AFD

ARKHANGAI

geres
ACTING FOR CLIMATE SOLIDARITY

THE ENERGY EFFICIENCY OF PUBLIC BUILDINGS IN ARKHANGAI PROVINCE

CEMAATERR-II

TERRITORIAL APPROACH TO ADDRESS CLIMATE CHANGE AND ENERGY CHALLENGES

2021

GRATITUDE

The project steering committee is led by the Deputy Governor of Arkhangai province, the Department of Land Affairs, Construction and Urban Development, the Governor's Office of Arkhangai province, the Development Policy Department, the Chief Architect, Arkhangai Energy Regulatory Council, the soum Governor's Office, and the public building firefighters and treasurers all supported the baseline study.

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FOREWORD

GERES is an international development NGO created in 1976. It works to improve the living conditions of the most vulnerable and fight against climate change and its impacts. Climate-energy: adaptation and mitigation measures in rural areas and secondary cities - CEMAATERR is a multi-countries project launched in November 2016 with the financial support of Agence Française de Development. It involves 4 areas particularly vulnerable to climate change in Benin, Cambodia, Morocco, and Mongolia. The building sector has been identified as a priority of the energy transition for subnational stakeholders with real responsibilities and a potential to federate other public and private local actors. The second phase of CEMAATERR-Mongolia aims at improving education conditions through three complementary axes:

- Pilot interventions in educational buildings demonstrate the feasibility and relevance of optimizing energy efficiency in public buildings to improve the comfort and well-being of occupants and users, reduce energy savings expenses and reduce air pollution;
- A gradual rise in skills of professionals in the building sector, allowing the emergence of a local supply of low carbon solutions related to energy efficiency services;
- Awareness of territorial stakeholders (public authorities, associations, citizens, etc.) and capacity building of subnational institutions for energy-climate planning and monitoring

Partners:

- Geres Mongolia NGO
- Government of Arkhangai province
- Arkhangai province Construction Union NGO
- Energy Efficiency Project, GIZ Mongolia
- Daatstai Khugjliin Ireedui (Future of Sustainable Development) NGO

A project steering committee led by the Deputy Governor of the Arkhangai province has been established, ensuring an inclusive multi-stakeholder process. It includes representatives of the following entities:

- Representatives of the Governor's Office, its relevant departments, and divisions
- Energy Regulatory Council
- Department of Land Affairs, Construction, and Urban Development
- Citizen's Representatives Assembly of the Arkhangai province
- Arkhangai province's Construction Union NGO
- A representative of the "Energy-efficient building refurbishment in Mongolia" project implemented by the Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ)
- Daatstai Khugjliin Ireedui (Future of Sustainable Development) NGO representing the local civil society
- Geres NGO project team

"The energy efficiency study of public buildings in Arkhangai province" was conducted under the guidance and support of the project steering committee within the framework of multi-stakeholder cooperation. A detailed field study of the selected 6 soums representing the whole province was selected by the Project steering committee and the project team and was conducted by BEEC LLC.

ROLE OF THE STAKEHOLDERS IN THE STUDY

Project steering committee: Soum and the province Governor's Office provided opportunities to liaise with departments. In addition, provided the soum's detailed survey transport and research team with a location, data collection, and safety during the survey.

Technical committee of the project: Collected information on energy saving and basic construction information from public buildings in 19 soums of Arkhangai province from relevant organizations and provided possible primary information from the province database.

Arkhangai Province Department of Land Affairs, Construction and Urban Development: Collected primary information on public buildings in Arkhangai province, provided the necessary information and public building designs from selected 6 soums from their archives.

Arkhangai Energy Regulatory Council: Collected information on heating sources, fuel consumption, and electricity consumption of selected 6 soums of Arkhangai province from the database of the relevant offices. Provided information on public building heating systems ownership and legal relationships between local community organizations. Also, provided advice during the baseline survey.

Geres International Technical Advisor (Marc Glass, Clementine Laratte, Marina Dubois): Supported the baseline survey of private housing and analyzed the results of a gender equality survey. Also, reviewed the baseline research report.

"BEEC" LLC - the contractor for the detailed study of the selected 6 soums: Made the necessary measurements to issue energy licenses to the public buildings in the selected soums and interacted with local organizations, which is the survey's main purpose. Clarified the situation. The study results were presented at the Technical and Project steering committee meetings.

CEMAATERR II Project Team: Responsible for coordinating stakeholders in the scope of the study on the Energy Efficiency in Public Building in Arkhangai Province. Primary data from province organizations were processed and consolidated. Organized the project steering committee and technical consultation meetings and conducted a detailed study of 6 selected soums. Prepared the baseline research reports and publications.

Compiled by: Project Manager B. Oyuntuya, Project Technical Specialist Ts. Enkhee, Project Technical Consultant (Construction Energy Saving Center, MUST) J. Gankhuyag, Prof. B.Munkhbayar, Program Technical Advisor Marc Glass, Program Coordinator Clementine Laratte

ACTIVITIES IN ARKHANGAI PROVINCE

Since 2012

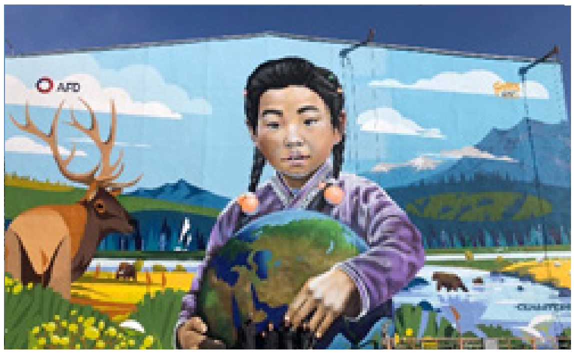
40 three-season energy-efficient greenhouses adapted to climate change have been established and supported in 14 soum health centers, schools, and community groups. As a result of the projects, the diversity and nutritional status of the people has improved, the number of sustainable jobs has increased, and the household income has diversified.

Since 2017

“Arkhangai province's participatory risk assessment for climate change vulnerability” was conducted at the province level. The survey assessed past and future vulnerability risk assessments with citizens. Prioritized and categorized adaptation options to address the challenges posed by climate change.

Since 2018

Built an energy-efficient “Temporary Shelter” to protect victims of domestic violence. The temporary shelter is a building that fully complies with the building's thermal protection standards. An energy audit confirmed that the building is in the “B” category, which is good for energy efficiency. Temporary shelters serve residents of 19 soums of the aimag and provide regular protection for victims of domestic violence.



Since 2019

The training was organized by the Governor's Office organized the training, the Secretariat of the Citizens 'Representative Khural, and the Future of Sustainable Development NGO for 430 citizens' representatives from 18 soums, 90 technical staff, and decision-makers to identify ways to reduce climate change and its impact. In collaboration with the Governor's Office and the Citizens' Representative Khural, a public awareness campaign on climate change was organized in 31 baghs of 11 soums for 2,500 people.

CHALLENGES OF ARKHANGAI AIMAG TO COVER AND ADJUST CLIMATE CHANGES

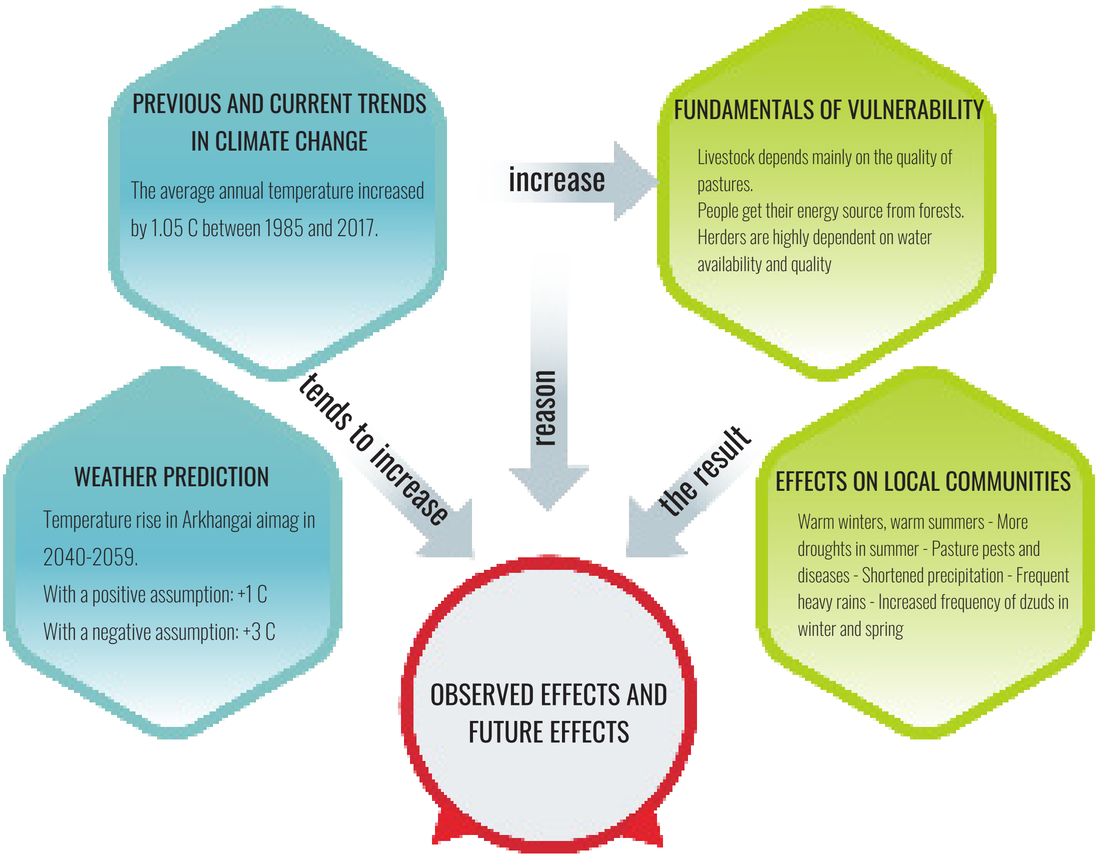
- 41% of the population is settled, and 59% is rural
- The main component of the aimag's economy is agriculture and pastoral livestock, which accounts for the majority of 75% of the workforce
- 18.2% of the territory is covered by forests. This has decreased by 156,000 hectares over the last decade due to forest fires, illegal logging, and forest pests.
- Surface water levels are also declining: 2.8% of rivers, 25.2% of springs, and 12.6% of lakes have dried up. In some areas, pastures have been abandoned due to deteriorating water quality
- 8% of the aimag's territory is classified as high, 10% as a medium and 33% as low desertification

Mongolia has a harsh continental climate, long dry cold winters, and hot summers. The average temperature fluctuates between -22C in January and + 28C in July. Extremely high fluctuations in temperature and precipitation highlight large areas and topographic systems. Arkhangai aimag, located in the center of Mongolia and the northern part of the Khangai mountain range, has water resources from large rivers, so it has a high potential to generate clean energy and collect rain and snow water. The average annual precipitation is 232.3 mm.

The program identified a participatory risk assessment for climate change vulnerability (CVRA) in Arkhangai aimag. As a result, it was found that Arkhangai aimag has been significantly affected by seasonal climate change since 1995. Local people felt and understood climate change.

Changes in the quality of pastures, forests, and water resources are harming the livelihoods of local people. According to the current warming trend, the climate is expected to warm by +3C between 2040-2059 and +6C between 2090 and 2099, which will have catastrophic consequences for the people of Arkhangai province.

EFFECTS AND CONSEQUENCES OF CLIMATE CHANGE IN ARKHANGAI PROVINCE



ENVIRONMENTAL IMPACT

- Deterioration of local pastures, deterioration of quality, and reduced crop yields.
- Significant reduction in water resources
- Due to illegal logging and pests, forest cover has declined over the last 20 years.
- The environment has been degraded and polluted by human activities.

SOCIO-ECONOMIC IMPACT

- For herders, overcrowding has led to overgrazing to overcome the problem
- Land disputes continue due to a lack of natural resources such as water and good quality pastures
- Due to deforestation, fuel availability is scarce
- The number of migrants coming from the countryside to the cities has increased-
- Disputes between mining companies and local people have increased

SUMMARY

Under the CEMAATERR-II project, Geres conducted a baseline study of the energy efficiency in the public buildings of all 19 soums of the Arkhangai province.

The objective is to understand better the energy and building sector's energy efficiency and classify the issues of public buildings of soums using energy consumption and energy efficiency. In addition, analyzed existing data information on the public buildings regarding the energy efficiency issues in the whole province.

General analysis was covered over the 241 buildings of 18 soums on the available data obtained from the local authorities. In addition, an on-site detail study and analysis was conducted in 62 buildings of 6 soums from the 4 regions of Arkhangai selected by the Project steering committee. And, sampling a questionnaire has been addressed to 172 households of the Erdenebulgan soum.

SCOPE OF THE STUDY:

The scope of the study has been defined by the Project steering committee and Geres to identify the actual condition of energy efficiency of the public buildings in Arkhangai:

- To classify into a common typology of the buildings in Arkhangai
- To identify the energy demand of public buildings, and the carbon footprint from fuel combustion
- Energy assessment of the public buildings in the selected soums, identify the gaps
- To identify the actual energy and fuel consumption of the public buildings, and their cost
- Construction sector's applied regulations, standards for the public building, and the implemented programs
- Gender knowledge on the energy efficiency and gender issue in the households at the center of the province

OBJECTIVES:

- Classify Arkhangai province's public buildings into common classes by their construction structure and energy consumption.
- Identify the main gaps between the energy efficiency regulation and the field implementation.
- Identify the common energy issues of a public building, and develop energy efficiency solutions.

THE HEATING SEASON IN ARKHANGAI PROVINCE:

Although Arkhangai province has a warmer climate than the northern provinces of Mongolia, all soums have different climatic conditions depending on their geodetic location. Therefore, according to the decision of the Project steering committee members, the study was conducted in 4 regions of Arkhangai province depending on the issues, climate, and geodetic location. According to the Minister of Energy's resolution, the heating season of the public buildings continues for 242 days, from September 15 to May 15. The outdoor air rated temperature used to estimate heat demand is (-28.6°C) by Mongolian Building Normative and Codes. The absolute minimum temperature reaches (-53°C), and the maximum temperature reaches (+35°C).

CONSTRUCTION CLASSIFICATION OF THE PUBLIC BUILDINGS:

There are currently 241 public buildings in use in 18 soums of Arkhangai province. The public buildings' construction structure has been classified into four types: wooden construction, brick construction, rock construction, and lava stone block construction. Roughly 74% (178 buildings) have volcanic rock block masonry, and 19% have wooden structures. A total of sixty-two public buildings were assessed on-site, and heating energy consumption was determined to get an energy efficiency label. Of the 62 public buildings, 45 got "E," and 12 got "D" labels in the selected 6 soums.

PUBLIC BUILDING ENVELOPE:

From the fieldwork result, it was clear that most buildings have insulation issues. Out of 62 public buildings, only eight buildings had insulated external walls correctly, and only two buildings insulated roofs as stated in the normative. The insulation of the floor and over shallow foundations have been disregarded entirely. Therefore, the U value of the insulation and density is not meeting the norms and standards. Almost 70% of Arkhangai province territory is within the continuous and periodic permafrost range. As per construction objects, many buildings have cracks or damages, regardless of the selection of shallow foundation structures that shall prevent permafrost soil degradations.

TYPES OF HEATING SYSTEMS AND HEAT DEMAND OF THE PUBLIC BUILDINGS:

Five soums of the Arkhangai are connected to the centralized heating system. The rest 14 soums have individual or partial heating systems with water heating furnaces. Institutions with multiple buildings, such as soum schools and hospitals, have a partial heating system. A system that supplies various facilities from one heating source but not all buildings in the area. Most kindergartens, governor's offices, and police stations have heat-only boilers for the individual heating system. Of 18 soum, except Erdenebulgan, the annual total heating volume of public buildings in the heating season is 708800 m^3. Accordingly, the estimated heating loads of buildings will be Q=16 MW. The summary of the sources' heat installed energy production capacity is 29.21 MW. (ERC of Arkhangai). Some public buildings have heat energy demand out of the installed capacity of water heating furnaces. The main factor of high demand is the heat loss through the building envelope.

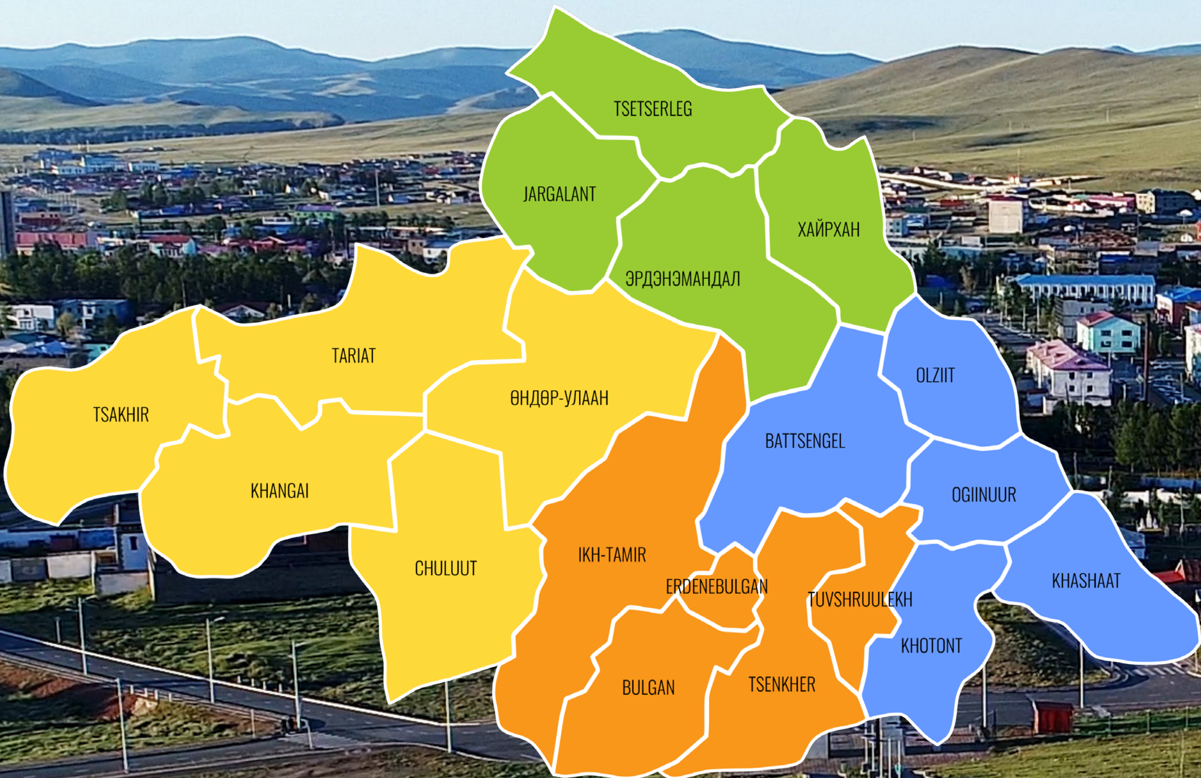
FUEL CONSUMPTION AND GREENHOUSE GAS EMISSION FROM THE FUEL COMBUSTION FOR THE PUBLIC BUILDING HEATING:

The estimated annual coal consumption of the centralized heating system of Erdenebulgan soum and other public buildings of 18 soums is 28650 tonnes. Out of 39000 tons of CO_2 emission from heating public buildings, the maximum amount of GHG emitted in Erdenebulgan soum's centralized heating system with a total annual emission of 20040 tons of CO_2 or 51.4%. In Arkhangai province, most public buildings use coal as a heating source, but some soums use only wood during the heating season.

COMPILABILITY OF THE PUBLIC BUILDINGS AT SOUMS WITH BUILDING NORMS AND CODE:

Assessed the surveyed buildings following "Building thermal performance" /BNaC 25-01-20/. Out of the total 57 buildings surveyed, no facilities fully meet the normative requirements. The buildings surveyed were built following the 2009 norms, so there were significant inconsistencies with the updated norms. One of the problems is the lack of construction norms and standards at the construction and planning stages. There was a building normative before 2020; there is a gap in the field's implementation level and normative supervision.

CHAPTER 1 CURRENT CONDITIONS OF PUBLIC BUILDINGS IN ARKHANGAI



87 SECONDARY SCHOOL

12 POLICE BUILDING

4 THE CENTRALIZED HEATING BOILER HOUSE

109 PUBLIC SERVICE BUILDING

29 KINDERGARTEN

241 PUBLIC BUILDING

AGING OF **PUBLIC BUILDINGS**

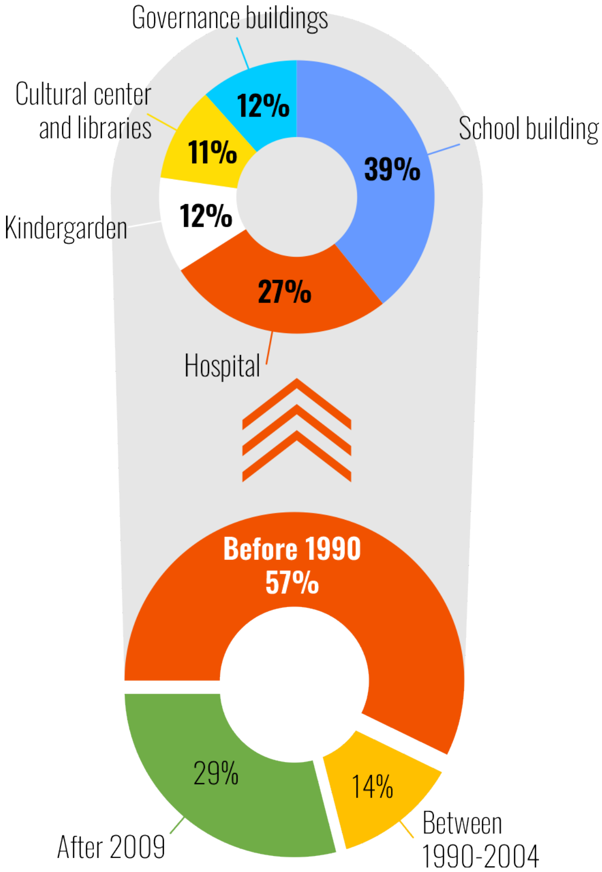
The primary data of 241 construction objects in 18 soum were collected and analyzed within the study's objectives. As for the aging of construction, buildings can be categorized into the following categories:

- **Buildings built before 1990,**
- **Buildings constructed between 1990-and 2008,**
- **Buildings built after 2008.**

The reason for categorizing buildings by the categories mentioned above is that until the 1990s, public buildings were built according to building codes before the 1990s. In 2008, when new building codes and regulations were approved, previously constructed buildings were categorized into buildings constructed between 1990 and 2008. The rest of the public buildings are categorized as built after 2008.
Based on primary data of all the buildings of the 18 soums, 57% are the construction objects built before the 1990s. Out of these pre-1990 buildings, 39% are the buildings belonging to the schools, such as girls' and boys' dormitories, classroom buildings, kitchens, and warehouse construction.

- Dormitory for boys and girls
- The kitchen
- Classroom
- Warehouse

Graph 1. **Aging and purpose of public buildings**



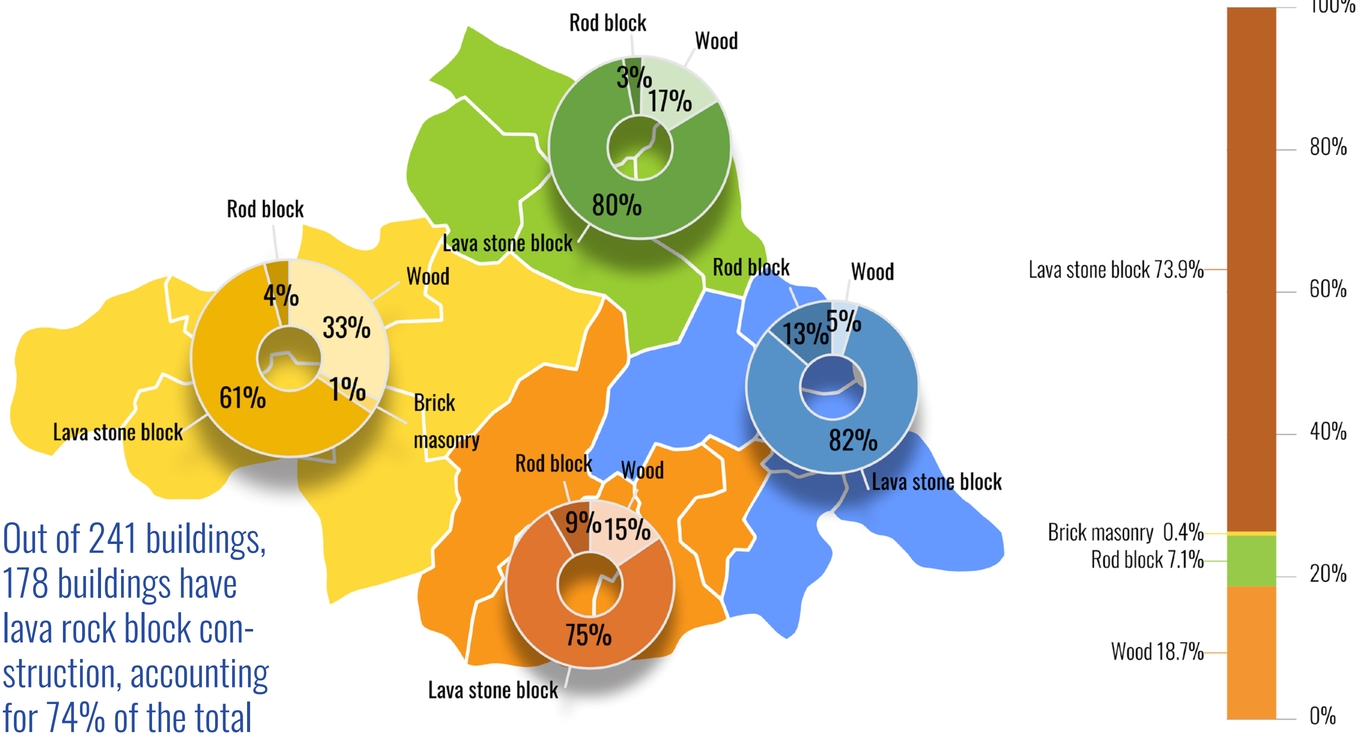
Source: Arkhangai province LRCUDD database

CLASSIFICATION OF PUBLIC BUILDINGS BY CONSTRUCTION STRUCTURE

Public buildings of the Arkhangai province can be classified into four categories based on the obtained information from the local authorities and from the result of the comprehensive study on the energy efficiency of public buildings in 6 soums. Public buildings' roof and insulation material information is not specified in detail in the integrated database. However, based on the construction structure, materials are buildings:

- Wooden construction
- Brick construction
- Rock construction
- Lava stone block construction

Graph 2. **Classification of a public building by structure**



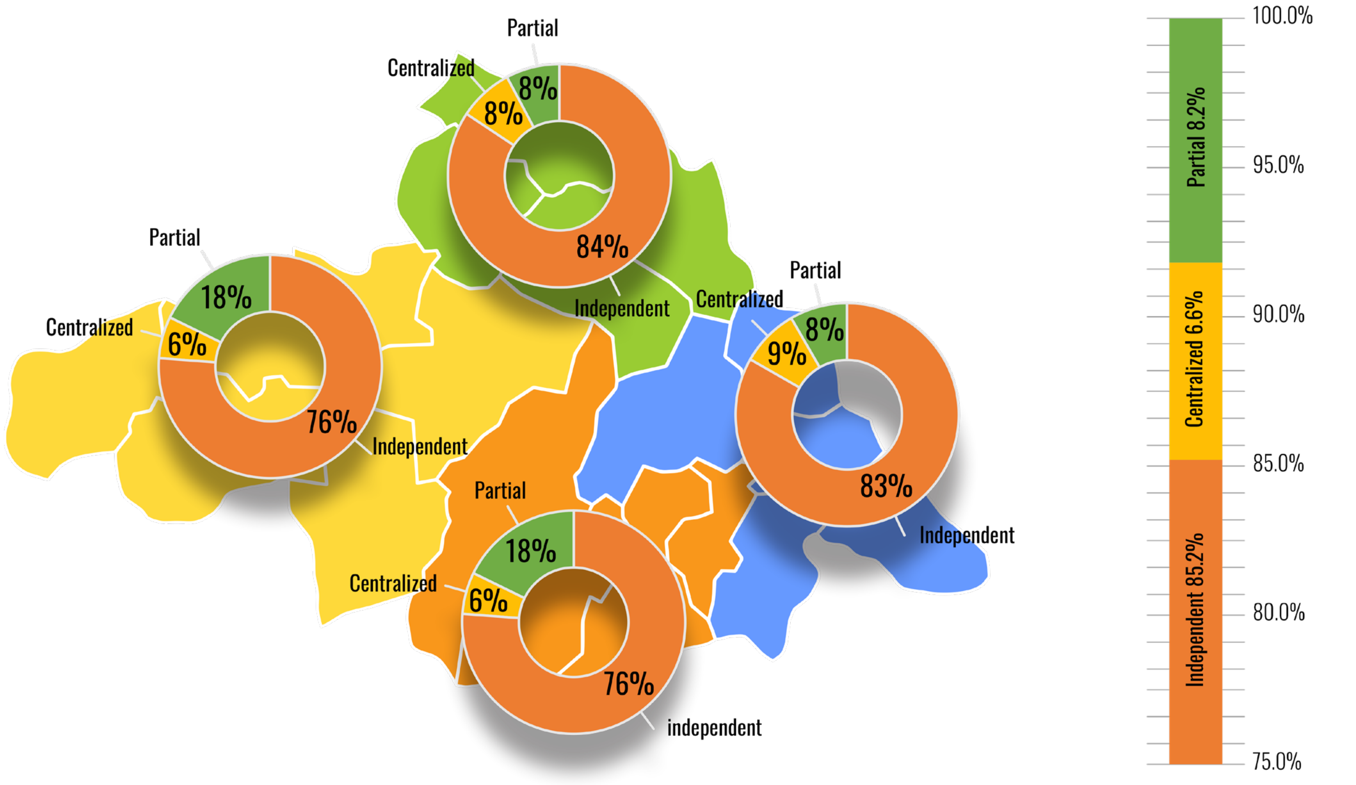
Out of 241 buildings, 178 buildings have lava rock block construction, accounting for 74% of the total buildings.

Source: Arkhangai province DLACUD database

HEATING SYSTEM AND COMMON WATER HEATING FURNACE OF PUBLIC BUILDING

According to engineering infrastructure data obtained from the Energy Regulatory Board and the General Architecture of Arkhangai aimag, 5 soums connected to the district heating system. The rest 14 soums have individual or partial heating systems. Public organizations with multiple buildings, such as soum schools and hospitals, typically have a partial heating system. A system that supplies various facilities by contract, from one heating source but not all public buildings in the area. Most kindergartens, governor's offices, and police stations have an individual heating system with heat-only boilers.

Graph 3. **Categories of heating systems in Arkhangai province**



Source: Arkhangai province Energy Regulatory Council database

PUBLIC BUILDING WATER HEATING BOILERS

Except for Erdenebulgan soum, Arkhangai aimag has a total of 102 fossil-fueled water heating boilers with a capacity of 29.21 MW in public buildings. Odkon LLC's water heating boilers account for 60.8% of the total water heaters installed in all soums. Handmade furnaces account for 15.8%. The manufacturers categorized the WHBs into the following four categories, as shown below.

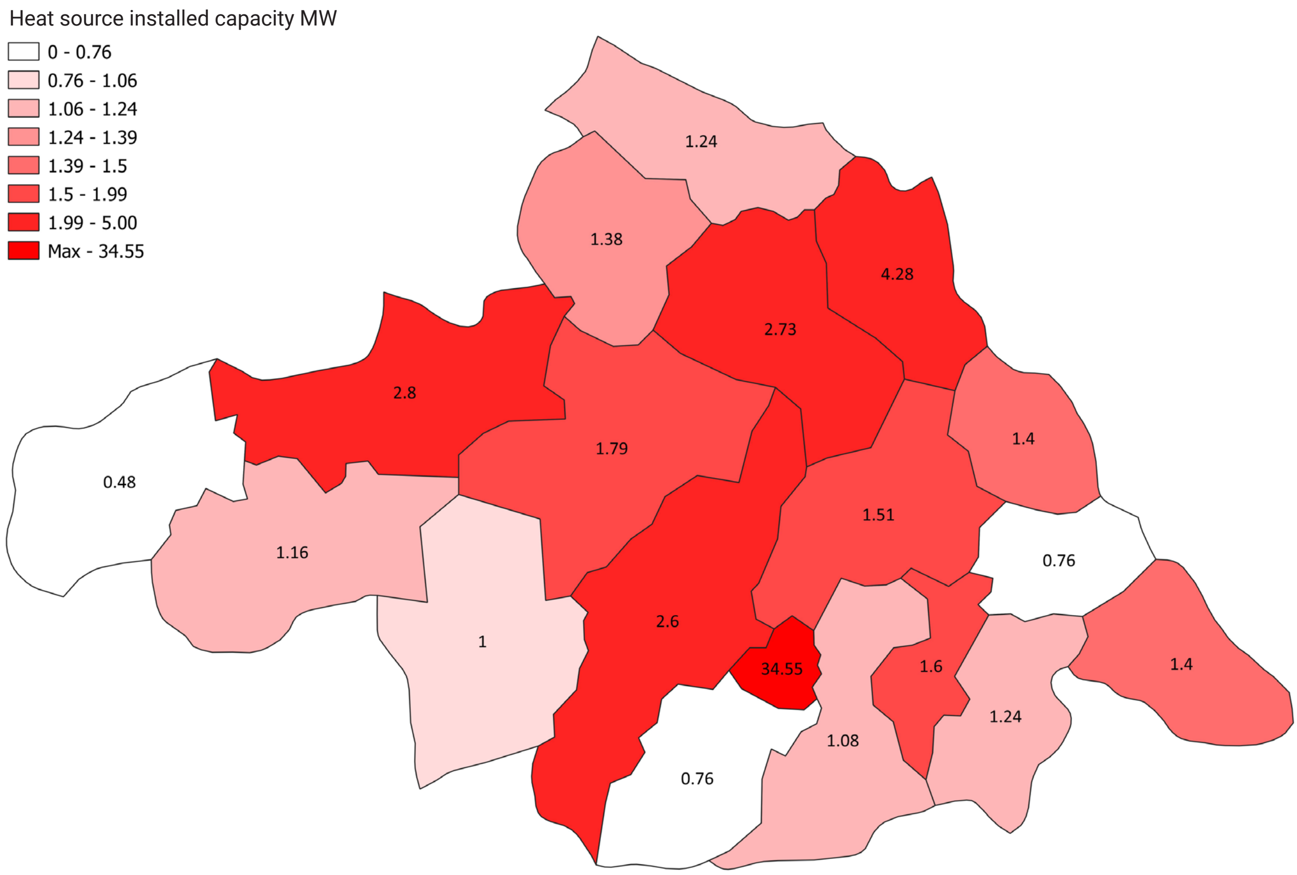
WHB of NRJ make, of Odkon CO.LTD

Handmade WHB

The WHBs of other manufacturers of PRC

The WHBs of different countries and manifactures

Graph 4. **The capacity of water heating boilers installed in Arkhangai province**



Source: Database of Arkhangai province's Energy Regulatory Council

OPERATING CONDITION OF HEAT ONLY BOILERS

During the field study, it was observed that the operation of the boiler and the regulating condition is not meeting the boiler regulating and exploitation regime.

- The upper part of the heating pipe is located at the top of the fire pit and passes through the smoke exhaust. So, it is often clogged with ash.
- Coal is wasted through the space between grates of the fuel hopper
- Heat transfer is poor due to insufficient air draft. Some boilers use an additional blower
- Measuring and monitoring equipment are not sufficient and are damaged
- Working condition is not safe for heat-only boiler operators
- The chimney angle is incorrect
- The boiler is open to rainwater
- The boiler room and house are not comfortable to operate. There is a lot of soot
- The water treatment system is missing.

HEAT DEMAND FOR PUBLIC BUILDING

According to the Minister of Energy's resolution, the heating season of the public buildings continues for 242 days, from September 15 to May 15. The outdoor air-rated temperature used to estimate heat demand is (-28.6° C) by Mongolian Building Normative and Codes. The absolute minimum temperature reaches (-53°C). During the daytime in winter, the outdoor air's actual mean temperature is (-14°C), and during the night falls to (-25°C).

During the heating season, the heating volume of public buildings in 18 soums, except for the Erdenebulgan soum, was a total of 708,800 m^3 during the 2019-2020 heating season. Approximately the estimated heating demand of public buildings is Q=16MW, and the total installed capacity of heat sources is 29.21 MW. The following table compares the total heating volume and the calculated heat load with the source capacity.

Table 1. **Heating demand and heating source installed capacity of 18 soums**

Region	Quantity of buildings	Heating volume ($м^3$)	Estimated heating load (MW)	Heat source installed capacity (MW)
Western (Tsakhir,Undur-Ulaan,Khangai,Tariat,Chuluut)	70	197488.90	4.46	7.23
Eastern (Ulziit,Ugiinuur, Khashaat, Khotont, Battsengel)	45	151403.00	3.42	6.31
Central (Ikh tamir, Bulgan, Tsekher, Tuvshruulekh)	67	172283.94	3.90	6.04
Northern (Tsetserleg,Jargalant, Erdenemandal,Khairkhan)	59	187616.40	4.24	9.63
Total	**241**	**708792.24**	**16.02**	**29.21**

Source: Arkhangai province Energy Regulatory Council
The estimated heat load was calculated following Con.Regulation 41-02-05 2.4

USER'S COMFORT OF THE PUBLIC BUILDINGS

During the interview with some employees, directors, and users, the following main issues were identified:

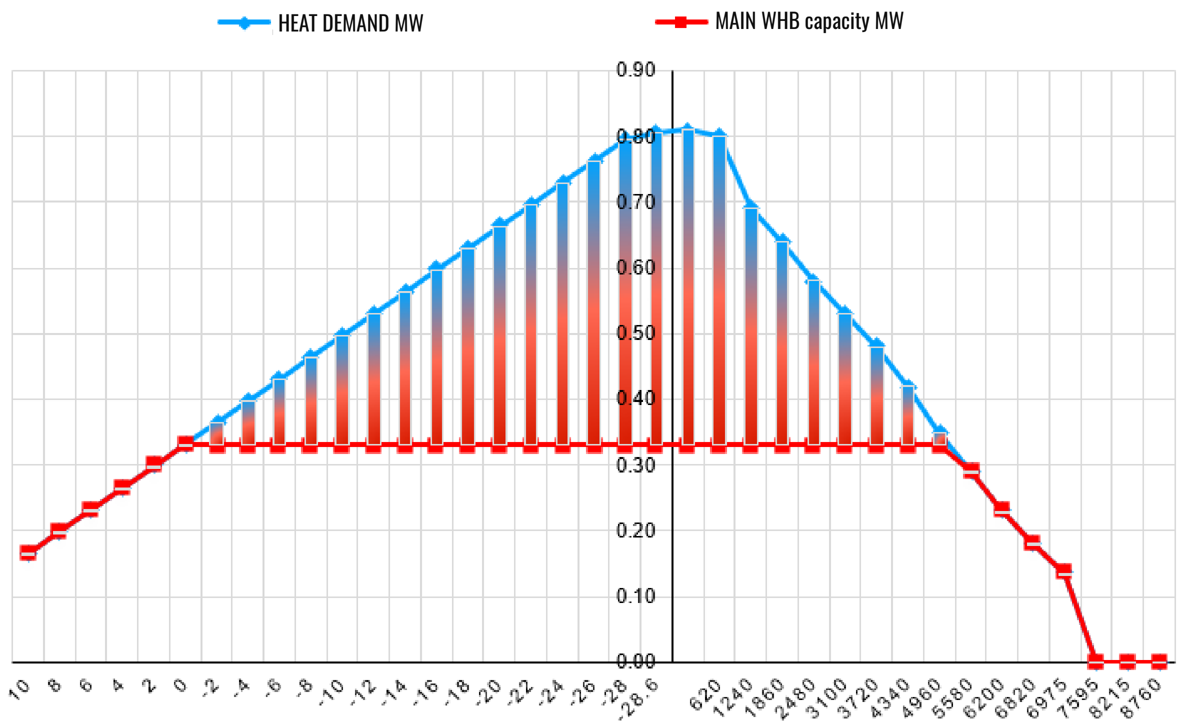
- People adapted to what they have (not aware of thermal comfort)
- Loss of control on the thermal comfort and heating system regulations
- Unnecessary energy-saving measures

Thermal comfort not only depends on the condition of the building and technical issues, user attitudes, and behavior affect. Administration of public organizations of soums raises thermal comfort issues, but it takes a lot of time to solve them. Users of public buildings were implementing unstable solutions and adapted to the current conditions by themselves.

The following graph illustrates the estimated heating load and the installed capacity of the WHB in Ugiinuur soum. The chart shows that at the beginning of the heating season, when the outside temperature reaches constantly below 0°C, some public buildings with the individual heating system have a deficit in the main heating furnace capacity. So, consumers use the reserved furnaces as an additional water heater boiler. The total heating boilers' total installed capacity is 0.37 MW, while the estimated heat demand for the heating season is 0.81 MW. During the cold winter months, if a kindergarten or school's one of the boilers breaks down, the whole heating system falls apart.

Because of this technical miscalculation, users of these organizations cannot winter comfortably.

Graph 5. **Comparison of the annual heat load of Ugiinuur soum and the capacity of the main heating furnace**



Source: Arkhangai province Energy Regulatory Council
The estimated heat load was calculated following Con.Regulation 41-02-05 2.4

Education buildings: Due to the studding environment's insufficient thermal condition, students have colds and flu very commonly during the winter season. As for kindergartens, indoor air quality, temperature difference, and thermal comfort in classrooms do not meet the health normative. Because of these issues, children are suffering from health problems.

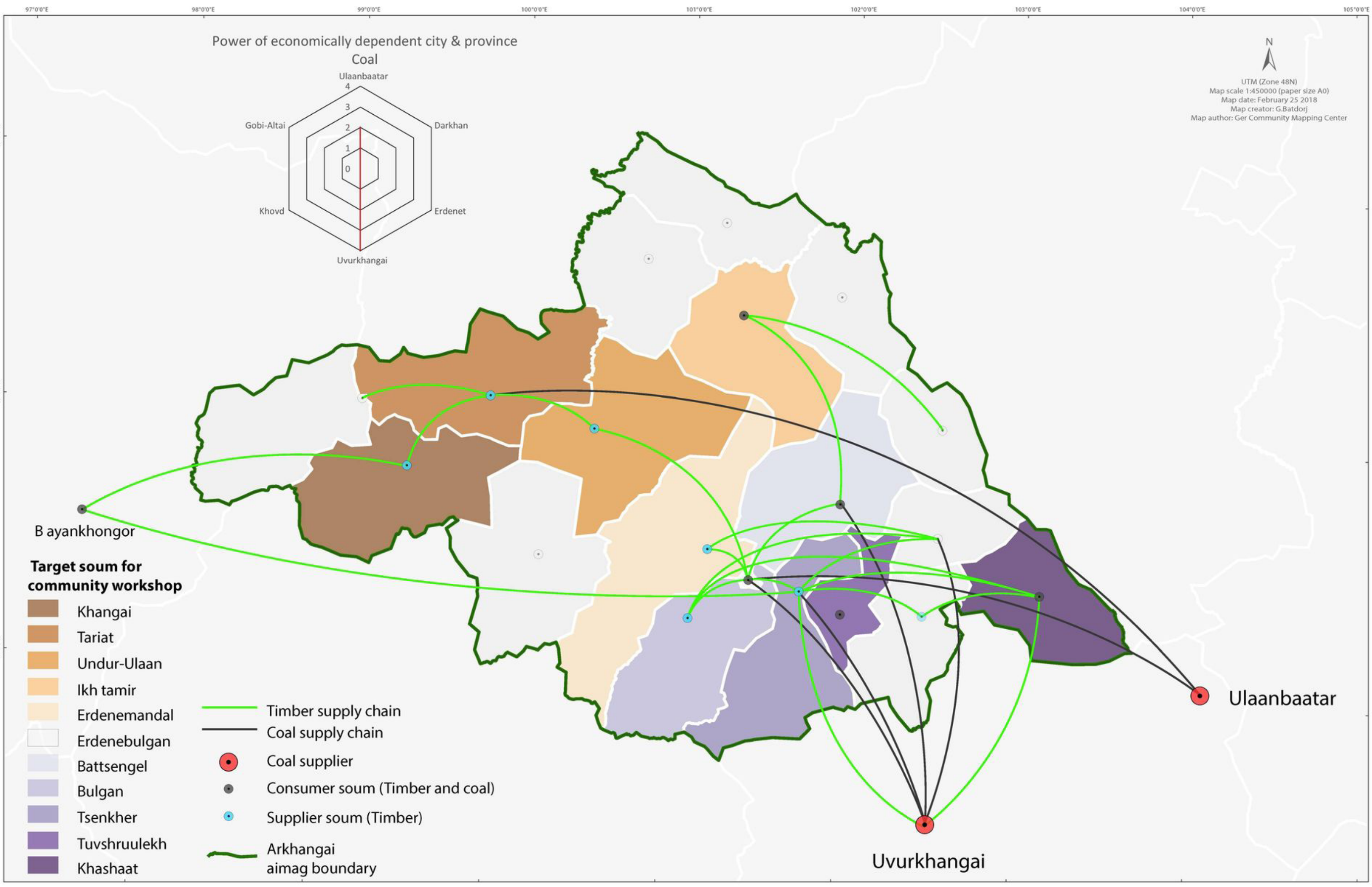
Health centers: Although the hospitals' thermal comfort is relatively good, some rooms are chilling, and some are too hot due to a malfunction of the heating system.

Public service buildings: As for cultural and social service organizations. The cultural centers' buildings operation is not regular, and the heating is not working regularly. Therefore, the cultural center's staff and local authorities do not pay much attention to thermal comfort. Usually, in the winter, people participate in cultural events in outdoor clothing, and employees work in uncomfortable thermal conditions.
Some public service organizations are taking unnecessary energy efficiency measures, such as reducing heating and decreasing firing. Usually, local people lack knowledge about the efficiency of energy-saving solutions. And, they are not aware of the most suitable energy-efficient methods for their buildings.

FUEL CONSUMPTION OF PUBLIC BUILDINGS

The energy source of the public buildings of the Arkhangai province is fossil fuels. The Arkhangai province is one of Mongolia's few provinces without a coal mine, regardless of fossil fuel consumption. Therefore, the coal is supplied by the mine site of "Bayanteeg" JSC, a part of the Ongi river coal deposits of the Uvurkhangai province.

Figure 3. **Coal purchase locations**



Source: CEMAATERR-I project, Community-based Climate vulnerability risk assessment of Arkhangai province, 2019

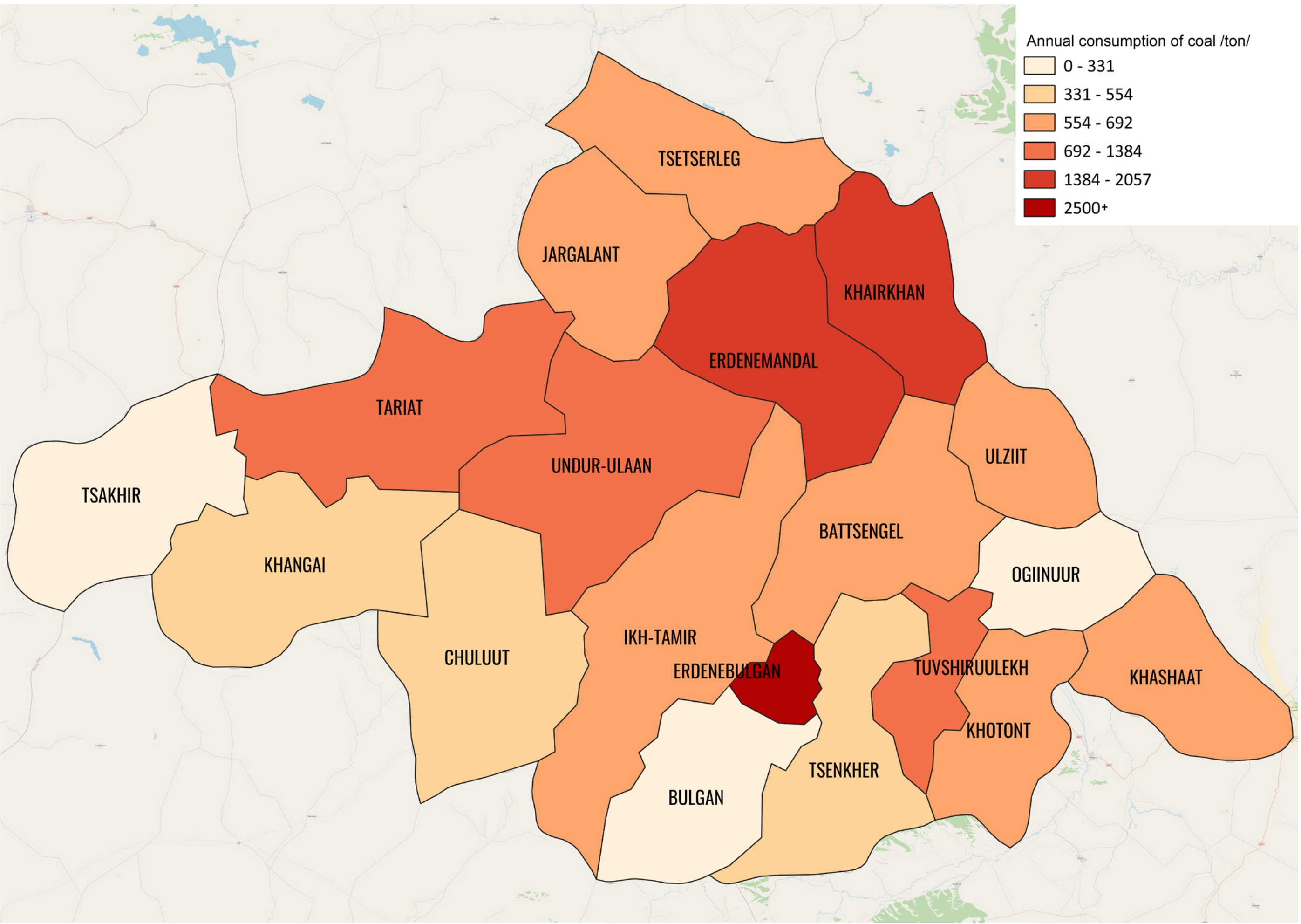
The estimated annual coal consumption in a total of Erdenbulgan soum's public building connected to the centralized heating boilers and the rest of 18 soums is 28650 tons. The coal consumption of regions is shown in the table below.

Table 2. **Coal consumption**

Regions of Arkhangai	Number of main boilers/quantity/	Annual coal consumption /tons/
Western	19	3752.62
Eastern	12	2264.42
Central	31	17597.78
Northern	13	5033.15
Total	75	28647.97

Source: Arkhangai province Energy Regulatory Council

Graph 6. **Fuel consumption of the whole Arkhangai province**



Source: Arkhangai province Energy Regulatory Council

Graphic 6 illustrates the annual coal consumption of each sum of the Arkhangai province. The fuel consumption of each soums directly depends on the following factors:

- Heat consumption of public buildings
- Type and ignite quality of fuel
- Number of public buildings and capacity
- Installed capacity of the boiler

As per Erdenebulgan soum, with the highest population density and largest heat consumers base, spend 14735.11 tons of coal annually. The above-mentioned "Bayanteeg" coal mine coal was transported to the Erdenebulgan soum of Arkgangai province via auto road in 406 km. According to the National regulation of Energy tariff, it is the main reason for the high rate of heating tariff in Arkhangai.

USE OF FIREWOOD

Raw wood is used as the fuel for heating the public buildings in some sums. Wood is much easier to access and cheaper in Arkhangai than purchasing coal from the distant coal mine. But, wood has a much lower caloric value than coal. It can't produce enough heat to supply thermal comfort to the users during the winter. Some public buildings' heat-only boiler capacity is not enough to heat the building, and using the wood makes it more inefficient.

On the other hand, some WHB, such as handmade furnaces, are made to use only wood due to the boiler's operational conditions and the low quality of the metal details, which have metal parts that are not suitable for coal.

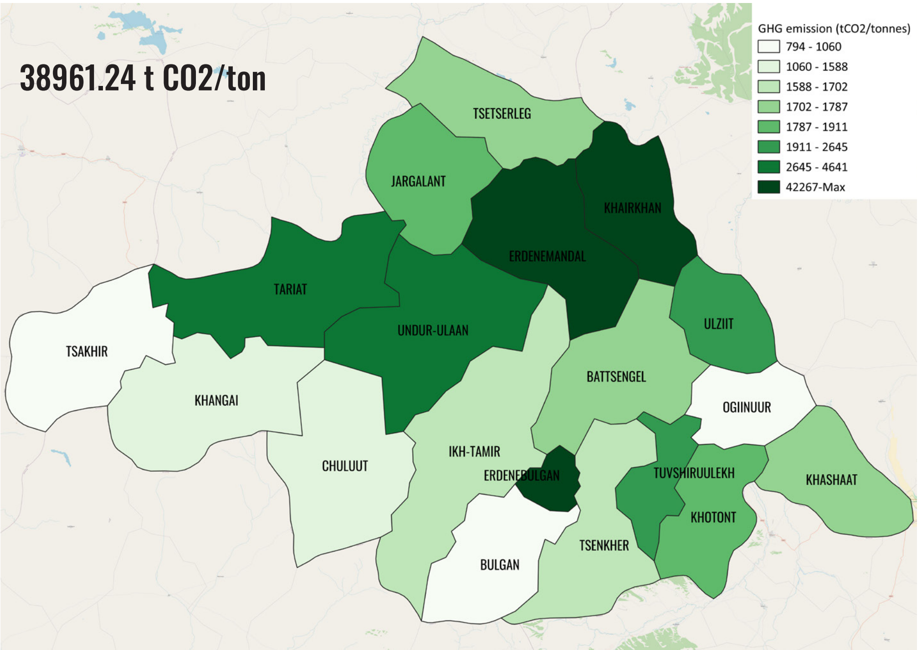
Generally, in the Arkhangai province, households usually use wood for heating all season. Even the nomadic herders living close to the forest are using wood for heating and cooking throughout all seasons. Using the wood for domestic purposes also collected wood from any sustainable management plan that contributes to deforestation and climate change. Forest degradation accelerates year by year. The main reasons for substituting coal with wood for the heating of public buildings according to the users. Although the reasons mentioned above are giving the exception to the use of wood, it contributes to deforestation and unrestorable damage to the ecosystem.

GHG EMISSION FROM THE FUEL COMBUSTION FOR THE PUBLIC BUILDING HEATING

Including GHG emissions from the centralized heating system in Erdenebulgan soum and public building's heat only water heating boilers in other soums, the province emits 38961.24 tons of CO2 per year, of which 20039.75 tons or 51.4% are emitted from centralized heating system of Erdenebulgan soum, province center.

The following figure demonstrated the CO_2 emission volume and rating of each sum of the Arkhangai sum during the heating season. Fuel expenditure is estimated based on the data record provided by the Energy Regulatory Council of Arkhangai province. The CO_2 emission is calculated using the corresponding methodology, such as IPCC Guidelines, based on the coal analysis report attached to the 2019 Investors report of the Bayanteeg JSC

Graphic 7. **GHG emissions from fuel combustion**



Although the Bayanteeg coal used province-wide has a higher caloric value classified under the D and G category of the coal, it has higher carbon content based on the quality analysis (C=78.23%). Although the coal expenditure is relatively minor, its GHG emission level is higher by 30.5% than standard fuel emission.

Source:" Geres" NGO estimated based on B.Namkhainyam etc.: Study determining GHG emission factor for Mongolia, 2013, IPCC Guidelines for National GHG Inventories, 2006

CHAPTER 2 THE DETAILED FIELD STUDY OF PUBLIC BUILDINGS IN SELECTED 6 SOUMS

4 REGION

6 SOUMS

BUILDING ENERGY PASSPORT

62 PUBLIC BUILDINGS

SUMMARY OF FIELD STUDY

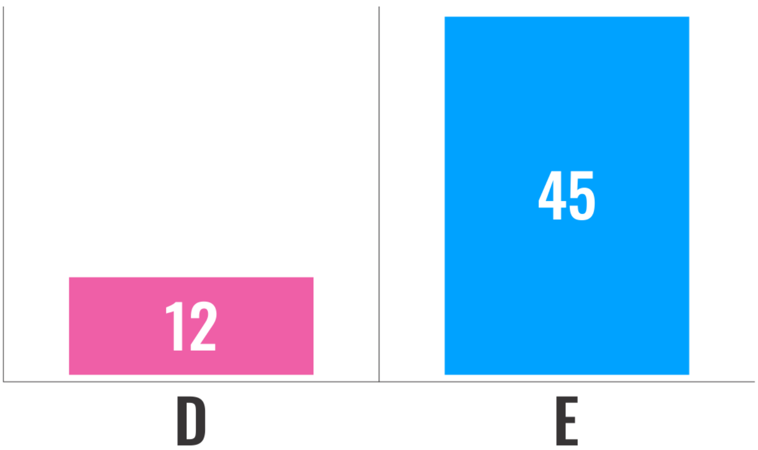
Detail study of “The energy efficiency of the public buildings in Arkhangai province” was conducted to measure and collect primary data of public buildings in Khangai, Undur-Ulaan, Tsetserleg, Tsenkher, Ugiinuur, and Khashaat soums, selected by the steering committee of the CEMAATERR-II project. The actual condition of the buildings, heating system, heat, and electricity energy actual consumption was studied within the field study. A total of 62 public buildings were studied, of which 5 were unusable or demolished due to new construction. In the end, a total of 57 buildings were assessed. The age of public buildings in soums is classified as pre-1990 or pre-market buildings, between 1990-2008 or until the construction sector adopted thermal protection norms. Between 2009-and 2020 buildings were insulated in some way. 26 were built in pre-1990, 8 between 1990-2008, and 28 between 2009-2020.

Based on the data collection questionnaire and information provided by the Energy Regulatory Council of Arkhangai province, selected 6 soums to consume about 400 tons of coal during the heating season. The amount of CO2 emitted from coal is 544 tons per year. It is also noteworthy that electricity consumption has increased by at least 30 percent during the heating season. Further research suggests that the unprofessional building owner’s exploitation of the heating system and the workers' poor professional skills affect electricity consumption. The heating energy consumption and heat loss estimations of public buildings were estimated based on the “Building thermal performance” BNaC 25-01-20. Out of 57 public buildings, 44 buildings are included in energy efficiency class E, and 13 buildings are in class D. The result of the energy efficiency performance indicates that the energy efficiency of public buildings must be improved.

SOUM PUBLIC BUILDING ENERGY CONSUMPTION CLASSIFICATION

The calculation was performed in accordance with "Building thermal protection" code (BNbD 25-01-20). It is estimated that there are 44 buildings in category E and 13 buildings in category D out of 57 buildings. The buildings in class D include relatively insulated buildings built since 2009. Table 3 recommends that Class D buildings be rehabilitated on economically viable grounds, while Class E buildings are recommended for economic rehabilitation or demolition.

Graph 8. **Energy efficiency classification of public buildings in soums**



19 дугаар хүснэгтийн дагуу D ангиллын барилгуудыг эдийн засгийн үндэслэлтэй нөхцөлөөр сэргээн засварлах шаардлагатай гэж зөвлөсөн байдаг бол E ангилалд багтсан барилгуудыг эдийн засгийн үндэслэлтэй нөхцөлөөр сэргээх эсвэл нураах зөвлөмж өгдөг.

SOURCE: "BEEC" CO.LTD ESTIMATION RESULT ACCORDING TO THE BNAC 25-01-20 "BUILDING THERMAL PERFORMANCE."

Table 3. **Energy efficiency classification of residential and public buildings**

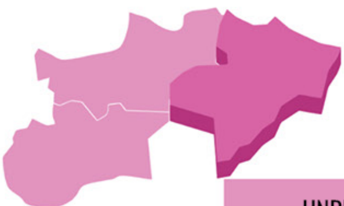
Class	Class definition	Ration of the estimated and normative value of the specific heating and ventilation consumption, %	Recommendations from the governmental organization
A++	Passive	Less than 20%	Economic support
A+	Low energy building	From 40% to 20%	
A	High energy efficient	From 65% to 40 %	
B	Energy-efficient	From 90% to 65%	
C	Normative level	From 90% to 110 %	Normative value should be met
D	Non-energy-efficient	From 110% to160%	Renovation based on economic condition
E	Non-energy efficient	Above 160%	Renovation based on economic condition or to demolish

Source: BNaC 25-01-20 "Building thermal performance."

TABLE 4. RECOMMENDATION OF ENVELOPE INSULATION FOR 57 PUBLC BUILDING OF THE SELECTED SOUMS





SOUM	NO	BUILDINGS	STRUCTURE TYPE	BUILT YEAR
	1	School 1st building	masonry	1959
	2	School 2nd building	masonry	1990
	3	Sport hall	masonry	2013
	4	Dormitory 1	masonry	2012
	5	Dormitory 2	masonry	1990
	6	Canteen	masonry	1990
	7	Health center	masonry	2009
	8	Kindergarden	masonry	1990
HASHAAT	9	Governor`s office	masonry	2013
	10	Police	masonry	2010
	11	School 1st building	masonry	2012
	12	School 2nd building	stone masonry	1985
	13	School 3rd building	masonry	1954
	14	Sport hall	masonry	2009
	15	Dormitory 1	masonry	1975
	16	Kindergarden	masonry	1990
	17	Health center	masonry	2011
	18	Cultural center	stone masonry	1965
OGIINUUR	19	Governor`s office	masonry	1978
	20	Police	masonry	2010
	21	School building	masonry	1990
	22	Dormitory	masonry	2015
	23	Dormitory	masonry	1989
	24	Canteen	masonry	2013
	25	Kindergarden	masonry	2012
TSETSERLEG	26	Kindergarden	masonry	1958
	27	Police	masonry	1958
	28	School building	masonry	1980
	29	Dormitory	Wooden	1980
	30	Dormitory	Wooden	1980
	31	Sport hall	masonry	2010
	32	Rented building	Wooden	1980
	33	Health center	masonry	1982
	34	Mother resting	masonry	1982
	35	Storage of dead body	masonry	1982
	36	Garage	masonry	1982
	37	Elderly room	masonry	2018
	38	Bag leader`s quarter	masonry	2018
	39	Police	masonry	2010
TSENKHER	40	Governor`s office	masonry	1980
	41	Kindergarden	masonry	2007
	42	School	masonry	2016
	43	Dormitory	masonry	1985
	44	Sport hall	masonry	1987
	45	Cultural center	masonry	1987
	46	Governor`s office	Wooden	1953
	47	Public meeting	masonry	2018
KHANGAI	48	Hospital	masonry	2013
	49	Police	masonry	2010
	50	Dormitory	masonry	1988
	51	Dormitory	masonry	1975
	52	Sport hall	masonry	2016
	53	Dormitory	masonry	1986
	54	Health center	masonry	2010
	55	Kindergarden	masonry	2011
	56	Cultural center	masonry	2008
UNDUR-ULAAN	57	Governor`s office	Wooden	1983
	58	Police	masonry	2013

INSULATION OF ENVELOPE			
ROOF	WALL	FLOOR	WINDOW
✓	✓	✓	✓
✓	✓	✓	✓
✓	✓	✓	✓
✓		✓	✓
✓	✓	✓	✓
✓	✓	✓	✓
✓	✓	✓	✓
✓	✓	✓	✓
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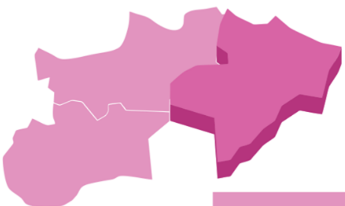
✓	✓	✓	✓
✓	✓	✓	✓

HEATING DEMAND AND CLASSIFICATION OF PUBLIC BUILDINGS

Out of 62 surveyed, public buildings of the soums, kindergarten, and sports hall in Khangai soum were excluded from the energy efficiency calculation because the kindergarten and gymnasium buildings are out of service due to cracks permafrost and out of service time. Also, the cultural centers in Khashaat, Tsetserleg, and Tsenkher soums were not completed and, therefore, excluded from the calculation. Thus, the energy efficiency classification was conducted for a total of 57 buildings. The estimation was performed in accordance with "BUILDING THERMAL PERFORMANCE." From the result, 44 buildings are classified as E class while 13 buildings belong to class D.

Source: "BEEC" Co.Ltd recommendations

TABLE 5. BUILDING HEATING ENERGY LOAD AND THEIR CLASSIFICATIONS

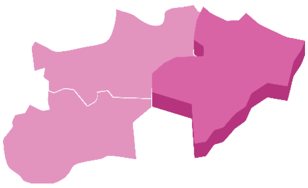
SOUM	No	BUILDINGS	STRUCTURE TYPE	BUILT YEAR	ROOF TYPE	FLOOR TYPE
	1	School 1st building	masonry	1959	Gable roof	On the ground
	2	School 2nd building	masonry	1990	Gable roof	On the ground
	3	Sport hall	masonry	2013	Sandwich roof panel	On the ground
	4	Dormitory 1	masonry	2012	Flat roof	On the ground
	5	Dormitory 2	masonry	1990	Gable roof	On the ground
	6	Canteen	masonry	1990	Gable roof	On the ground
	7	Health center	masonry	2009	Gable roof	On the ground
	8	Kindergarden	masonry	1990	Gable roof	On the ground
HASHAAT	9	Governor`s office	masonry	2013	Flat roof	On the ground
	10	Police	masonry	2010	Gable roof	On the ground
	11	School 1st building	masonry	2012	Gable roof	On the ground
	12	School 2nd building	stone masonry	1985	Gable roof	On the ground
	13	School 3rd building	masonry	1954	Gable roof	On the ground
	14	Sport hall	masonry	2009	Gable roof	On the ground
	15	Dormitory 1	masonry	1975	Gable roof	On the ground
	16	Kindergarden	masonry	1990	Gable roof	On the ground
	17	Health center	masonry	2011	Gable roof	On the ground
	18	Cultural center	stone masonry	1965	Gable roof	On the ground
OGIINUUR	19	Governor`s office	masonry	1978	Gable roof	On the ground
	20	Police	masonry	2010	Gable roof	On the ground
	21	School building	masonry	1990	Gable roof	On the ground
	22	Dormitory	masonry	2015	Flat roof	On the ground
	23	Dormitory	masonry	1989	Gable roof	On the ground
	24	Canteen	masonry	2013	Gable roof	On the ground
	25	Kindergarden	masonry	2012	Gable roof	On the ground
TSETSERLEG	26	Kindergarden	masonry	1958	Gable roof	On the ground
	27	Police	masonry	1958	Gable roof	On the ground
	28	School building	masonry	1980	Gable roof	On the ground
	29	Dormitory	wooden	1980	Gable roof	On the ground
	30	Dormitory	wooden	1980	Gable roof	On the ground
	31	Sport hall	masonry	2010	Flat roof	On the ground
	32	Rented building	wooden	1980	Gable roof	On the ground
	33	Health center	masonry	1982	Gable roof	On the ground
	34	Mother resting	masonry	1982	Gable roof	On the ground
	35	Storage of dead body	masonry	1982	Gable roof	On the ground
	36	Garage	masonry	1982	Gable roof	On the ground
	37	Elderly room	masonry	2018	Gable roof	On the ground
	38	Bag leader`s quarter	masonry	2018	Gable roof	On the ground
	39	Police	masonry	2010	Gable roof	On the ground
TSENKHER	40	Governor`s office	masonry	1980	Gable roof	On the ground
	41	Kindergarden	masonry	2007	Gable roof	On the ground
	42	School	masonry	2016	Flat roof	Above grade
	43	Dormitory	masonry	1985	Gable roof	Above grade
	44	Cultural center	masonry	1987	Gable roof	Above grade
	45	Governor`s office	wooden	1953	Gable roof	On the ground
	46	Public meeting	masonry	2018	Gable roof	On the ground
KHANGAI	47	Hospital	masonry	2013	Gable roof	On the ground
	48	Police	masonry	2010	Gable roof	On the ground
	49	Dormitory	masonry	1988	Gable roof	Above grade
	50	Dormitory	masonry	1975	Gable roof	On the ground
	51	Sport hall	masonry	2016	Flat roof	Above grade
	52	Dormitory	masonry	1986	Gable roof	Above grade
	53	Health center	masonry	2010	Gable roof	Above grade
	54	Kindergarden	masonry	2011	Flat roof	Above grade
	55	Cultural center	masonry	2008	Flat roof	Above grade
UNDUR-ULAAN	56	Governor`s office	wooden	1983	Gable roof	On the ground
	57	Police	masonry	2013	Gable roof	On the ground

U WALL	U ROOF	U FLOOR	S WALL	S ROOF	S WINDOWS	CLASS	KWH.YEAR	S HEATING AREA	V HEATING VOLUME
1.65	1.53	0.55	533	1560	49.3	E	662247	606	2714
1.65	1.53	0.55	546	544	1.2	E	338271	931	3916
0.32	0.25	0.55	550	496	30.24	D	215559	421	3916
0.26	0.2	0.32	705	437	12.15	D	199349	1135	4018
1.65	1.53	0.55	585	390	2.8	E	251308	667	2807
1.65	1.53	0.55	310	450	2.7	E	246220	381	1710
0.28	1.53	0.55	343	273	24.75	E	189574	464	1610
1.65	1.53	0.55	568	567	25.5	E	382931	768	5452
0.26	0.183	0.55	520	496	41.25	E	212888	843	3571
0.3	0.25	0.55	133	144	0	D	34975	122	374
0.26	0.83	0.36	755	775	75.6	E	431764	1318	5584
1.65	1.53	0.55	286	465	21	E	271190	395	1674
1.65	1.53	0.55	249	576	36.7	E	272732	490	2073
0.26	0.25	0.36	550	496	30.24	D	215559	421	3916
1.65	1.53	0.55	554	941	29.5	E	556574	800	3389
1.65	1.53	0.55	568	567	25.5	E	382931	768	5452
0.28	0.18	0.55	259	468	29.2	D	144003	398	1591
2	1.53	0.55	435	630	27	E	414649	521	2709
1.65	1.53	0.55	249	440	16.8	E	239255	374	1144
0.3	0.25	0.55	133	144	0	D	34975	122	374
1.65	1.53	0.55	1154	1440	21.6	E	1014985	2511	9216
0.32	0.83	0.55	538	353	11.5	E	168289	610	2400
0.32	0.83	0.55	430	398	38	E	164681	738	2308
1.65	1.53	0.55	138	155	0	E	102015	148	465
0.2	0.19	0.55	360	360	25.2	D	92172	519	1624
1.55	0.83	0.55	320	610	20	E	246821	585	1830
1.65	1.53	0.55	232	384	11.2	E	170808	368	1152
1.65	1.53	0.55	1115	1436	133	E	1020067	2369	9009
0.38	1.53	0.55	297	512	32.4	E	236991	440	1792
0.38	1.53	0.55	276	416	1.5	E	191807	357	1456
0.26	0.25	0.36	550	496	30.24	D	215559	421	3916
1.65	1.53	0.55	276	416	1.5	E	250699	357	1456
1.65	1.53	0.55	440	621	18	E	382514	533	2173
1.65	1.53	0.55	175.4	180	0	E	123589	154	630
1.65	1.53	0.55	138	110	2.25	E	84733	94	385
1.65	1.53	0.55	100	50	3	E	48629	43	175
0.38	1.53	0.55	144	131	4.5	E	65907	112	458
0.38	1.53	0.55	164	161	4.5	E	78611	138	563
0.3	1.53	0.55	133	144	0	D	34975	122	374
1.65	1.53	0.55	396	311	21.6	E	263083	550	2021
0.32	1.53	0.55	284	551	18	E	241678	525	1928
0.27	0.25	2.2	1480	1400	96	E	974600	3784	15400
1.65	1.53	3.9	434	388	6.9	E	529437	744	2328
1.65	1.53	3.9	878	880	37.8	E	1186513	1478	7040
1.65	1.53	0.55	308	222	19	E	180655	213	666
0.27	0.25	0.55	180	261	9	D	56530	250	783
0.38	1.53	0.55	329	301	9	E	161340	515	1610
0.3	1.53	0.55	133	144	0	D	34975	122	374
0.32	1.53	2.2	755	775	75.6	E	668748	1318	5584
1.65	1.53	2.2	756	1700	49	E	940499	1445	5950
0.27	0.25	0.19	493	472	15.75	D	145076	401	2836
1.65	1.53	2.2	422	381	4.5	E	460944	648	2363
0.27	0.83	3.9	387	280	24.75	E	278426	477	1820
0.27	0.8	3.9	681	510	20.5	E	436735	900	3882
0.32	0.22	2.3	519	573	7.68	E	191441	510	2076
1.45	1.53	0.55	249	440	16.8	E	239255	374	1144
0.3	0.25	0.55	133	144	0	D	34975	122	374

Source: "BEEC" Co.Ltd estimation result according to the BNaC 25-01-20 "Building thermal performance."

POWER AND ENERGY CONSUMPTION OF PUBLIC BUILDINGS IN **UNDUR-ULAAN SOUM**

Locations of the public buildings at Undur-Ulaan soum



UNDUR-ULAAN SOUM

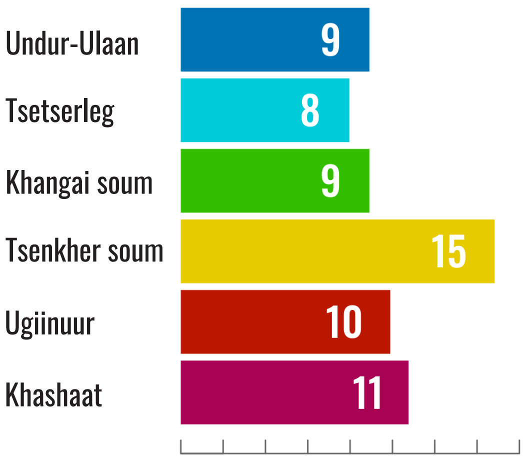
The heating energy consumption and electricity consumption of the building were determined. The use of coal for heating the building was surveyed and the electricity consumption was obtained from the electricity distribution companies through the Energy Regulatory Council of Arkhangai province.

Table 6. **Public buildings at Undur-Ulaan soum and their fuel consumption**

#	Organizations	Building designation	Capacity of educational organizations	Heat source	Annual fuel consumption Coal, ton	Annual fuel consumption Wood, m3	Electricity consumption kWh/year
1	Educational organizations	School. 1st building	781 students	Collective heating with heat only boiler	300	45 (Kitchen)	43245
2		School. 2nd building					
3		Sport hall	85 employees				
		Dormitory					
4		Kindergarten	251 children 33 employees	Water heat only boiler	60	64(Ger)	18302
5	Public service organizations	Health center			40	60 (Kitchen)	23873
6		Cultural center			30	48	3700
7		Governor's office			28	48	13264
8	Public safety organization	Police station					

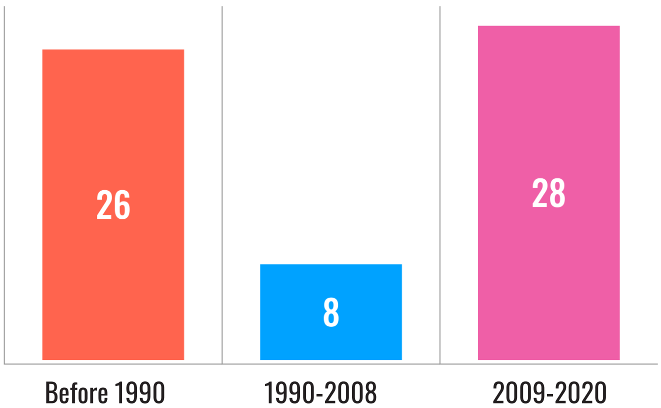
PRIMARY OF PUBLIC BUILDINGS IN **SELECTED SOUMS**

Graph 9. **The number of public buildings in soums.**



Source: "BEEC" CO.LTD questionnaire survey result. 2020

Graphic 10. **Aging of the building**



Source: "BEEC" CO.LTD questionnaire survey result. 2020

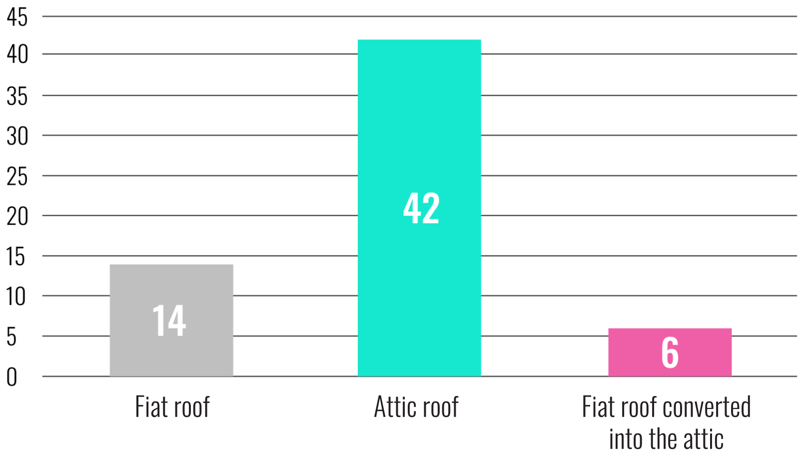
By the decision following the Cemaaterr-II Project steering committee meeting, a detailed field study of "The energy efficiency of the public buildings in Arkhangai province" was conducted for Khangai, Undur-Ulaan, Tsetserleg, Tsenkher, Ugiinuur, Khashaat soums by "BEEC" LLC. The building energy consumption, heating system, building envelope, and electricity consumption were studied for 62 buildings with collected primary data. Each soum has approximately 10 public buildings.

AGING OF THE BUILDING

In terms of agings, the surveyed public buildings were classified as built before 1990 during socialism, between 1990-2008 during democracy, and between 2009-2020 according to the building thermal performance norm. The below graphic shows that 28 buildings are somehow insulated.

BUILDING ENVELOPE

Graphic 11. **Types of roof**

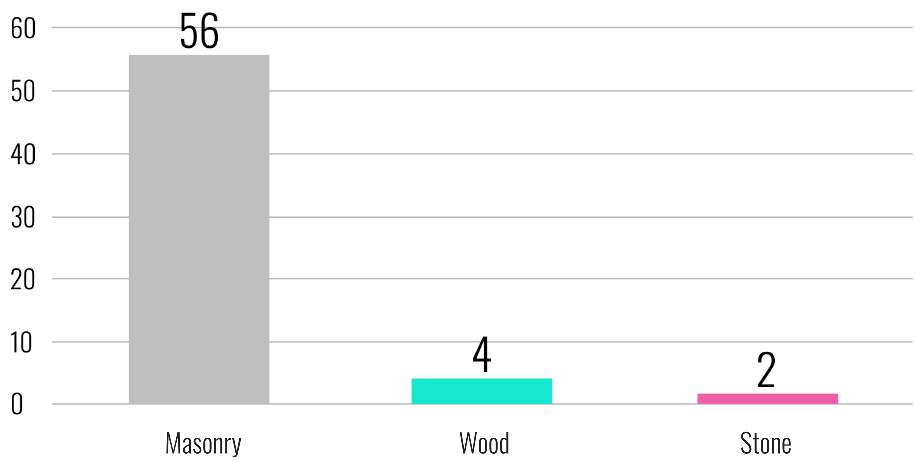


Эх сурвалж: Би И И Си ХХК-ийн суурь судалгааны асуумж. 2020 он

Roof: Public buildings built before 1990 mostly have gable roofs, while buildings built after 1990 have gable and flat roofs. In some cases, flat roofs were reconstructed with gable roofs due to their poor construction quality and unregular maintenance. For example, the kindergarten of Tsenkher soum has a gable roof; the thickness of the roof insulation was designed to be 20cm in the design drawing according to the building norm of the buildings built after 2009, the actual thickness was 5cm (additional of other types of the material layer).

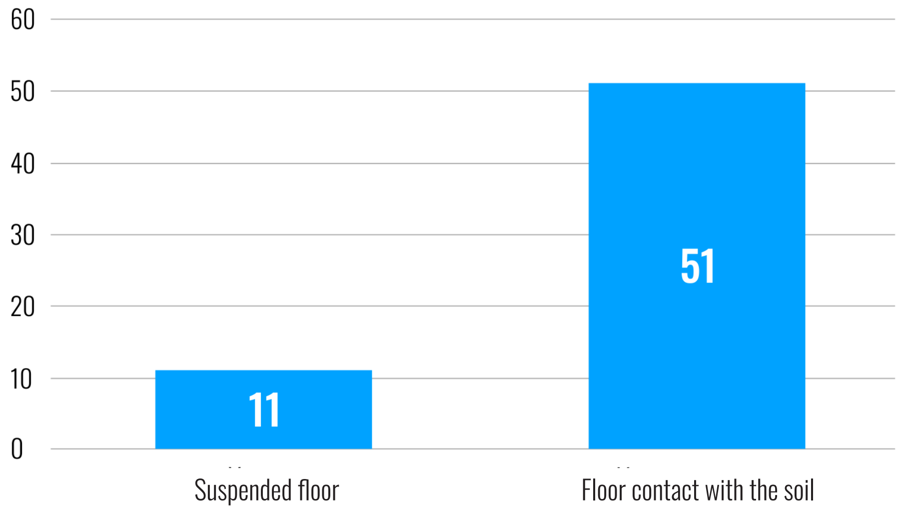
Graphic 12. **Types of external** wall

External wall: Predominant masonry wall structures are the local materials such as gravel or volcanic rocks. Also, very few cases used wood or stone to construct the external wall. The external wall of the buildings built after 2009 consist of block+EPS+brick masonry structures, while the walls of the old buildings are insulated with an aluminum panel with PU insulation. There were cases of reinsulating buildings that already have insulated.



Эх сурвалж: Би И И Си ХХК-ийн суурь судалгааны асуумж. 2020 он

Graphic 13. **Types of floor**



Source: "BEEC" CO.LTD questionnaire survey result. 2020

Floor: Depending on the soum location, buildings located at Khangai, Undur-Ulaan, Tsetserleg have suspended floors, while buildings located at Tsenkher, Khashaat, Ugiinuur soum have the floor directly on the soil. Though buildings have suspended floors, there were cracks on the floor and the wall. Moreover, the suspended floor is not sufficiently insulated. The suspended floor should be insulated as external wall insulation.

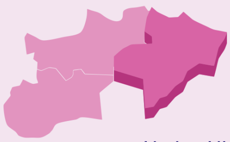
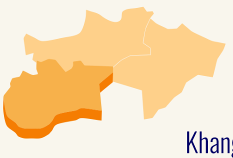
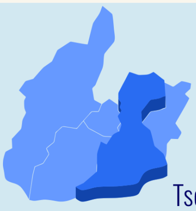
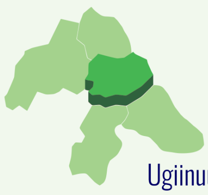
REAL COAL CONSUMPTION AND GREENHOUSE EMISSIONS OF SOUM PUBLIC BUILDINGS

Coal in the surveyed soums is sourced from the Bayan Teeg mine in Bayankhongor aimag. The price of one ton of coal is 110,000-135,000 MNT in 2019, depending on the distance between the mine and the soum. Out of 6 soums surveyed, Ogiinuur soum used wood for heating. Tsenkher soum kindergarten also uses wood. Although Ogiinuur soum does not seem to emit CO2 due to the use of wood for heating, more detailed research is needed on its environmental impact. The CO2 emissions from coal are estimated to be 1.36 kg of CO2 emissions per kg of coal burned, and the carbon emission coefficient is derived from the following sources.

B.Namkhainyam: Study determining GHG emission factor for Mongolia, 2013

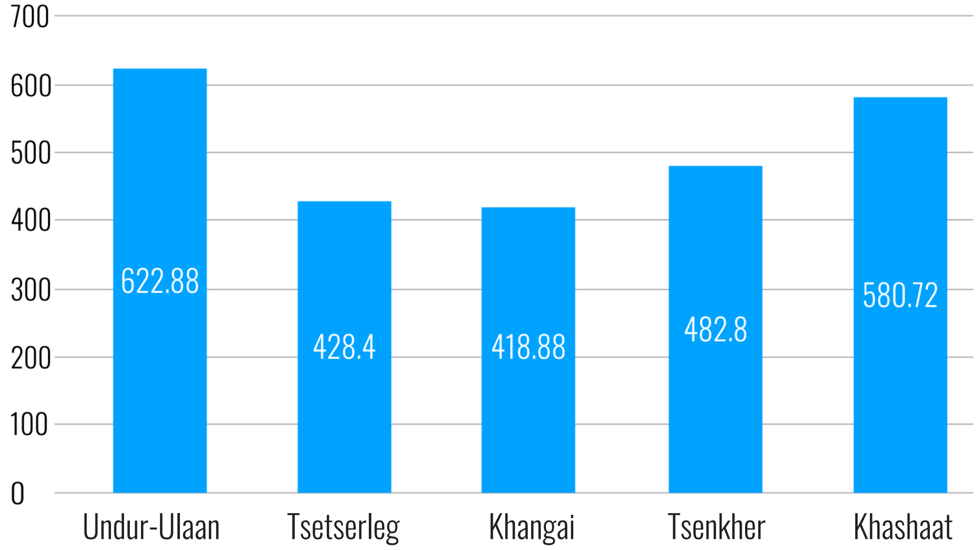
IPCC Guidelines for National GHG Inventories, 2006

Table 7. **Annual fuel consumption in soums**

Soum	Organization	Annual, ton	Total
 Undur-Ulaan	School	300	
	Health center	40	
	Kindergarden	60	458
	Cultural center	30	
	Governor`s office	28	
 Tsetserleg	School	220	
	Health center	45	
	Kindergarden	25	315
	Cultural center	new	
	Governor`s office	25	
 Khangai soum	School	200	
	Health center	70	
	Kindergarden	new	308
	Cultural center	electricity	
	Governor`s office	38	
 Tsenkher soum	School	320	
	Kindergarden	Wood	
	Cultural center	New	355
	Governor`s office	35	
	Hospital	School	
 Ugiinuur	School	Wood	
	Kindergarden	Wood	
	Cultural center	Wood	0
	Governor`s office	Wood	
	Hospital	Wood	
 Khashaat	School	230	
	Kindergarden	50	
	Cultural center	New	427
	Governor`s office	80	
	Эмнэлэг	67	

Source: "BEEC" Co.Ltd questionnaire survey from Energy Regulatory Council

Graph 14.**Annual GHG emission /ton/year/**



Source: BEEC Co.Ltd determined based on: B.Namkhainyam etc.: Study determining GHG emission factor for Mongolia, 2013, IPCC Guidelines for National GHG Inventories, 2006

THE OPERATIONAL CONDITION OF THE HEAT ONLY BOILERS

During the field study, it was observed that the operation of the boiler and the regulating condition is not meeting the boiler regulating and exploitation regime.

- The upper part of the heating pipe is located at the top of the fire pit and passes through the smoke exhaust. So, it is often clogged with ash.
- Coal is wasted through the space between grates of the fuel hopper
- Heat transfer is poor due to insufficient air draft. Some boilers use an additional blower
- Measuring, and monitoring equipment are not sufficient and are damaged
- Working condition is not safe for heat-only boiler operators
- The chimney angle is incorrect
- The boiler is open to rainwater
- The boiler room and house are not comfortable to operate. There is a lot of soot
- The water treatment system is missing.

"We found that operators 'knowledge about the operating principle of the heat only boiler is poor, working condition is not safe, water temperature and pump pressure are regulated by operators themselves based on their sense. Operators said that the supply water temperature from the boiler does not exceed 60⁰C"

ACTUAL ELECTRICITY CONSUMPTION OF THE PUBLIC **BUILDINGS IN SOUMS**

All the studied soums are supplied with electricity from the central electricity grid, namely "Electricity distribution network of the Erdenet- Bulgan." The electricity supply is reliable, does not have voltage deviation, and limitation is low. Schools and new kindergartens at each soums consume comparably high electricity because of the bigger area to light and high-performance pumps for the heating system.

Although, above mentioned consumptions, main electricity consumer is food service of schools and kindergartens. Schools in soum centers usually have a food court for pupils from 1st grade to the 4th grade. Every kindergarten in every soum has food services. Every kitchen has an electric stove for a mass food ventilation system to extract vapor from the cooking.

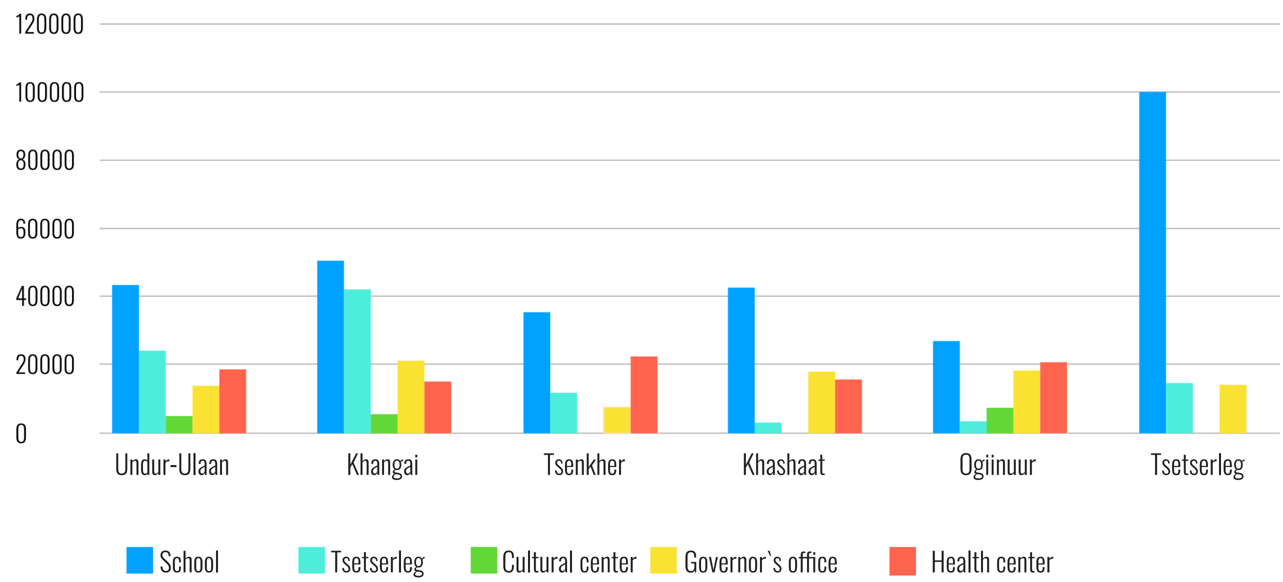
It was easier to determine electricity consumption for each building because the regular wattmeter had been installed on the grid. The following table shows the last three years' average electricity consumption. In Tsenkher, Khashaat, and Tsetserleg soum, cultural centers are new constructions without electricity connection during the baseline study in 2020.

Table 8. **Actual electricity consumption /kWh.year/**

Buildings/ soum	Undur-ulaan	Khangai	Tsenkher	Khashaat	Ugiinuur	Tsetserleg
School	43245	50201	35209	63306	68015	100459
Kindergarden	23875	42029	11095	23495	24966	14078
Cultural center	4348	4781			9596	
Governor's office	13264	6656	20928	20735	26428	13759
Health center	18302	21940	14398	15212	20120	

Source: Energy regulatory council of Arkhangai province. Data analyses by "BEEC" Co.Ltd.

Graph 15. **Actual electricity consumption in soums /kWh.year/**



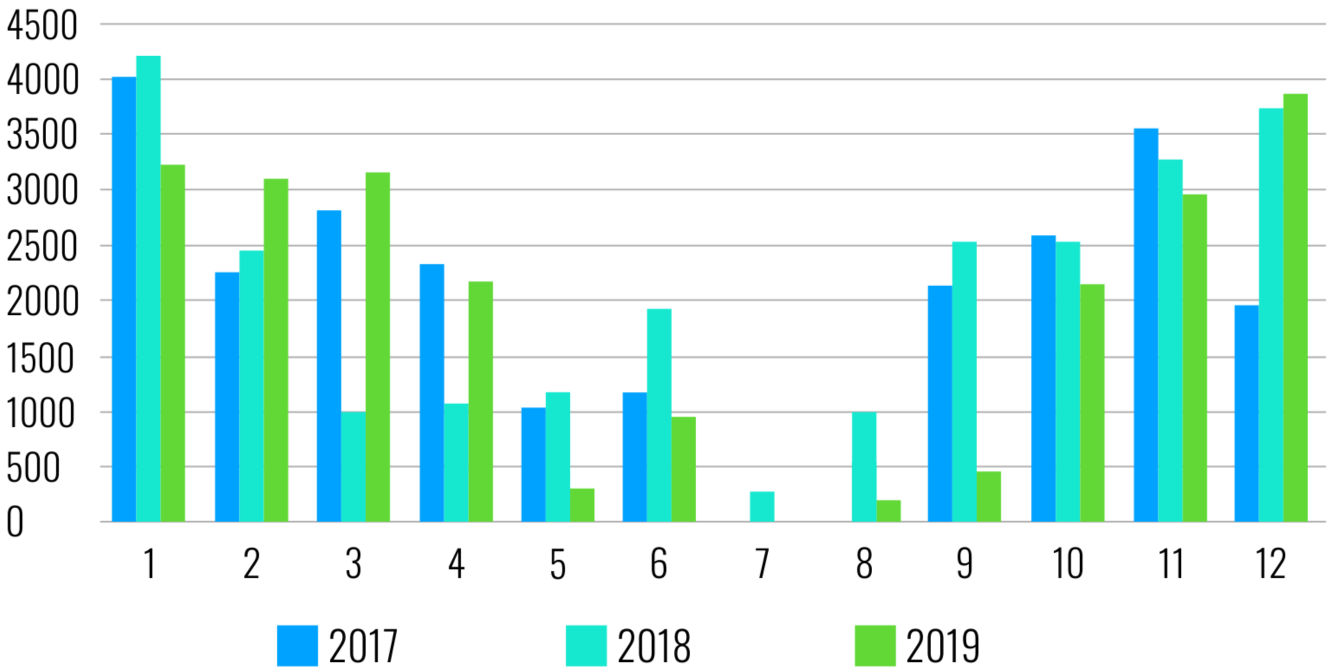
Source: Energy regulatory council of Arkhangai province. Data analyses by "BEEC" Co.Ltd.

Table 9. **Three-year electricity consumption of the kindergarten at Undur-Ulaan soum /kWh. month/**

SOUM	UNDUR-ULAAN		
MONTHS	2017	2018	2019
1	4026	4215	3232
2	2259	2458	3120
3	2815	966	3160
4	2318	1077	2160
5	1041	1180	297
6	1182	1939	943
7		250	
8		965	167
9	2140	2532	474
10	2591	2546	2151
11	3571	3284	2966
12	1975	3744	3882

Clarifying the highest electricity consumption from the users during the survey, all answered that it is a heating system pump. This coincided with the monthly electricity consumption. For example, the annual electricity consumption of Undur-Ulaan soum kindergarten is broken down by month, and the figures are shown in Table 9 and Graphic 19. It is estimated that the heating system pumps consume 30-50 percent of the electricity during the heating season. Therefore, it is necessary to make hydraulic balancing for the system and improve operators' professional knowledge.

ГРАФИК 16. **Three-year electricity consumption of the kindergarten at Undur-Ulaan soum /kWh. month/**



Source: Energy regulatory commission of Arkhangai. Data analyses by "BEEC" Co.Ltd

COMPLIABILITY OF THE PUBLIC BUILDINGS IN SOUMS WITH BUILDING **NORMS AND CODES**

At design stage: In some buildings, the required thermal resistance had been copied directly from the typical modular drawing without calculating it. For example, in the Undur-Ulaan soum, the floor heat transmission coefficient was calculated as the floor in contact with the soil, between K = 0.068-0.465 W/m² °C, or for 4 zones. Still, in reality, the floor was the suspended floor with a heat transmission coefficient of K = 3.9 W/m² °C. Therefore, the heat transmission coefficient of the floor in direct contact with the outdoor air must be the same as the heat transmission coefficient of the wall equalling K = 0.31 W/m² °C

At the construction stage: The insulation thickness of the surveyed building roof was specified in the design following the norms, but there were some cases of underperformance. For example, the kindergarten roof at Tsenkher soum was designed to be 20 cm thick but 2 cm thick.

Zoning of heating degree days: According to the normative of 2020, Arkhangai province belongs to zone I. Therefore, heating degree days that buildings need to heat have been considered equal to 7000°C·day..

Table 10. **Heating degree days zoning**

ZONE NUMBER	HDD, ⁰C·DAY	CITIES AND PROVINCES
I	7000	Ulaanbaatar, ARKHANGAI, Gobi-Altai, Zavkhan, Selenge, Uvs, Central and Khuvsgul
II	6500	Bayan-Ulgii, Bayankhongor, Bulgan, Erdenet, Darkhan
III	6000	Uvurkhangai, Khovd, Khentii, Dornod, Dundgobi, Sukhbaatar
IV	5000	Dornogobi, Gobi-Sumber, Umnugobi

Source: BNaC 25-01-20 "Building thermal performance."

Thermal performance requirement of the building envelope: The buildings surveyed must meet the requirements shown in table 11. However, during the field measurement, the below indicators were partially met. Eight buildings met the external wall requirement (Table 11), and 2 buildings passed both roof and wall requirements (table 11).

Table 11. **Thermal resistance requirement of building envelopes (R_T^{req})**

LOCATION ZONE	I (7000)					
BUILDING TYPE/ DESIGNATION	1		2		3	
	R, m2K/W	U, W/m2K	R, m2K/W	U, W/m2K	R, m2K/W	U, W/m2K
Wall	3.85	0.26	3.3	0.3	2.4	0.42
Roof	5.7	0.18	4.4	0.23	3.25	0.31
Non heated attic, basement ceiling	5.05	0.2	4.4	0.23	3.25	0.31
Window, balcony door	0.65	1.54	0.55	1.82	0.38	3.08
Tope opening	0.43	2.35	0.38	2.67	0.33	3.08
Floor, basement wall	2.2	0.45	2	0.5	1.8	0.56
Door	1.8	0.56	1.7	0.59	1.6	0.63

Source: "BNaC 25-01-20 "Building thermal performance."

ENERGY SAVING RECOMMENDATIONS

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PERMAFROST AND BUILDING ENVELOPE DAMAGE:

Almost 70 percent of the territory of Arkhangai province is in the continuous and intermittent permafrost zone. The buildings were designed with a hollow foundation to prevent distortion due to permafrost, but the fact that damage is still occurring indicates that the measures are inappropriate. Therefore, a detailed geotechnical study of the soil and a basic technological solution for the permafrost is needed.

DECREASE HEAT LOSS BY FLAT AND GABLE ROOFS:

Out of the 57 buildings assessed by the energy efficiency assessment, only two buildings fulfilled the BNaC. This result indicates that attention is required.

Roof attic: 42 buildings were built with gable roofs, while 6 flat roofs were reconstructed into gable roofs. Insulating the roof attic is the cheapest way to reduce heat loss and be implemented as a priority. In addition, to perform any maintenance following BNaC 25-01-20 “Building thermal performance.”

Flat roof: A common problem in Arkhangai soums is that flat roofs have been retrofitted as gable roofs due to rainwater penetration through the flat roof. In the future construction of new and old flat-roofed buildings, it must include insulation and waterproof layer in the design according to the related norms

IMPROVE THERMAL INSULATION OF THE BUILDINGS:

While the dominant energy consumption is energy for heating, the most economical and long-term effective way to reduce heat loss is to insulate the building’s envelope. Insulation has many advantages, such as restoring the building’s appearance, prolonging the building’s life, and creating a comfortable thermal environment. Therefore, all buildings to be renovated or constructed after January 1, 2021, shall be constructed in accordance with BNaC 25-01-20 “Building thermal performance,” and the local climate zoning of the heating season of all buildings in Arkhangai province shall be considered as a Zone I building. The roof insulation should be 20 cm thick, the wall insulation 15 cm thick, and the floor and foundation insulation 10 cm thick.

INSULATION MATERIALS:

Insulation materials are currently classified in the Mongolian market as mineral wool and foam types. Mineral wool insulation includes rock wool, fiberglass, and sheep wool insulation, while foam insulation includes EPS board, XPS board, and polyurethane insulations. Note that 20 cm thick mineral wool insulation is equivalent to 80 cm thick lava stone slag.

DECREASE HEAT LOSS BY THE WALL AND ENVELOPES OF THE BUILDING:

Out of the 57 buildings surveyed, 8 buildings are fulfilling wall and envelope standards. However, by evaluating the insulation work performance of some buildings, the insulation work was not done with the proper technology. The insulation material thickness was selected depending on the local climate zoning and estimated outside air temperature. Some buildings' estimation of outside air temperature was selected incorrectly at the design stage. In the BNaC 25-01-20 "Building thermal performance." the climate zoning of Arkhangai is counted as one zone.

DECREASE HEAT LOSS BY THE WINDOW AND INFILTRATION:

The windows usually had double-glazed windows with PVC frames and double-glazed windows with wooden frames. It should also be refurbished with an authorized laboratory-tested window with a certificate of origin that adheres to building code replacement technology.

DECREASE HEAT LOSS BY THE FLOOR:

Depending on the specific characteristics of the region, buildings with hollow floors are predominant. Still, the floor has a lot of heat loss due to incorrect Energy efficiency study of public buildings in Arkhangai province Cemaaterr II- Mongolia 2020 calculations during the design. Insulation of new buildings to be constructed and maintained following BNaC 25-01-20 "Building thermal performance."

IMPROVE THE ENERGY EFFICIENCY OF THE HEATING SOURCE:

The furnace used in public buildings of soums are mostly NRJ type of water heating boilers. However, the water heating boiler's technical specifications and brands were unknown in some buildings. The most common operational difficulties of water heating boilers are:

The upper part of the heating water-wall tubes is located in the upper part of the fire pit over the smoke exhaust, causing the ash clogs.

Due to the large space of the fire pit sole, a lot of coal is plugged into the space, and the rest is unburned.

Heat transfer is not processing well because of the insufficient primary airflow of the furnace.

The water heating boiler's monitoring equipment number is insufficient, such as thermometers and manometers.

TRAINING OF ADMINISTRATIVE AND OPERATIONAL OFFICERS:

Training is needed for heat-only boiler operators who control the regime of the local heating system to strengthen their capacity. Provide administrative officers with general knowledge of heating sources, systems, and occupational safety. Usually, the boiler regime is not adjusted regularly. The pump output adjusts the head pressure to their work experience, increasing the electricity consumption by 30-50 percent during the heating season. There is also a lot of unbalanced heat due to the lack of regular hydraulic adjustments.

CHAPTER 3 HOUSEHOLD BUILDING'S CONDITIONS IN ERDENEBULGAN SOUM

HOUSEHOLD SAMPLE SURVEY

HOUSEHOLD STUDY

Under the development of the LEEAP in Arkhangai province, household building's current conditions were studied. The study objective was to identify the house structure material, energy consumption, and heat source types of households in Erdenebulgan soum.

According to the discussion with the Erdenebulgan soum mayor's office and the Department of Land Affairs, Construction, and Urban Development, for the study, the private houses of the Erdenebulgan soum were divided into three zones (Figure 3). For the accuracy and representability of the Erdenebulgan soum private houses, the sample houses were selected randomly from the zones. The study areas and methods were discussed and approved by the PSC and technical actors.

The research was conducted using a survey in 172 private houses with on-site measurements. By the results, houses categorized the buildings by structure and identified the fuel and electricity energy consumption. The on-site measurement and a survey from households were conducted by students of the Vocational training center of Arkhangai province.

Within three zones of the Tsetserleg sum of Arkhangai province:

- 65 private houses in the western zone or Arslan tsokhio and beyond Tsagaan davaa
- 38 private houses in the southern zone or Tamir district
- 69 houses in the eastern zone or Tsogt mountain, Bor hills, and Naranbulag area were studied, respectively.

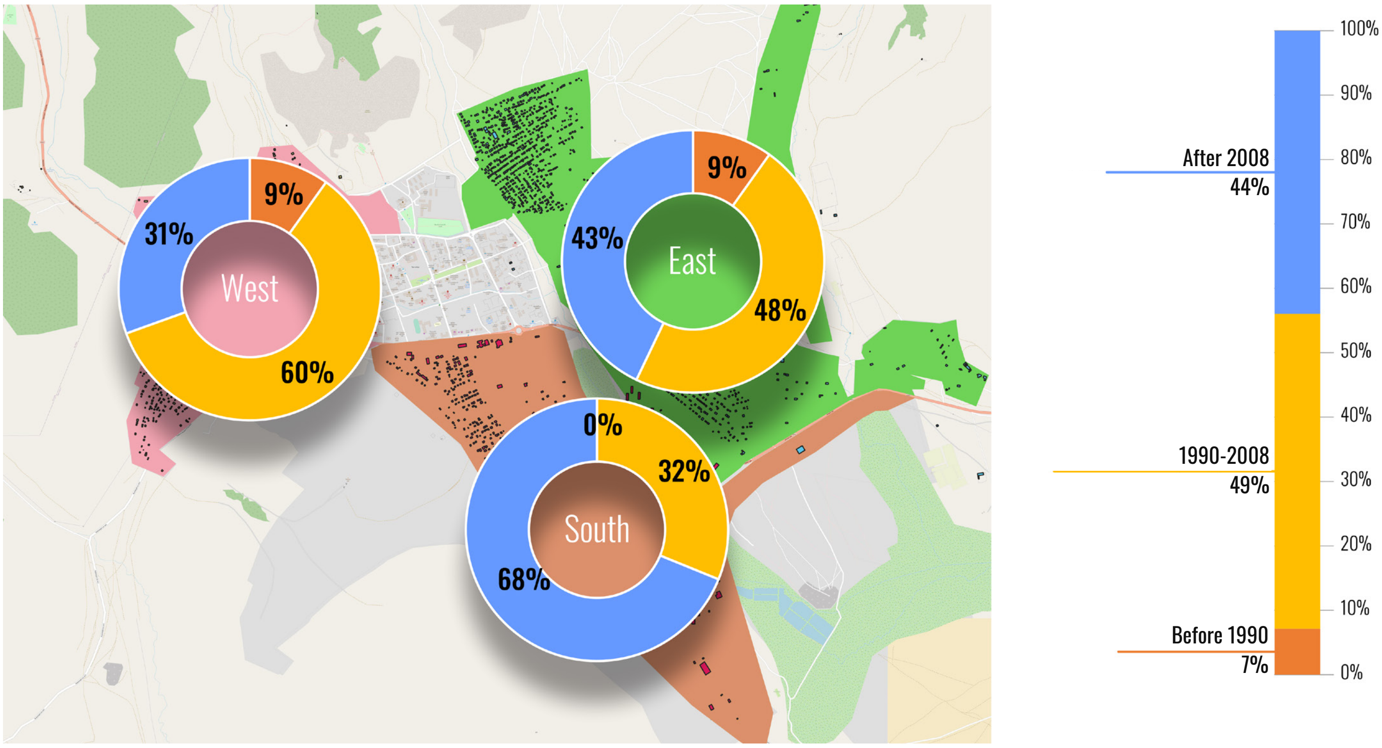
AGING OF THE **PRIVATE HOUSES**

The private houses of the Erdenebulgan soum can be classified into three categories based on their aging, as-built before 1990, between 1990-2010, and beyond 2010. Among the surveyed houses, half of 49% of the total private houses were built between 1990 and 2010. According to the study results by region (Graph 17):

- The eastern zone is dominated by private houses built between 1990-2010,
- The western zone is dominated by private houses built between 1990-2010,
- The southern zone is dominated by buildings constructed after 2010.

Based on the aging analysis, the southern and western zones of the Erdenebulgan soum contain a higher concentration of private houses (Graph 17). This situation is directly related to recent decades of urban planning and engineering network extension toward the city's south. Regardless of the absence of the thermal power plant and heating network in the southern zone, the accessibility to the freshwater and sewage water network triggers the interest to settle in the south and west regions of the city.

Graphic 17. **Categories of Aging of households.**



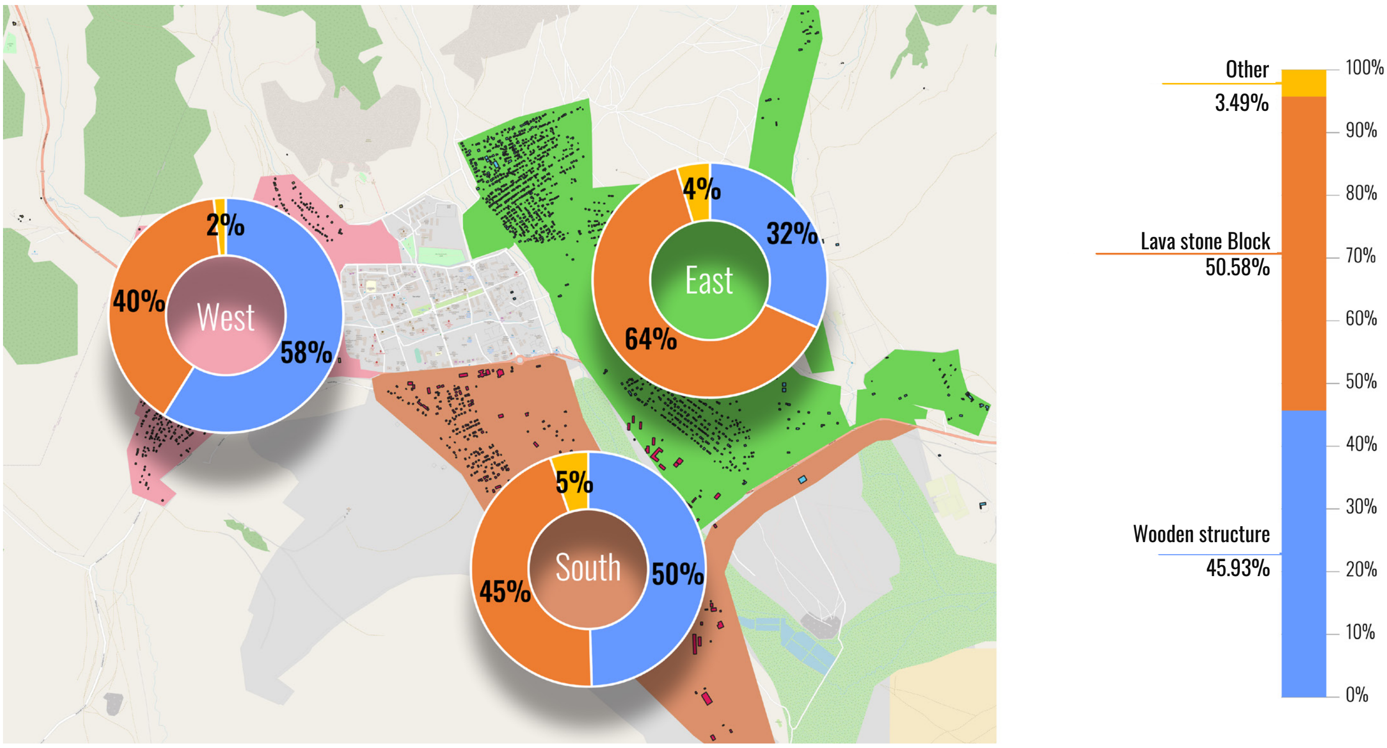
Source: "Geres" NGO 2020 baseline study questionnaire

CLASSIFICATION OF PRIVATE HOUSES BY CONSTRUCTION **STRUCTURE**

From the survey result, half of 50% of houses are built of lava stone blocks (Graph 23). The study identifies the following common structure classification of private houses:

- Lava stone block masonry
- Wooden structure
- The other types of block masonry.

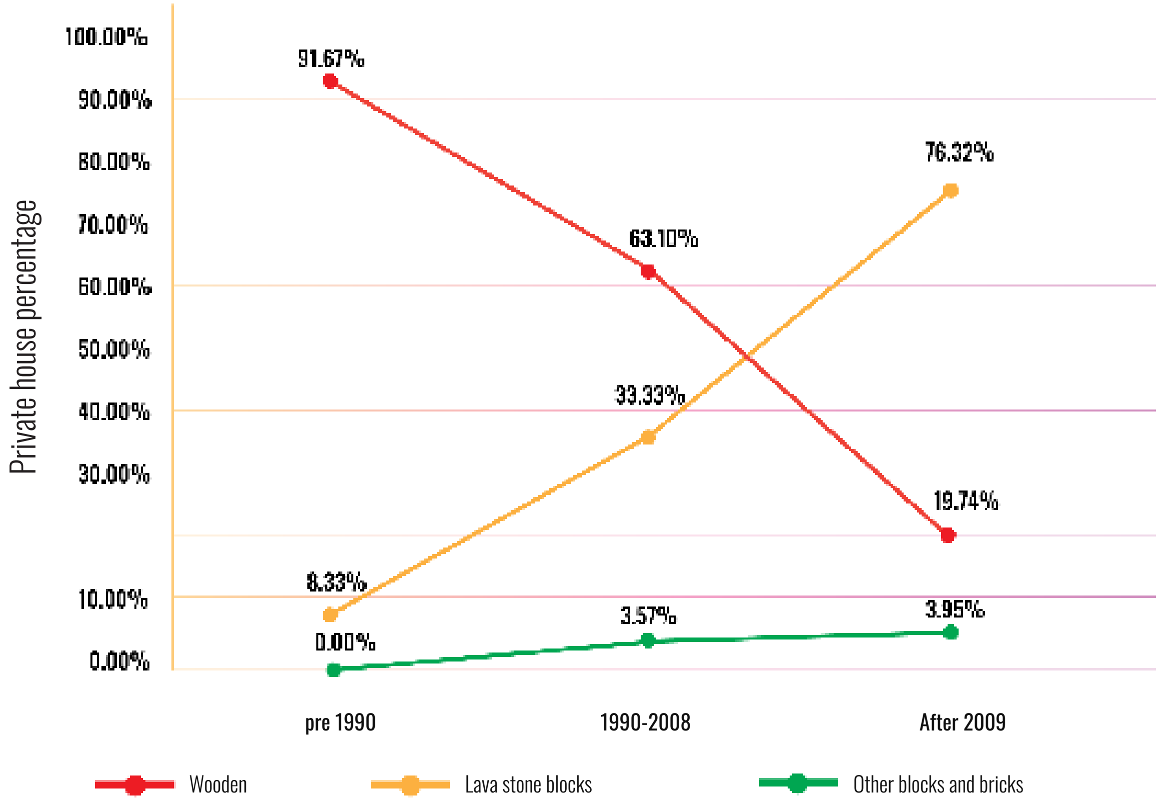
Graph 18. **Categories of households construction structure**



Source: "Geres" NGO 2020 baseline study questionnaire

By analyzing n the construction structure and comparing it with the built year, lava stone block masonry in households has increased since 2010. On the contrary, the construction of wooden buildings was reduced by 78.47%.

Graph 19. **Usage ratio of construction materials by construction year**



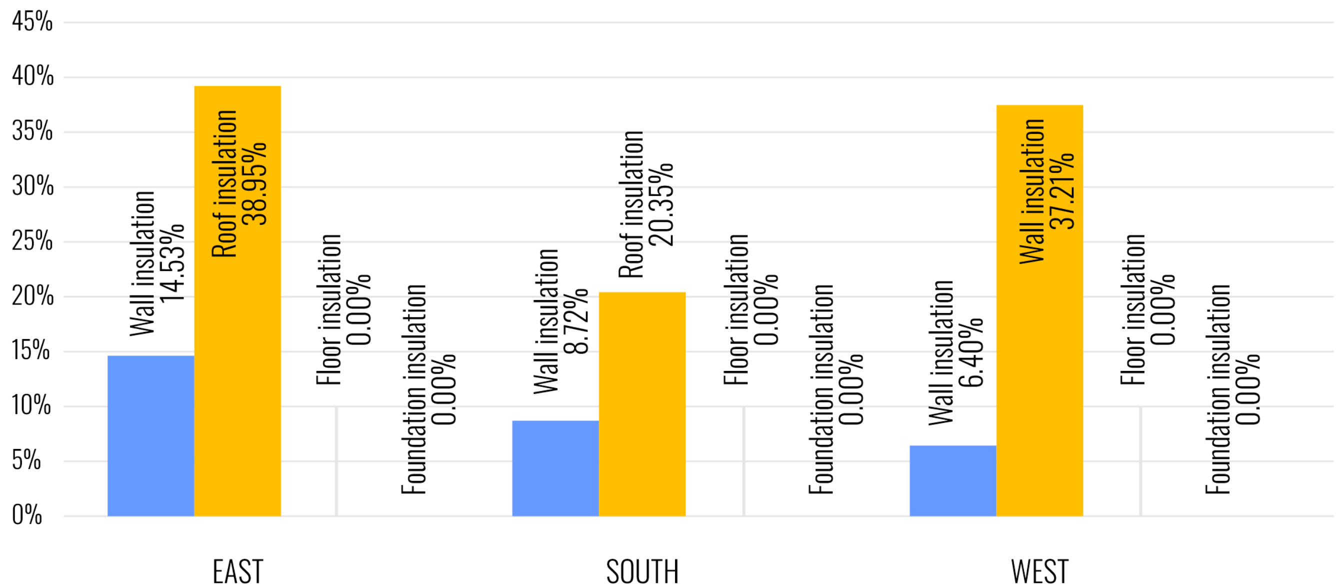
Source: "Geres" NGO 2020 baseline study questionnaire

As part of the survey, a study was conducted on the thermal protection of private households in Tsetserleg. A total of 172 households surveyed did not insulate their floors and foundations

INSULATIONS OF **PRIVATE HOUSES**

According to the survey results, out of 172 households, 51 households insulated their walls, and 166 households somehow insulated their roofs. Not even a single house has an insulated floor or foundation. The following graphic illustrates the thermal insulation ratio of the private houses within the zones of Erdenebulgan sum.

Graph 20. **Insulations of private houses**



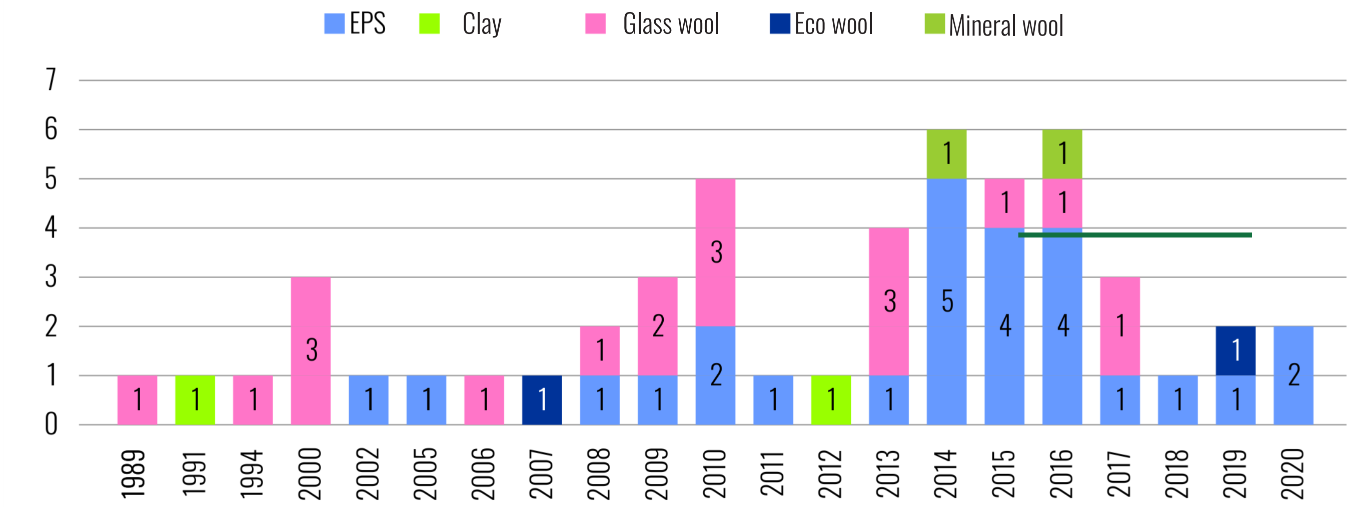
Source: "Geres" NGO 2020 baseline study questionnaire

EXTERIOR WALL **INSULATIONS OF HOUSES**

Out of 172 families, only 51 houses had insulated the external wall. The most common insulation materials of 51 households are EPS panels, which account for 51%, and glass wool insulation, 37%. The insulation method depends on the insulation materials. The following methods were the most common method of insulation:

- EPS or foam. Placed on the exterior wall of the building and plastered with clay.
- Glass wool, eco wool, and mineral wool. Mostly fitted between the columns or sandwiched between the inner and exterior masonries.

Graph 21. **Wall insulation materials of private houses**

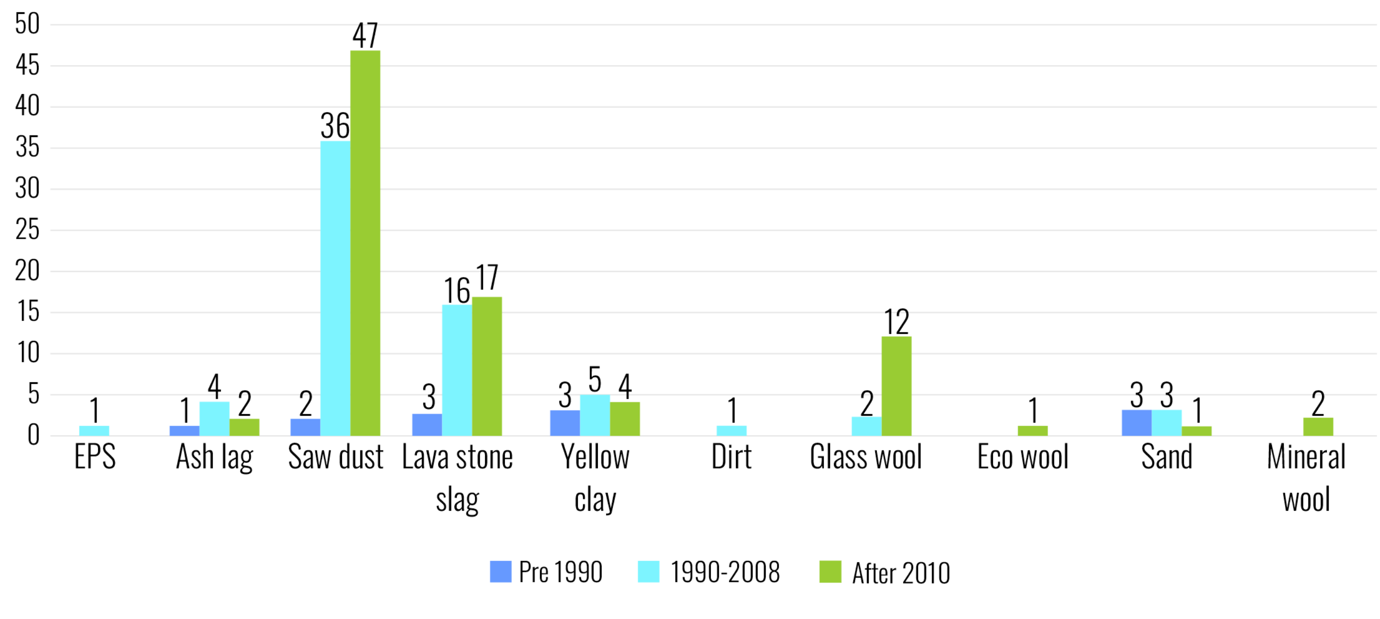


Source: "Geres" NGO 2020 baseline study questionnaire

ROOF INSULATION

All households surveyed had a gable roof structure. Out of 172 households, 166 households had their attics insulated somehow. Households with roof insulation are often insulated with sawdust. Although insulating with sawdust is a very common and easy method, it can easily absorb moisture and lose its insulation quality if not insulated according to sophisticated technology. The following graphic demonstrates the insulation type of roof attic usage ratio compared to the building's age. From the graphic, houses built after 1990 are mostly insulated with sawdust, and some houses are insulated with lava stone slag. But, insulation materials such as EPS, XPS, and fiberglass are rarely used.

Graph 22. **Usage timelapse of roof insulation materials**



Source: "Geres" NGO 2020 baseline study questionnaire

HEATING TYPE AND FUEL CONSUMPTION OF PRIVATE HOUSEHOLDS

Common types of heating and boilers

In line with the study's objectives, the heating system and power energy tariffs were surveyed. The households of Erdenebulgan soum are not connected to the centralized heating system. They have an individual heating system and traditional wall cookers. The most common heating systems used in households are shown in the following table-

Conventional wall cookers,

Low-pressure heaters

Other heating systems (electric heating and single furnace).

Source: "Geres" NGO 2020 baseline study questionnaire

It is common to use traditional hand-made stoves in conventional wall cookers and low-pressure heating systems. These are constructed in a low-cost and customary method, are easier to use, and have significantly high sales in the local markets. Hand-made stoves are preferred over other types of furnaces. Out of the total participating households in the study, 97% use a handmade stove.

At roughly dozens of sales points in Erdenebulgan soum of Arkhangai province, hand-made stoves brought from Ulaanbaatar are available. Depending on the thickness of the metal plate, those sold for 35000T-450000T. Moreover, at the province level, individual artisans buy materials from Ulaanbaatar, make stoves, and sell them locally, which is directly related to the continuous usage of this type of stove.

Table 13. **Typology of heating system**

Type of heating	Quantity of households use	Percentage
Low-pressure heater	38	22.10%
Conventional wall cookers	131	76.20%
Other types of heating systems	3	1.70%
Only stove	1	0.60%
Electric	2	1.20%

Source: "Geres" NGO 2020 baseline study questionnaire

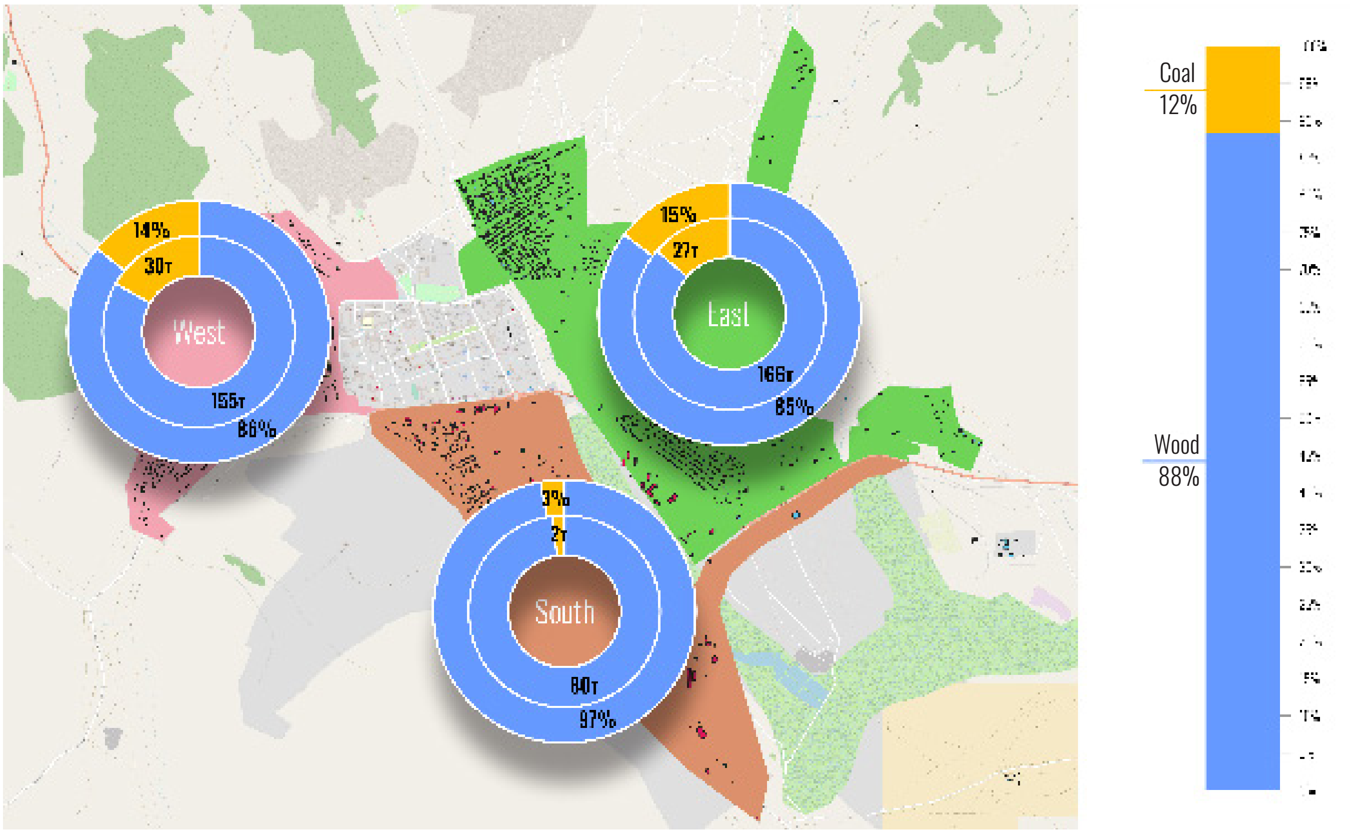
TYPES OF **FUEL AND CONSUMPTION**

The households of Arkhangai province predominantly use wood fuel for their heating. Out of total buildings, 87% use wood fuel, and 11% use coal. The fuel consumption is related to several issues such as building thermal insulations, the volume of buildings, the number of family members, and lifestyle.

The thermal imbalance induces discomfort in consumer well-being and increases energy expenditure. In cases where houses have better coverage insulations, the average fuel consumption is 1 ton, while in uninsulated buildings, the fuel consumption is higher. The following graph illustrates fuel consumption and fuel types. The fuel consumption directly depends on the following factors:

- Building thermal insulation
- Fuel type
- Stove types
- Human behaviors

Graphic 23. **Types of fuels and consumption**

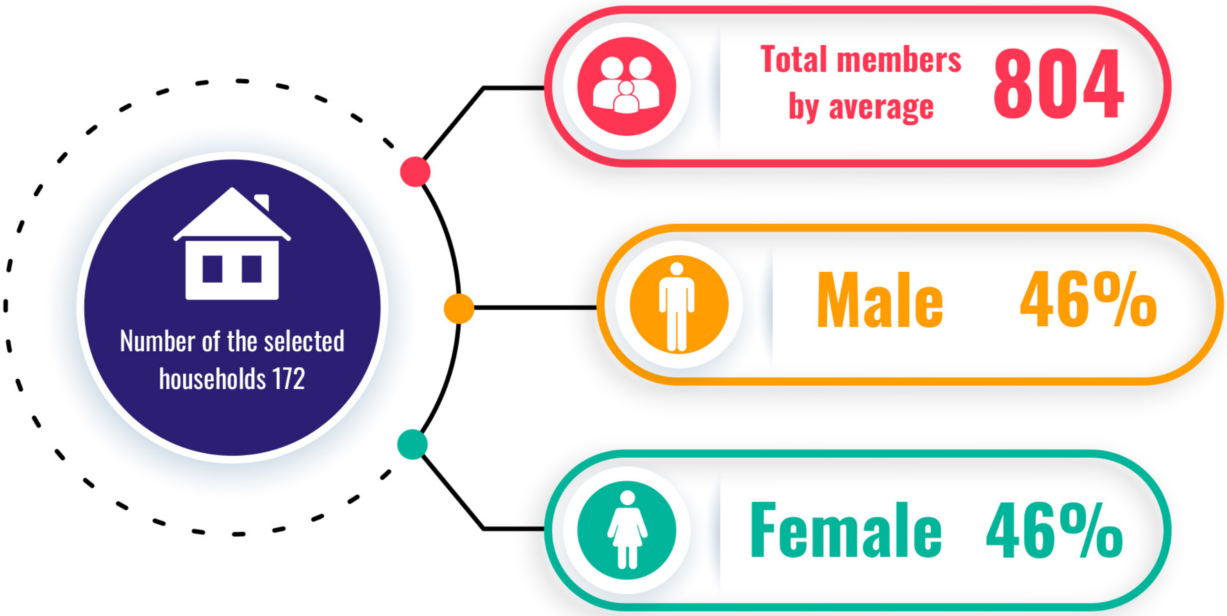


Source: "Geres" NGO 2020 baseline study questionnaire

GENERAL CONDITIONS OF THE HOUSEHOLDS IN ERDENEBULGAN SOUM

The study was held in 172 households with 804 people, and the average number of family members was 4. The interview was mostly made with one or two people. The household with the largest number of members had seven members. Family members were 46% male and 54% female. The following table is shown household members and gender ratio.

Table 13. **Household member's**



Source: "Geres" NGO 2020 baseline study questionnaire

From the questionnaire result, most households have answered that thermal comfort is normal and warm during the winter. Few households answered it was cold. The following table shows the answer of the owner who have valued the comfort of their houses. "But we seeing the buildings has heat loss. Based on the culture, people avoid saying bad things related to their home. And people are familiar with the current conditions of their house."

Table 14. **Answers to the comfort questions**

Value meaning	Count of answers
Bad	9
Average	92
Good	68
Comfortable	7

Source: "Geres" NGO 2020 baseline study questionnaire

The next table shows thermal comfort in the houses during the winter to the building's insulation. As a result of the survey, none of 172 households have the floor and foundation insulations.

GENERAL KNOWLEDGE ABOUT THE ENERGY - **GENDER AT THE HOUSEHOLD LEVEL**

In Arkhangai, the household is not connected to the central heating system. Due to the limitation of the efficient heating source, children, pregnant women, and the elders have more tendency to get sick during the cold season than in resident apartment areas. Women are responsible for heating buildings and providing thermal comfort for the family due to traditional Mongolian culture (heating the home and paying electricity bills). Mainly, women are not completely satisfied with their thermal comfort, and children often get sick due to the cold environment in the house during the winter. Regarding selecting the fuel type and amount, men are dominant in deciding the type of heat source and the amount of fuel without proper knowledge of their own house. On the other hand, women and girls provide thermal comfort without knowing the fuel characteristics, heating source type, and building energy consumption.

DYNAMICS INVOLVED IN FAMILY MEMBERS 'DECISIONS

Renovation decisions

Male 7%
Female 10%
Together 58%
Influence of other people 24%

Construction of new house

Male 14%
Female 1%
Together 85%

Participation

Low 9%

High 45%

Medium 55%

Source: "Geres" NGO 2020 baseline study question-

GENDER DYNAMICS ON ENERGY CONSUMPTION

AWARENESS OF ENERGY EFFICIENCY

Female 8%

Male 36%

Both don't have enough information 56%

ELECTRICITY PAYMENTS

Female 81%

Male 14%

Together 5%

FUEL PROCUREMENTS

Female 9%

Male 71%

Together 20%

Source: "Geres" NGO 2020 baseline study questionnaire

RECOMMENDATIONS TO IMPROVE ENERGY EFFICIENCY OF PUBLIC BUILDINGS IN ARKHANGAI

To improve the energy efficiency of the public buildings, throughout the enhancing thermal comfort of users and to decreasing the Carbon footprint from heating public buildings, the following recommendations would be implemented step by step.

Reduce the heat loss of the building: The thermal insulation condition of existing public buildings and households needs to be improved step by step. The public building's insulations need to be renovated based on the building energy performance certificate and in accordance with BNaC 25-01-20, "Building thermal performance." effective from January 2021. Gable roof attic insulation, windows, and door insulations have great energy efficiency effects. Also, these insulations can be done through all seasons with easy methods. Reducing the heat loss of a building reduces the fuel consumption used to heat the building and increases the thermal comfort of working and studying throughout all seasons. The most common method to decrease the heat loss of the building is to insulate the building envelope.

Improve current heating system: The heating system needs to be improved step by step.

- To identify each building's exact heat demand and capacity of the existing boilers and pumps.
- It will decrease fuel consumption and electrical energy consumption during the heating season. Need to improve heat regulation and exploitation. There were missing regulating and monitoring instruments almost in every heater and boiler. Monitoring energy production and distribution is a main part of the heating system regulation. Heating system regulation will be difficult to manage without monitoring equipment.
- Need to insulate the pipeline and equipment. Insulations must be done all over the outdoor and indoor pipelines and boiler rooms. A significant amount of heat energy is constantly lost during the heat distribution through the uninsulated pipeline. So, it needs to be appropriately insulated

Electricity energy consumption: The following recommendations should be implemented to increase energy efficiency in public buildings.:

- To promote energy-efficient electrical appliances in the local procurement.
- Improve user's behavior of daily electricity usage.
- Raise awareness of the importance of energy efficiency and energy savings.

Protection from permafrost-related damages:

A detailed study of permafrost impacts on buildings needs to be conducted soon. The study results will help improve the new construction and renovation blueprint of buildings in the areas with permafrost. To protect buildings from permafrost-related damages, implement foundation insulation technology at all construction stages and insulate existing building foundations in permafrost areas.

Awareness-raising activities:

Following topics would be included in the awareness-raising activities:

- Spread the information on how to improve the energy efficiency of the buildings.
- Spread information on energy efficiency importance, advantages of the energy savings, and proper energy consumption of user's behavior.
- Spread the energy efficiency laws and regulations, thermal comfort and indoor air quality, and building energy efficiency measures.

Organize training and advocacy work:

Training can include the following topics for the local decision-makers:

- Introduction of construction norms and codes. Highlight the energy efficiency measures.
- Introduction of the energy efficiency law and regulations and their integration, including the responsibility of public actors.
- Guidance on how to improve the implementation of regulation and norms, especially at the soum level.
- Guidance of the heating system's management and selecting the heating equipment based on the heating demand.

The following subjects would be included in the training to improve the capacity of local employees in the construction sector:

- Introduction of the building energy efficiency norms, standards, and regulations. Introduction of the various insulation and waterproofing materials with thermal performance. Introduction and guidance of the building insulation technologies.
- Guidance of the heating equipment selection based on the building heat demand.

Training on the following topics should be provided to improve the capacity of local workers in charge of water heaters and heating systems:

- Operational instruction for the heating system, including the operation and monitoring of the furnace.
- Selection of operation temperature regime and distribution and supply heating pipeline regulation related to the outdoor air temperature.
- Operational instruction of the ancillary equipment, such as pumps and thermostats, improves the heating system's energy efficiency.
- Workplace safety training

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