frac{T_c - (T_o \pm x)}{T_c - T_o} \quad \text{if} \quad T_h > T_c$$

This relationship shows that a given change in outdoor temperature has a proportionally greater impact on the lower-temperature process, making its heat losses more sensitive to ambient variations, which is one way to explain why high-temperature processes generally exhibit less seasonal variation compared to low-temperature processes.

Given a cluster c and an outdoor temperature, the daily heat demand $Q_{d,c}$ can be calculated using the linear regression parameters from Jesper et al. (for details, see Equations 6.1 and 6.2 in [4]). The next step involves constructing a *cluster-blend matrix* that defines the relative share of each cluster for weekdays and weekends. Although the clusters exhibit a general trend - from Cluster 0 (representing higher temperature levels) to Cluster 4 (lower temperature levels) - the cluster distribution tables C1 and C2 in [4] do not provide sufficient detail to determine an overall temperature distribution for the heat demand. Therefore, IMPRO requires a separate input: a user-defined temperature distribution across defined temperature levels. The definition of temperature levels is generally flexible, as they are used solely to categorize clusters into subgroups within this methodology.
The specific temperature associated with each level is determined by the user and does not influence the computational results. However, reference values for each level are provided in the section on standard load profiles and can serve as a basis for creating custom profiles.
After calculating the daily heat demand for each cluster, each value is then weighted by its corresponding share from the cluster-blend matrix, distinguishing between weekdays and weekends (see Table 1). This results in up to four heat demand values per day - one per cluster - that must then be distributed across the temperature levels. Figure 1 illustrates the logic behind this allocation. The core principle is to "fill" the highest temperature level with the cluster that shows the lowest dependency on outdoor temperature (e.g., Cluster 0). If the cluster's share exceeds the share allocated to a temperature level, the residual is transferred to the next lower level. As an example, Figure 1 shows this principle for workdays.

As an example, consider a workday:

- The top temperature level T4 covers 25% of the heat demand.
- Cluster C0, with a share of 40%, is used to fill T4.
- The remaining 15% of C0 is then assigned to the next level, T3, which also covers 25%.
- After accounting for the 15% from C0, T3 still requires 10%, which is then filled by the next cluster, C1.

This allocation continues across all clusters and temperature levels, ensuring that clusters with low temperature dependency are prioritized for high temperature levels. This step ensures consistency between the cluster-based heat demand and the defined temperature level distribution.

Table 1: Exemplary cluster-blend

cluster	*workday-share*	*weekend-share*	*temperature level*	*temperature-share*
0	40 %	10 %	*1*	25 %
1	0 %	25 %	*2*	25 %
2	50 %	25 %	*3*	25 %
3	10 %	25 %	*4*	25 %
4	-	15 %	*5*	0 %

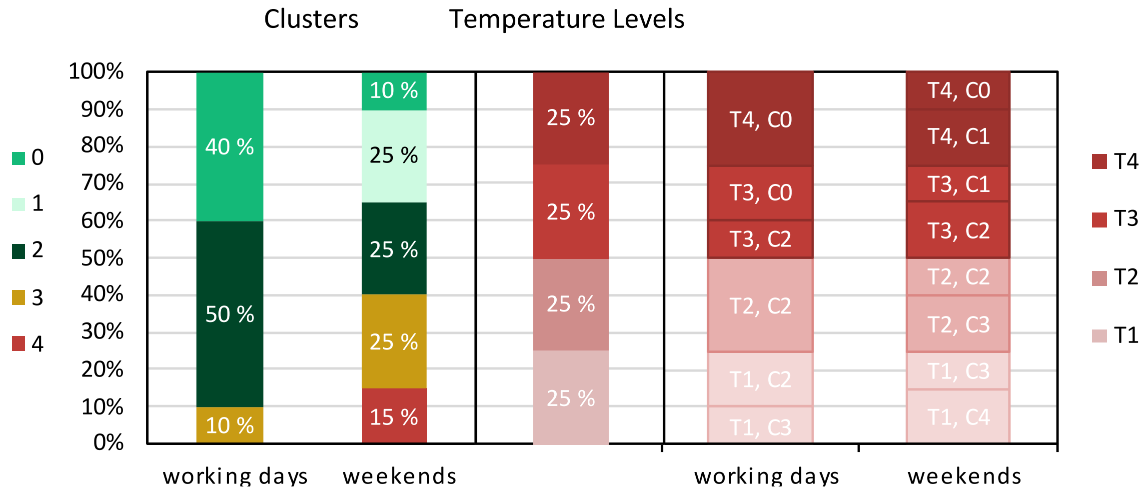

Figure 1: Temperature distribution based on cluster- and temperature blend

Figure 2 shows the resulting heat load profile with four temperature levels for one year, based on the exemplary values from Table 1. The ambient temperature curve in this case is based on measurements from Trondheim in 2023. The daily demand curves highlight the inherent differences between the clusters. While heat demand at temperature level 1 fluctuates significantly between summer and winter months, temperature level 4 remains nearly constant throughout the year. This effect is most evident in summer, where heat demand at T1 is barely noticeable, whereas T4 maintains a steady demand on workdays.

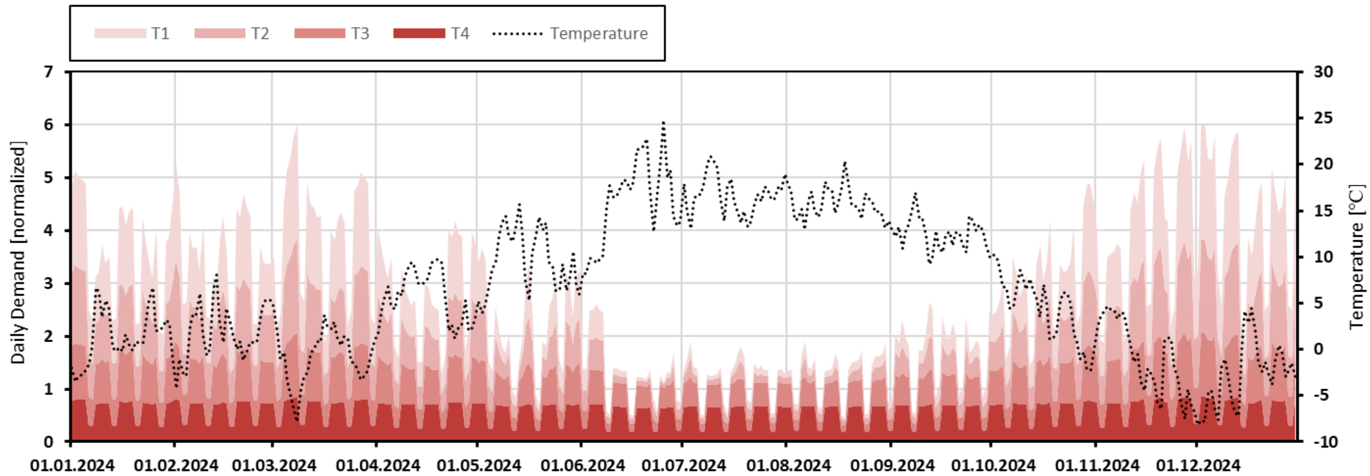

Figure 2: Exemplary daily heat demand profiles on four different temperature levels over one year

This example underscores the methodological approach presented in this work. Rather than aiming to replicate specific industrial processes, this method enables users to classify types of heat demand based on their dependency on ambient temperature and heat sink temperature levels. This abstraction facilitates the analysis of different industry types within larger energy system models, offering insights into cross-sectoral interactions and decarbonization strategies.

Achieving hourly resolution

An important enhancement of the existing methodology is the refinement of time resolution from daily to hourly values. This is accomplished by incorporating shift-based operational load profiles, as introduced by Bühler et al. [8]. Specifically, the authors define four standard industrial thermal load profiles: three-shift, two-shift, and two variations of one-shift operation (with and without a base load on weekends). These profiles are derived from industrial experience, available process information and data from the industry.

Figure 3 presents a representative week based on the same cluster-blend and temperature level distribution shown in Table 1. Cluster 4 and 3 follow a 3-shift profile, while clusters 2 and 1 are assigned to a 2-shift profile, both exhibiting relatively low variation across the week with slightly elevated demand during operational hours. Cluster 0 is represented by a 1-shift base profile, characterized by significantly higher demand during working hours and a consistently low base load during nights and weekends. It is important to note that operational profiles are assigned to clusters, not temperature levels. This distinction allows for a flexible blending of shift-based profiles within each temperature level, based on the cluster-to-temperature correlation illustrated on the right side of Figure 1. For example, on weekdays, temperature level T3 is composed of 15% Cluster 0 and 10% Cluster 2. Consequently, the operational profiles of C0 and C2 are combined in the same proportion to represent the load profile of T3.

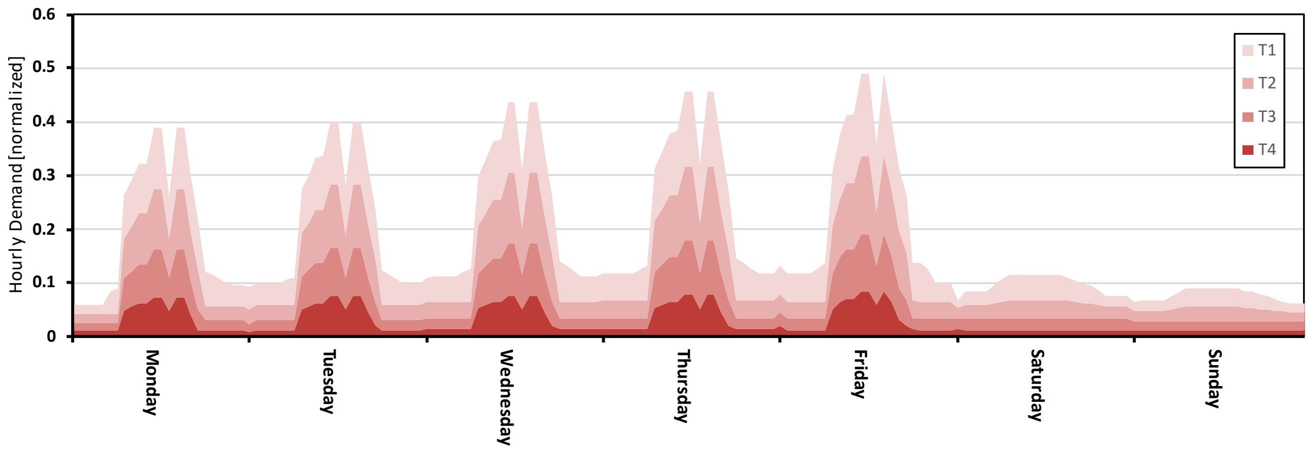

Figure 3: Representative weekly heat load curve with hourly resolution

While this approach is inherently limited in detail - since the generalized load curve shapes are not specific to individual industrial sites - it serves the purpose of generating standardized load profiles for broad industrial sectors. This approximation is sufficiently precise to capture daily variations in industrial heat demand based on the operational patterns of the industry in question. It is, however, encouraged to extend this work by incorporating industry-specific operational patterns that would allow for a significant increase in detail when it comes to representing individual industry sectors or sites.

Excess Heat

To enhance the utility of this methodology, the IMPRO tool has a functionality for generating excess heat production profiles based on the previously described heat demand profiles. By assuming that a fixed percentage of the heat demand results in excess heat at lower temperature levels, a direct correlation between demand and excess heat can be established.

IMPRO Tool

The methodology presented in this publication is implemented in a user-friendly Excel-based tool called IMPRO (Industrial Demand Profile Generator), available via GitHub. The tool incorporates all concepts introduced in this paper to generate hourly heat demand profiles across multiple temperature levels and industry sectors. Users can either create custom demand profiles or choose from a set of presets, which include default values for the industry sectors described in the Standard Load Profiles section. The next section outlines the process for creating custom profiles using IMPRO.

Users begin by selecting the preset "Custom" and then input a cluster-blend matrix (see Table 1) along with corresponding temperature levels and a shift-based operational profile for each cluster. For the cluster blend, one can either utilize tables C1 and C2 from Jesper et al. as a basis or define fully customized blends for specific applications. In addition, a weekend scaling factor can be defined to adjust the relative relationship between heat demand on weekends and weekdays. Note that it is not necessary for the cluster-blend matrix to sum to 100 %, as these parameters are used solely to create normalized profiles. The weekend scaling factor is particularly useful for initially establishing the relative distribution of clusters during the weekend and then scaling the entire weekend blend to match the desired relationship between weekday and weekend heat demand.

Once the normalized profiles are generated, they are scaled to a total demand specified by the user. A reference year is defined to ensure that the distribution of weekdays and weekends is consistent with other energy system model input data, such as temperature profiles, electricity demand profiles, or electricity market price curves.

The IMPRO tool offers a selection of temperature profiles, with the option to add custom profiles. Excess heat availability is modelled by assigning a relative share of heat demand to each temperature level, which is then converted into excess heat at a different temperature level.

The tool outputs yearly heat demand profiles for temperature levels T1 through T5, available in both daily and hourly resolutions, and provides excess heat availability as hourly values.

Notes on Using IMPRO

- A table containing the relative shares of clusters per industry sector from Jesper et al. is included within IMPRO and can serve as a starting point for creating custom cluster-blends for heat demand profiles. Note that the "CHP" column indicates the proportion of industry consumers operating a combined heat and power plant, which were excluded from the analysis. Therefore, when using the table as a basis for cluster-blends, the CHP values can be disregarded.
- The values in the Jesper et al. table do not account for differences between weekday and weekend heat demand. When scaling both cluster-blends to 100%, weekend heat demand can be unrealistically high. One approach is to use the weekend scaling factor to match base load heat demand and thereby ensuring a consistent demand curve between weekdays and weekends.
- The "1-shift" operational profile is not recommended for clusters with a weekend share because it does not account for any weekend demand. This omission can result in a total output heat demand that deviates from the user-specified total. In such cases, the "1-shift base" profile is recommended.

Standard Load Profiles (SLP)

In addition to generating customized industrial heat demand profiles based on user-defined cluster blends and temperature level distributions, the IMPRO tool also offers predefined standard load profiles (SLPs) for several industry sectors. These profiles are constructed using default weekday and weekend cluster blends derived from Table 4 in Jesper et al. [4], combined with sector-specific temperature level distributions from Rehfeldt et al. [9], who analyzed industrial heat demand characteristics across European countries.
The predefined profiles cover key industry sectors and reflect typical process heat requirements by assigning demand shares to four standardized temperature levels (T1-T4). These levels are selected based on typical energy carriers and industrial applications - for example, hot water systems for T1, steam-based processes for T2, and high-temperature applications such as furnaces in the steel, cement, and glass industries for T4.
While IMPRO supports up to five customizable temperature levels for greater flexibility, all predefined SLPs are currently based on the four standard levels shown in Table 2.

Table 2: Temperature level distribution for SLP sectors, based on figure from Rehfeldt et al. [9]

Sector	*T1: < 100 °C*	*T2: 100 – 200 °C*	*T3: 200 – 500 °C*	*T4: > 500 °C*
Iron and Steel	3 %	0 %	3 %	94 %
Basic Chemicals	20 %	11 %	2 %	67 %
Non-Metallic Minerals	3 %	10 %	15 %	72 %
Pulp and Paper	12 %	82 %	4 %	2 %
Food, Beverages and Tobacco	43 %	43 %	8 %	6 %
Machinery and Transport	21 %	61 %	18 %	0 %
Non-Ferrous Metals	7 %	7 %	20 %	66 %

The standard load profiles (SLPs) shown in Figure 4 are generated using default parameters embedded within the IMPRO tool. These include industry-specific cluster blends and temperature level distributions, which can be found in the “Additional Information” section. To generate an SLP, users select a preset industry sector and an outdoor temperature profile, and scale the result to the desired annual heat demand.
Figure 4 illustrates the SLPs for seven key industry sectors under the same outdoor temperature profile. The visualization highlights the combined effect of IMPRO’s two main inputs: the cluster blend, which captures sector-specific seasonal variations, and the temperature level distribution, which disaggregates total heat demand across defined temperature levels (T1-T4). The integration of these components creates a flexible modelling approach capable of producing a virtually unlimited number of unique heat load profiles. As seen in the figure, this method allows for the creation of sector-specific demand profiles with distinct characteristics. For example, the Machinery and Transport sector exhibits a relatively stable high-temperature demand throughout the year, with a pronounced seasonal variation in the lower temperature levels. In contrast, the Non-metallic Minerals sector shows a nearly constant demand profile dominated by high-temperature processes. These examples demonstrate IMPRO’s capability to reflect operational and thermal nuances of different industrial processes, enabling more accurate modelling of heat demand patterns in energy system analyses.

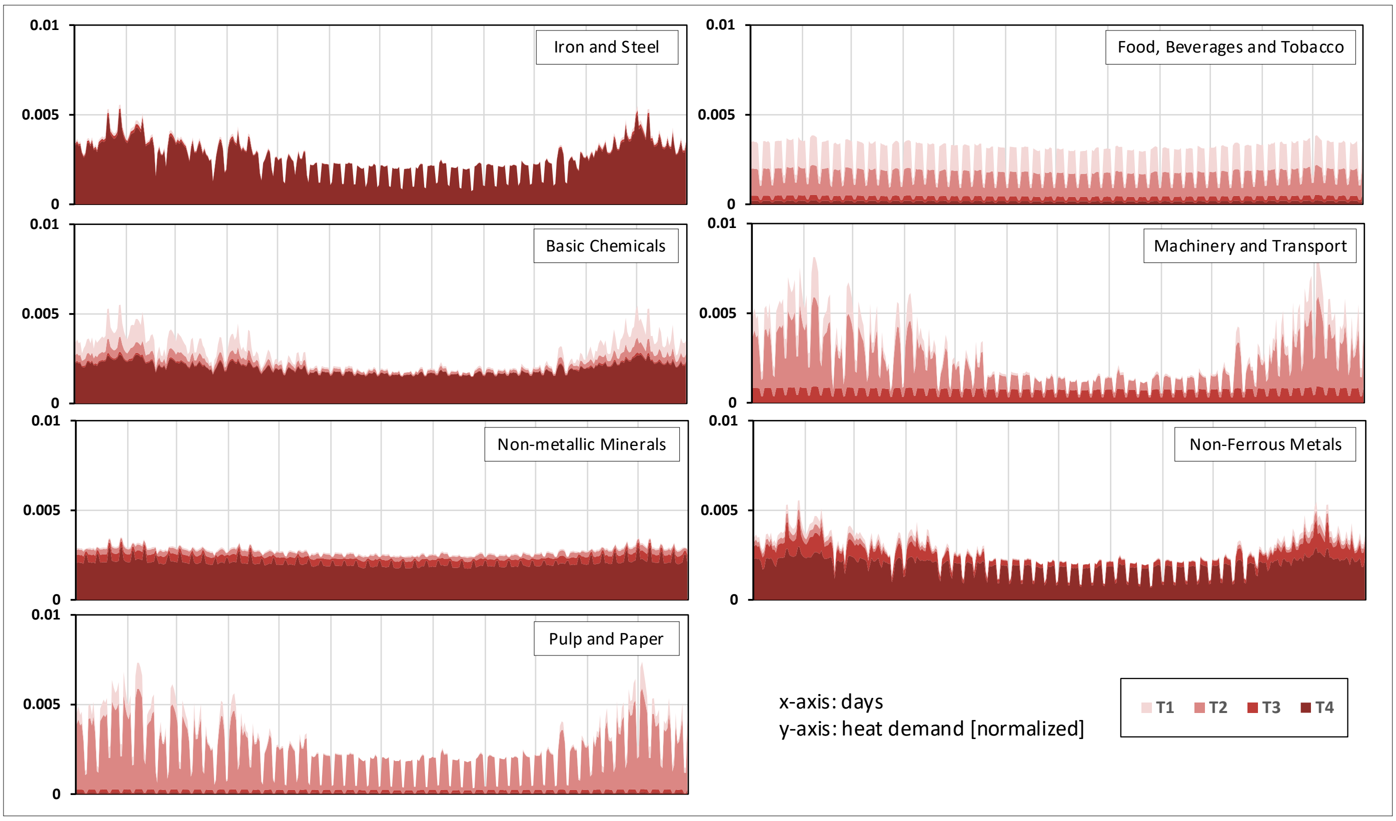

Figure 4: Graphical representation of standard load profiles (daily heat demand)

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Method Validation

Validating this method presents challenges due to the generalized nature of its results. IMPRO is designed to generate representative heat demand profiles for different industries rather than replicating site-specific data. A comprehensive validation would require an extensive analysis of real-world heat demand profiles across multiple temperature levels and industry sectors. However, such an approach would contradict the tool's purpose, as actual measurement data would always provide more accurate results than a model-based method. The need for IMPRO arises precisely because this type of data is often unavailable.

The cluster regression models from [4] were validated in their original publication by comparing actual gas consumption profiles with model-generated profiles, yielding satisfactory results. To demonstrate the applicability of IMPRO, we conduct a simplified proof-of-concept validation using heat demand data from a Norwegian dairy, available in [SOURCE]. The dataset includes hourly values for two primary types of demand: hot water (~65 °C) and steam (140 - 160 °C). However, the steam is also used to heat water, so both demand types cover overlapping temperature ranges.

Notably, the food industry cluster identified by Jesper et al. consists solely of cluster 0, which suggests minimal variation in heat sink temperatures and seasonal demand patterns. The default temperature level distribution for the Food, Beverages and Tobacco SLP includes small shares of T3 and T4 (8 % and 6 %, respectively), which are not considered in this analysis. Given the aggregated nature of the SLP across multiple subsectors, slight deviations in temperature level shares are expected. However, the low contributions from T3 and T4 confirm that high-temperature processes are of minor importance in this sector.

To generate a corresponding IMPRO profile, we use the SLP preset for the Food, Beverages and Tobacco sector, scale the profile to match the total annual demand of the dairy, and apply the 2024 ambient temperature profile for Røros, Norway (sourced from the Norwegian Centre for Climate Services [10]). The weekday cluster blend consists entirely of cluster 0, while the weekend blend includes 53 % cluster 0 and 37 % cluster 1. A "1-shift base" operational profile is used across all clusters to ensure a consistent base load during weekdays, with weekend demand scaled to 70 % to reflect reduced activity (see Table 3). Figure 5 compares the measured daily heat demand with the IMPRO-generated profile.

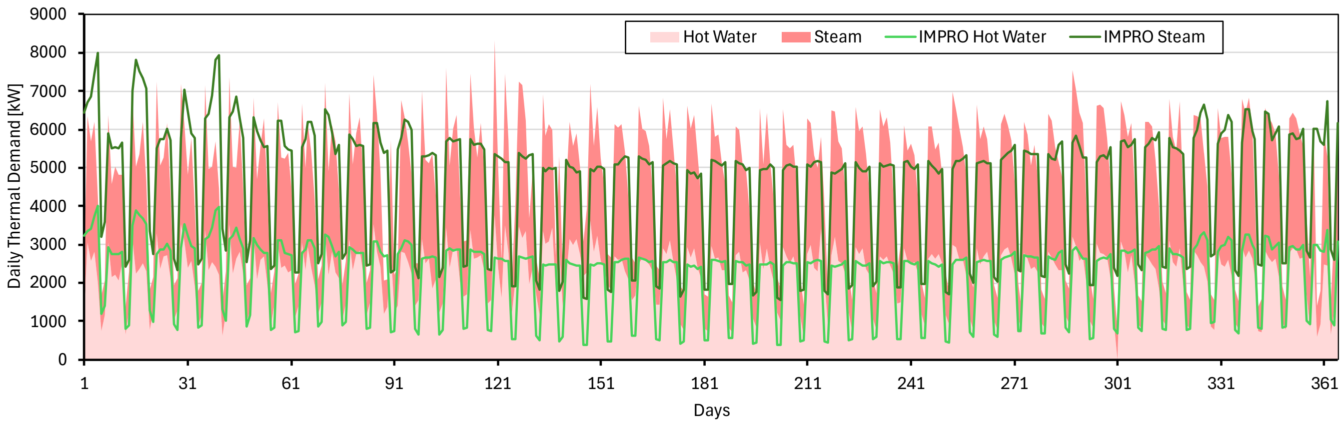

Figure 5: Daily Heat Demand comparison between measured data and a demand profile obtained from IMPRO

Figure 5 reveals a clear difference between weekday and weekend demand in the measured data, indicating that production is mostly inactive on weekends, which is accurately captured by the IMPRO profiles. The general separation of the heat demand into hot water and steam is also represented fairly well by the SLP, supporting the findings from Rehfeldt et al. [9]. Additionally, the measured data shows minimal seasonal variation, whereas the IMPRO-generated profile exhibits slight seasonal fluctuations despite being based on cluster 0, which has the least outdoor temperature dependency. This discrepancy suggests that the assumption from the original cluster regression study - that all industrial heat demand is somewhat influenced by outdoor temperature - does not hold in this case. However, the seasonal variation in IMPRO remains relatively small for cluster 0. The effect is amplified by the extreme winter temperatures in Røros, where temperatures can drop to -30 °C, resulting in an overestimation of heat demand in winter and an underestimation during summer. This inaccuracy would be less pronounced in regions with milder winters. Despite these differences, the overall daily demand patterns align well between the measured data and the IMPRO-generated profile.

To further assess the validity of the IMPRO model, we examine its ability to reproduce hourly variations in heat demand. Figure 6 presents two representative weeks: one in late May (ambient temperatures between 12 - 16 °C) and one spanning January and February (ambient temperatures between -18 to -2 °C). In addition to the hourly demand curves, the weekly average for the entire year is included to highlight broader trends rather than specific short-term fluctuations. As expected, IMPRO overestimates winter demand due to the assumed temperature dependency, which does not exist in this particular case. Additionally, a noticeable time lag occurs at the beginning of each workday, where the IMPRO-generated profile ramps up later than the actual production start time. This suggests that the standard shift-based operational profiles may not align with the specific production schedule of the dairy. However, the "1-shift base" profile adequately captures the general trend, with a consistent base load and characteristic daily demand fluctuations. While IMPRO cannot reproduce the unpredictable variations in real-world heat demand, as expected from a generalized methodology, it successfully captures the key weekly operational patterns.

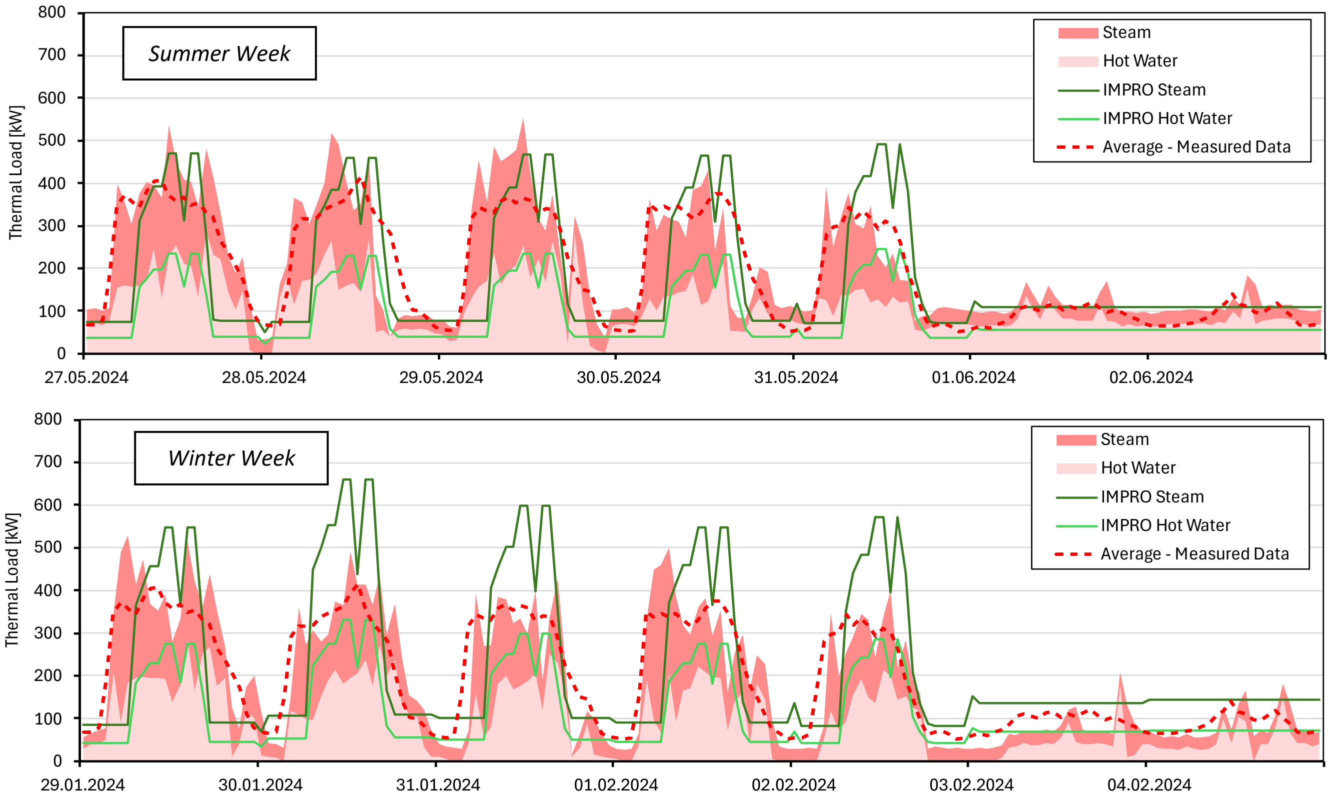

Figure 6: Comparison of weekly thermal load for a dairy and profiles created with IMPRO

Given the discussed limitations, IMPRO provides a reasonable approximation of industrial heat demand patterns for multiple temperature levels. The most relevant aspects - daily operational cycles and a nearly constant demand throughout the year - are well represented, even though deviations in hourly values and seasonal trends exist. However, the presented comparison is not sufficient to validate all the SLPs created with IMPRO. The residual SLPs thus remain unvalidated due to a lack of suitable datasets, which highlights the necessity of tools like IMPRO, as open-source high-resolution multi-temperature industrial heat demand data is scarce. We encourage other researchers with access to such data to compare IMPRO-generated profiles with real measurements to further refine and validate the methodology.

*Results and Discussion are **not** part of a methods article. However, if possible, please provide data that validate the method.*

Limitations

IMPRO relies on the assumption that heat demand correlates primarily with outdoor temperature, which may oversimplify the complex operational behaviour of industrial processes. While Jesper et al. establish a correlation between outdoor temperature and heat demand in the analysed gas consumption profiles, their dataset includes only industrial consumers with an annual gas consumption exceeding 1.5 GWh. This limits the applicability of IMPRO to industries with lower heat demand or those relying on alternative energy sources such as coal, oil or electricity. As shown in the previous section, some industries exhibit little to no correlation between heat demand and outdoor temperature, making the method unsuitable for detailed modelling of specific processes and heat sinks.

It is important to note that, due to the absence of direct validation for all SLPs (as previously discussed), IMPRO-generated profiles should be applied with caution when modelling specific industrial sites, particularly in studies requiring a high level of detail. The shift-based hourly operational patterns, adapted from a previous publication, are not sufficient to capture the complexity and variability of individual site operations. Instead, the SLPs developed in this work are intended to serve as generalized representations of broader industry sectors, reflecting aggregated behavior across multiple sites rather than site-specific dynamics.

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Acknowledgments

All contributors who do not meet the criteria for authorship should be listed in an acknowledgments section.

The authors acknowledge the contribution from Lukas Köster and Jan Bengsch, who provided the data used for validation of this methodology.

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Additional information

The following tables show the parameters for the standard load profiles available as presets within the IMPRO tool.

The abbreviations in Table 3 represent the operational shift-based profiles from Bühler et al.: 3-shift (3), 2-shift (2), 1-shift (1) and 1-shift base (1 (b)). [8]

Table 3: Mapping of shift-based operational profiles for standard load profiles

	CLUSTERS				
Sector	*0*	*1*	*2*	*3*	*4*
Iron and Steel	3	3	3	3	3
Basic Chemicals	3	3	3	3	3
Non-Metallic Minerals	3	3	3	3	3
Pulp and Paper	1 (b)	1 (b)	1 (b)	2	3
Food, Beverages and Tobacco	1 (b)	1 (b)	1 (b)	2	3
Machinery and Transport	2	2	2	2	3
Non-Ferrous Metals	3	3	3	3	3

Table 4: Cluster-blend matrix and weekend scaling factor for standard load profiles – weekends

Sector	*0*	*1*	*2*	*3*	*4*	*Weekend scaling factor*
Iron and Steel	0 %	42.9 %	28.6 %	28.6 %	0 %	170 %
Basic Chemicals	27.3 %	27.3 %	9.1 %	18.2 %	9.1 %	170 %
Non-Metallic Minerals	66.7 %	33.3 %	0 %	0 %	0 %	170 %
Pulp and Paper	0 %	50 %	12.5 %	25 %	12.5 %	70 %
Food, Beverages and Tobacco	52.6 %	36.8 %	0 %	0 %	0 %	70 %
Machinery and Transport	11.8 %	15.7 %	3.9 %	43.1 %	13.7 %	70 %
Non-Ferrous Metals	0 %	42.9 %	28.6 %	28.6 %	0 %	170 %

Table 5: Cluster-blend matrix for standard load profiles – workdays

Sector	*0*	*1*	*2*	*3*
Iron and Steel	57.1	28.6	14.3	0
Basic Chemicals	45.5	27.3	18.2	0
Non-Metallic Minerals	100	0	0	0
Pulp and Paper	37.5	37.5	0	25
Food, Beverages and Tobacco	89.5	0	0	0
Machinery and Transport	17.6	19.6	43.1	7.8
Non-Ferrous Metals	57.1	28.6	14.3	0

Table 6: Mapping of sector categorization from Jesper et al. [4] and Rehfeldt et al. [9]

Sector – Rehfeldt	*Sector - Jesper*
Iron and Steel	*Manufacture of basic metals*
Basic Chemicals	*Manufacture of chemicals and chemical products*
Non-Metallic Minerals	*Manufacture of non-metallic mineral products*
Pulp and Paper	*Manufacture of paper and paper products*
Food, Beverages and Tobacco	*Manufacture of food products*
Machinery and Transport	*Manufacture of machinery and equipment*
Non-Ferrous Metals	*Manufacture of basic metals*

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