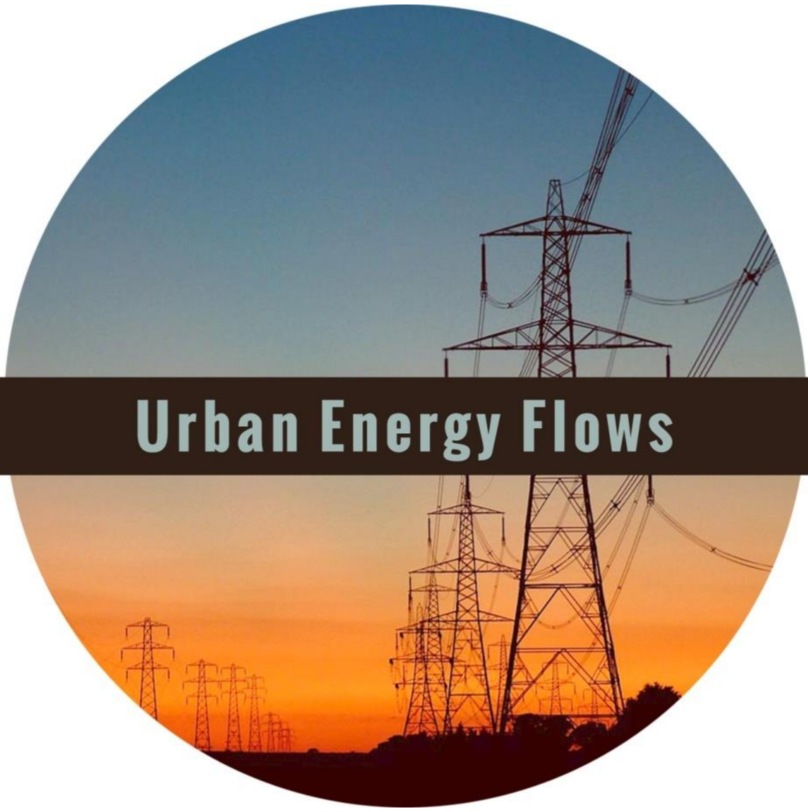

Urban Energy Flows

Rezhan Othman Mohammed

Abstract

The use of resources, Co٢ emissions, demand and the efficiency in managing formed the basis of this report, the various heating ١٧٥ MWh/a and cooling ١٥٨ MWh/a as well as the transmission and ventilation losses and internal and solar gains were analyzed to determine the final and net energy of each building types of the city of ١٠١,٠٠٠ inhabitants, building type I and II indicated more losses than it gained as a result of year of construction (١٩٦٠) and the U value ٠٫٦٤ , the other building types III and IV constructed in ٢٠٠٣ and ٢٠١١ respectively with U values of ٠٫١٠ and ٠٫١٧ demonstrates efficiency in heat retention and energy savings.

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Chapter One

Introduction

The impact of global warming on the energy consumption of a country for space heating and cooling depends on the current and future regional climate, the required thermal comfort inside buildings and technical building features such as thermal insulation quality. Quantitative projections of future energy consumption naturally depend on the key assumptions and models used to construct future climate scenarios (Christenson, ٢٠٠٥)

The German government has set itself ambitious goal by ٢٠٢٠ demand for heating in Germany is supposed to fall by ٢٠ percent compared to ٢٠٠٨, and primary energy consumption in the heating sector is supposed to be reduced by a huge ٨٠ percent by ٢٠٥٠. Overall, the federal government intends to achieve almost ٥٠ percent of the $CO_٢$ reduction goal through energy savings in the heating market. ("Climate goals cannot,"٢٠١٣)

The study shows that about ٤٠٪ of Germany's emissions come from the power generation sector. Germany needs an energy revolution to phase out coal and increase the share of renewable energies. At the same time, it is necessary to implement an energy efficiency program so that less energy is lost during the generation process.

In order to achieve the targets, one of the key priorities is the energy saving and the decrease of $CO_٢$ exhausts, therefore it is necessary to implement steps that would decrease the heating and cooling demand for both dwelling-houses and public houses. At the same time it is also important to guarantee the qualitative air flow exchange inside buildings.

Nevertheless this subject is broadly divided, Chapter one described the goals of the German government to reduce the demand for heating by ٢٠٢٠ in addition to primary energy consumption for heating sector by ٨٠ percent till ٢٠٥٠.

Chapter two locates the study area as well as the temperatures, precipitation, climatic variations

Furthermore, Chapter three describes the building envelopes and their various U values to determine the heat bearing capacity of each of the building in addition to the demand of heating and cooling.

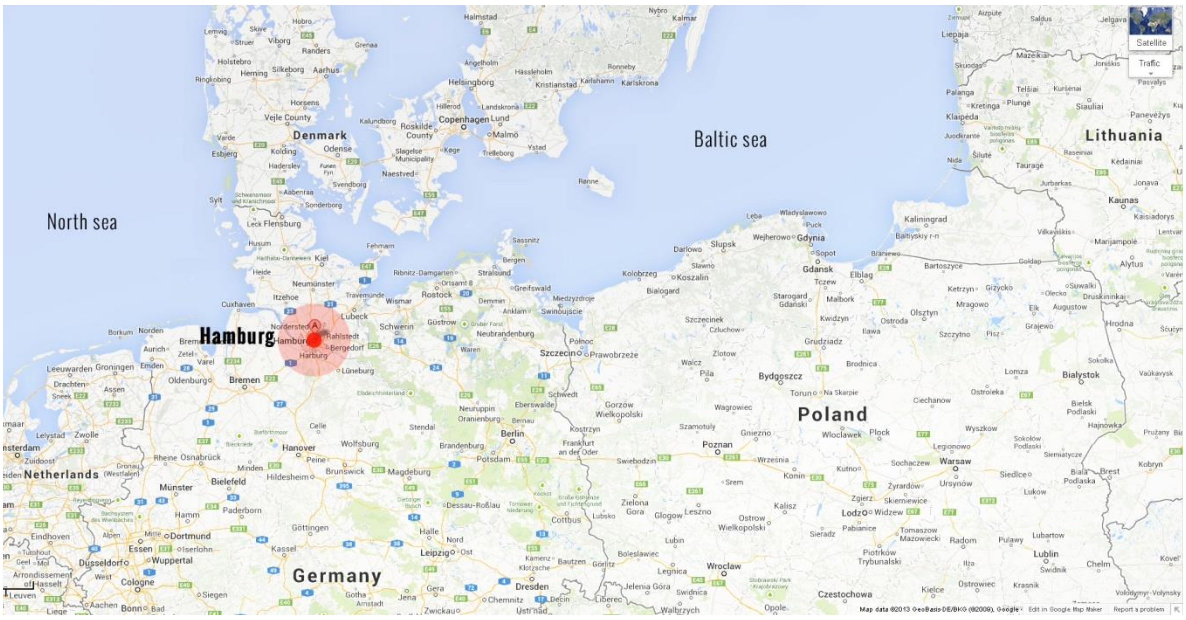
The electricity use of the city of ١٠١,٠٠٠ inhabitants and the buildings are described in chapter four and Chapter five the transportation overview, while chapter six looks at the energy consumption for water supply and disposal and

Finally, chapter seven describes the net and end energy of the building, comparing the transmission and ventilation losses and the solar and the internal heat gains to the overall heating and cooling demand.

Chapter two

Location

Figure ١: Location of Hamburg



Source: Google map

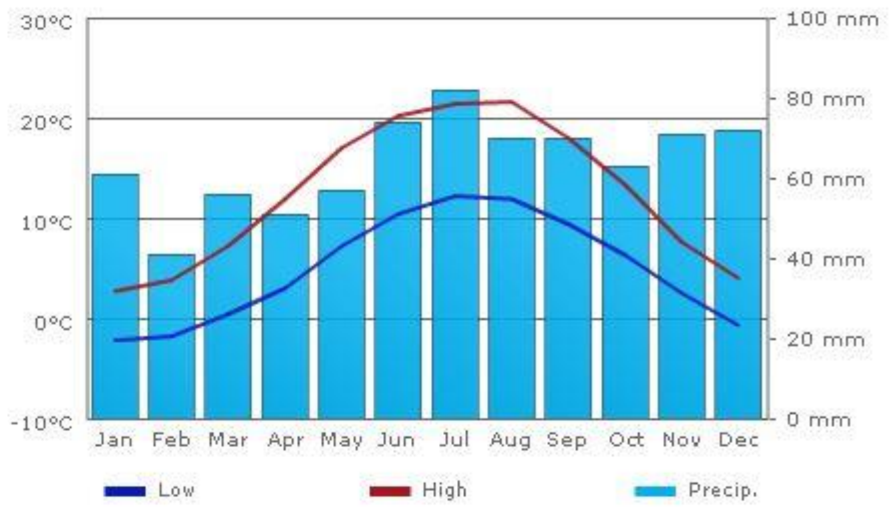
Hamburg is located on the Southern point of the Jutland Peninsula, directly between Continental Europe to its south and Scandinavia to its north. The North Sea is west and the Baltic Sea is northeast of Hamburg

Area:	٧٥٥ km^{٢}
Population:	١,٨١٣,٥٨٧
Density	٢,٤٠٠/km^{٢}
Climate data	

Totals and averages

Annual average high temperature:	١٢,٤ °C
Annual average low temperature:	٤,٩ °C
Average temperature:	٨,٦ °C
Average annual precipitation:	٧٦٨ mm
Days per year with precipitation:	١٣١ d.
Average annual hours of sunshine:	١٥٥٨ h.

Figure ٢: Precipitaion data



Source: http://www.climatedata.eu/climate.php?loc=gmxx٠٠٤٩&lang=en

Hamburg has an oceanic climate which means that it is a fairly wet and windy city, with prevailing westerly winds blowing in moist air from the North Sea. Summers are warm but rainy, with occasional and brief dry, sunny spells (Climate Hamburg)

Figure ٣: Average solar radiation in Hamburg

Region 2 Referenzort: Hamburg		Durchschnittliche monatliche Strahlungsintensität W/m²												Jährliches Strahlungs angebot kWh/m²
	Monat	Jan	Feb	Mrz	Apr	Mai	Jun	Jul	Aug	Sep	Okt	Nov	Dez	Jan bis Dez
Orientierung	Neigung													
Horizontal	0	22	50	83	150	202	190	196	167	108	62	30	15	934
	30	36	75	103	168	209	189	198	182	128	86	48	24	1057
Süd	45	40	82	105	166	200	177	187	177	130	91	54	27	1049
	60	42	84	103	156	181	158	167	164	125	92	57	29	992
	90	40	76	85	115	123	105	113	117	99	81	53	27	754
	30	22	49	80	145	194	178	186	159	105	61	30	14	895
Ost	45	22	48	77	139	184	167	175	151	101	58	30	14	853
	60	21	46	72	129	171	153	161	139	94	55	28	13	791
	90	17	37	56	102	132	117	124	108	74	44	23	10	617
	30	22	50	80	142	189	179	184	157	101	60	29	15	884
West	45	22	49	76	135	179	169	173	148	96	58	28	14	839
	60	21	47	71	125	165	155	159	136	89	54	27	13	777
	90	17	38	56	99	128	118	122	106	70	43	22	11	606
Nord	45	15	28	48	80	127	133	133	93	60	35	18	10	570
	60	14	26	44	75	104	106	107	83	56	32	17	9	492
	90	11	21	35	60	84	84	85	66	44	25	13	7	391
Temperatur														
Temperatur	°C	0,5	1,1	3,7	7,3	12,2	15,5	16,8	16,6	13,5	9,7	5,1	1,9	8,7

Source: (DIN ٤١٠٨ -٦)

Chapter three

Description of the building envelopes

TYPE ١ and ٢

The buildings are relatively old – built in the ٦٠s

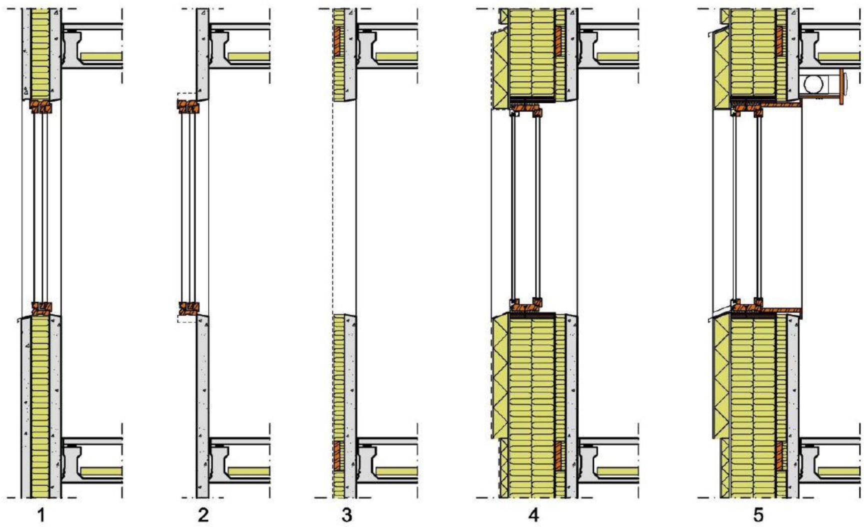
The key factors when creating the heating and cooling demand are the low efficiency coefficients of overall heat transfer.

U value of external walls ٠.٦٧ W/m²k, u value of windows ١, ١ W/m²k, u value of roof ٠,٣ W/m²k.

The necessary tasks in order to improve the energy effectiveness are

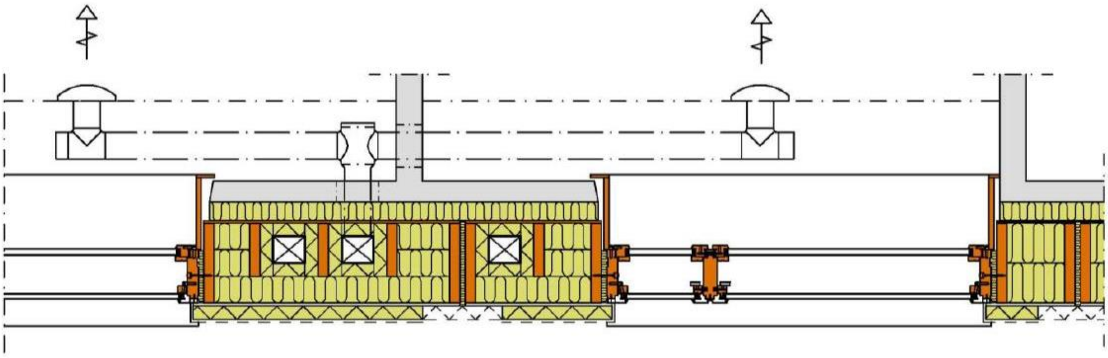
- Insolate external walls.
- Heat protective glazing (triple glazing windows)
- Insolate roof
- Insolate basement ceilings
- Ventilation system with heat recovery (see figure ٤)

Figure ٤: facade insulation



Source: http://www.paroc.lv/campaigns/Innova-Project?sc_lang=en

Figure ٥: vertical ventilation ducts installed for air supply



Source: http://www.paroc.lv/campaigns/Innova-Project?sc_lang=en

TYPE ٣

This type of building is built according passive house standards heating demand ≤١٥kWh/(m²a) Building envelope has a high efficiency overall heat transfer coefficients as well as high requirements of air tightness provides less energy demand for heating and cooling.

The Passive house (PH) standard is a set of voluntary criteria for an ultra-low energy use home. Originally developed in Germany for houses and low-rise multi-unit residential buildings, the standard has been applied to houses in a range of other countries and to commercial buildings as well. Important aspect of the criteria of the Passive house standard may be that it has relatively few mandatory requirements, thereby providing design flexibility, and that it focuses exclusively on energy consumption ("Bsi-٠٢٥: The passive," ٢٠٠٩)

U value of external walls – ٠,١٠ W/m²k,

U value of roof - ٠,١١ W/m²K, u value of windows (triple insulated glazing ٤٤ mm with argon filing- ٠,٧ W/m²K ("Inoutic / windows,")

TYPE ٤

The building is built from prefabricated wooden panels. The study on comparison of concrete- and wood-framed buildings show that wood-framed construction requires less energy, and emits less CO٢ to the atmosphere, than concrete-framed construction.

The lifecycle emission difference between the wood- and concrete-framed buildings ranged from ٣٠ to ١٣٣ kg C per m٢ of floor area. Hence, a net reduction of CO٢ emission can be obtained by increasing the proportion of wood-based building materials, relative to concrete materials. (Gustavsson) (see Appendix I,pages ١٩-٢٦)

U value of external walls ٠،١٧ W/m^{2}k

U value of roof ٠،١١ W/m^{2}k

U value of windows ٠،٧ W/m^{2}k

Heating and cooling demand of buildings

TYPE ١ (per building)

Heating demand: ١٦١ [kWh/a]

Cooling demand: ١٣٠ [kWh/a]

TYPE ٢ (per building)

Heating demand: ١٨٥ [kWh/a]

Cooling demand: ١٣٣ [kWh/a]

TYPE ٣ (per building)

Heating demand: ٦ [kWh/a]

Cooling demand: ٧ [kWh/a]

TYPE ٤ (per building)

Heating demand: ٤١ [kWh/a]

Cooling demand: ٨٢ [kWh/a]

Total energy demand for city - ١٠١ ٠٠٠ inhabitants

Heating demand total: ١٧٥ MWh/a

Cooling demand total : ١٥٨ MWh/a

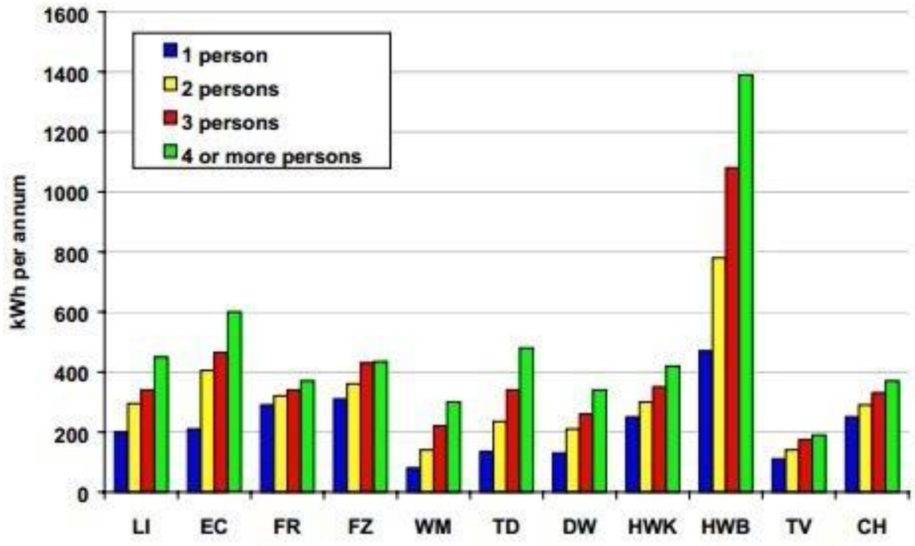
Chapter four

Electricity use

Electricity is used for many purposes for example, illuminating a space, cooking food, cooling a store, or running a production line. One of the biggest uses of electricity is for our water heating through Water Heating Cylinders. Water Heating Cylinders heats water with the use of electricity. However, today there are some alternative ways to heat household water in order to help reduce electricity costs. An example is through the use of solar energy, which isn't particularly reliable especially with Hamburg's unpredictable weather.

Electricity holds the greatest part of energy costs for any household type .The variation in average household electricity consumption for various domestic endues, with the number of persons in the household. As would be expected, hot water consumption per capita is independent of the number of people in the household. People living in one-person households recorded significantly less cooker use than large households. This figure bellow show Household appliance consumption (kWh per household per year by household size ١٩٩٥ Germany).

Figure ٦: Household consumption(kWh)



Key: **LI** = Lighting; **EC** = Electric cooker; **FR** = Fridge; **FZ** = Freezer; **WM** = Washing machine; **TD** = Tumble dryer; **DW** = Dishwasher; **HWK** = Hot water (kitchen); **HWB** = Hot water (bathroom); **TV** = Television; **CH** = Central heating pump and associated equipment.
Source: VDEW, 1997

Source: http://www.eci.ox.ac.uk/research/energy/downloads/countrypictures/cp_germany.pdf

During the ten-year period from ٢٠٠٢ to ٢٠١٢, the consumption of electricity by households rose in the in Hamburg, Germany and EU-٢٧ by ١٨ %. The overall household electricity consumption is likely to be influenced, in part, by the average number of persons living in each household and by the total number of households. Multiply the annual consumption in kWh per year by your local utility's rate per kWh consumed to calculate the annual cost to run an appliance. For example to estimate the number of hours that a refrigerator actually operates at its maximum wattage, divide the total time the refrigerator is plugged in by three. Refrigerators, although turned "on" all the time, actually cycle on and off as needed to maintain interior temperatures.

The average Electricity consumption per capita in ٢٠١٢ in Hamburg is (٦,٦٩٧ kWh).in depend on this data we can calculate average electricity demand for ١٠١٠٠٠ inhabitants.

TYPE ١ (per building)

Number of Buildings = ٥٠٠

Number of person living in each building = ٩٨

Electricity demand per Building = ٦٥٦٣٠٦ kWh

Average Electricity demand for TYPE ١= ٣٢٨,١٥٣,٠٠٠ kWh or ٣٢٨,١٥٣ MWh

TYPE ٢ (per building)

Number of Buildings = ٤٠٠

Number of person living in each building = ٦٣

Electricity demand per Building = ٤٢١٩١١ kWh

Average Electricity demand for TYPE ١= ١٦٨,٧٦٤,٤٠٠ kWh or ١٦٨,٧٤٦ MWh

TYPE ٣ (per building)

Number of Buildings = ٨٠

Number of person living in each building = ٥

Electricity demand per Building = ٣٣٤٨٥ kWh

Average Electricity demand for TYPE ١= ٢,٦٧٨,٨٠٠ kWh or ٢,٦٧٨ MWh

TYPE ٤ (per building)

Number of Buildings = ٤٨٠

Number of person living in each building = ٥٥

Electricity demand per Building = ٣٦٨٣٣٥ kWh

Average Electricity demand for TYPE ١= ١٧٦٨٠٠٨٠٠ kWh or ١٧٦,٨٠٠ MWh

Chapter five

Transportation needs (overview)

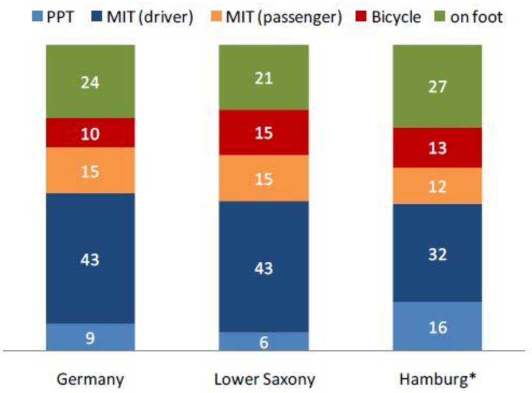
In Hamburg Most people use public transportation (bus, train, subway) or bicycles. If people live in area some far from subway station or bus station and have kids, they'd probably use their car a lot though too.

Hamburg is a pretty big city, Germany's second largest, and so getting around between neighbourhoods can require use of the excellent public transport system. There is a combination of U-bahn, S-bahn and bus services all of which are run by the HVV company and these will take you anywhere you need to be. Because they all run by the same company one ticket can be used on all.

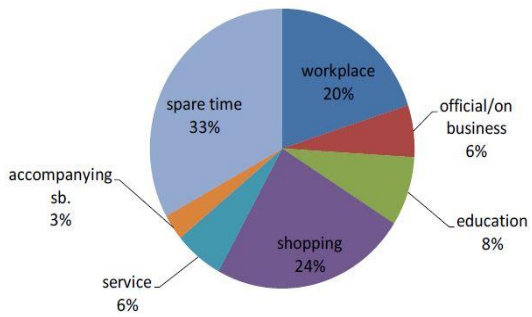
City of Hamburg provide bikes , there are two competing bicycle sharing systems. The one with the bright red bikes, StadtRAD (meaning CityBIKE), turns out to be simply the familiar DB CallBikes under a different name. and also people have their own bikes

The car has become the main means of passenger transport in most countries and also In Germany. Car transport also dominates the freight market. The proportion of energy consumed in road transport is correspondingly high compared with the other modes of transport. But improvements in conventional engine and vehicle technology and new propulsion systems can help to reduce the consumption of fossil fuels in particular and to save costs. In two figures below shows reasons for transportation in Hamburg and also Modal split of traffic volume in percentage.

Figure ٧: tranportation and modal split



Source: http://www.socialdata.de



source: infas: „ Mobilität in Deutschland", Bonn, ٢٠٠٨

Chapter Six

Water supply and Disposal

Water supply

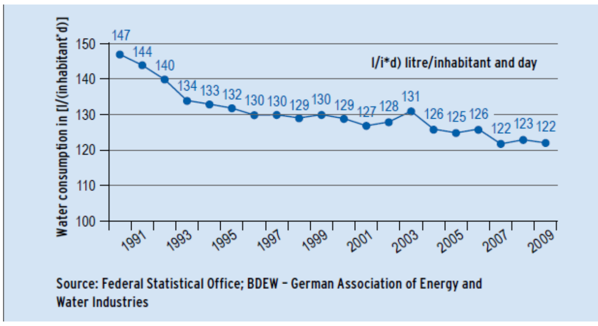
The available water resources of ١٨٨ billion m³ proved Germany to be water rich country, according to the federal ministry of environment, in the fiscal ٢٠٠٧, about ٣٢,٠ billion m٣ of water was abstracted from groundwater and surface waters for various uses by industry and supplying private households.

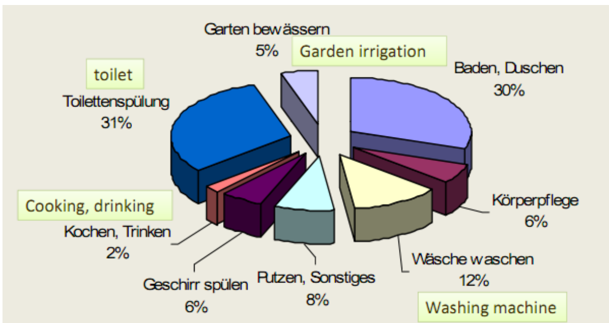
This is ١٧ percent of the potential water supply which indicated that over ٨٠ percent of available water remains unused currently, in application to the abstracted water volumes, the public water supply abstracted around ٥,١ billion m٣ of water to provide the population with drinking water.

Groundwater reserves are the most important source of drinking water, the second biggest user of water are the mining sector and the manufacturing industry which abstracted around ٧,٢ billion m٣ for industrial purposes, the thermal power plants have the largest water demand of about ١٩.٧ billion m³ as cooling water for energy production but for agriculture water only play a minor role in Germany.

In relation to a city of ١٠١,٠٠٠ households, emphasis are on energy consumption of water supply and disposal of the household, per capita consumption of water is [1]١٢٢ liters in ٢٠٠٩ as against the previous year's seen on his figure as well as the micro components of the water consumption.

Figure ٨: Individual water consumption and micro composition





Source: http://www.bmu.de/fileadmin/bmu-import/files/english/pdf/application/pdf/faltblatt_wasserwirtschaft_en_bf.pdf

Source: Lecture slide from Professor Wolfgang Dickhaut ,HafenCity university hamburg

[1] *Water Management in Germany* http://www.bmu.de/fileadmin/bmu-import/files/english/pdf/application/pdf/faltblatt_wasserwirtschaft_en_bf.pdf

From calculation the annual water consumption for the city ١٠١,٠٠٠ is about ٤ million m^3 (see appendix for break down calculations) and in relation to the mirocomponents, per capita consumption is ١٢٢ liters per day, of which around ٣١ percent is for toilet flushing, ٣٠ percent for bath and shower, washing machine ١٢ percent, plate washing ٦ percent, cleaning ٨ percent, these are considered to determine volume of waste water for the city which is ٣,٩٠٧,٦٩٠ m^3 which are also used to determine energy consumption for wastewater treatment and water supply.

Water Disposal

Energy consumption for water supply as stated by the [٢]Global water research coalition ٢٠٠٨, the kWh energy consumption for Germany is ٠،٩١ KWh/m^3 for water supply and ٠،١٠ kWh /m^3 for water treatment.

Based on the assumption of ١٥ hour/day water supply, the energy consumed for this duration is ٥,٥٧٥،٢ kWh / m^3, applying same to waste water, energy consumption for waste water treatment with ٠،٦٧ kWh/m^3 results to ٥,٩١٧،٤ kWh /m^3 per annual respectively.(detailed calculations in appendix).

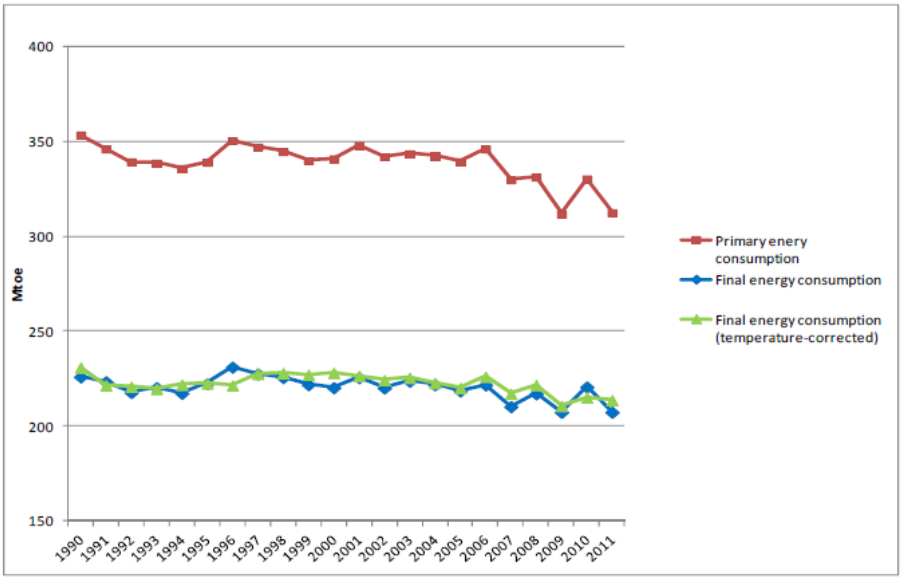
The objective of this report as earlier stated is to determine the energy consumption of a city with ١٠١,٠٠٠ inhabitants, the primary, end and net energy and also determine the efficiency from the total energy consumption from the end energy; the next chapter will be analyzing this phenomenon to proffer solutions where there is inefficiency.

[٢] *Water and Energy* http://www.iwahq.org/contentsuite/upload/iwa/Document/GWRC_Water_and_Energy_workshop_report.pdf

Chapter seven

Net and End Energy

Figure ٩: Primary and final energy consumption of Germany



Source: http://www.isi.fraunhofer.de/isi-media/docs/x/de/publikationen/National-Report_Germany_November-٢٠١٢.pdf

The above figure ٢ represents the trend in primary and final energy consumption in Germany in ٢٠ years with dynamics of changes resulting from different factors like the decline in GDP in five years between ٢٠٠٦ to ٢٠١١ between and relatively stable consumption for ten years between ١٩٩٦ to ٢٠٠٦ sequel to cold weather and peak in ٢٠٠١ but the overall trend indicator shows fell from ٣٥٥ Mtoe in ١٩٩٠ to ٣١٣ Mtoe in ٢٠١١ by almost ١٢ percent or ٠,٥ percent/yr. [٣](Source:- Energy efficient policies and measures in Germany ٢٠١٠).

In consideration to the primary energy consumption of Germany by ٣١٣ Mtoe in ٢٠١١, final energy consumption of ٢٠٨ Mtoe in ٢٠١١ respectively and its relation to this report, the breakdown of final energy consumption per capita from Germanys' population of

[٣] *Energy efficient policies and measures in Germany* ٢٠١٠, http://www.isi.fraunhofer.de/isi-media/docs/x/de/publikationen/National-Report_Germany_November-٢٠١٢.pdf

[٤]٨١,٣٧٤ million of the year ٢٠١١ (federal statistical office ٢٠٠٩), to Hamburg's population of [٥]١,٧٠٦,٦٩٦ million of the year ٢٠١١ (Statistische Ämter der läander,census ٢٠١١).

But emphasis are on the energy demand of the four types of building, the solar and internal heat gains, the transmission and ventilation loses of building types with respect to their U-values of the walls and other aspect in the city of ١٠١,٠٠٠ inhabitants which the table below represents.

Note: The other table on water is not dully represented

Table ١: Energy demand of different sectors

All building types	Energy consumption MWh/a
Heating	١٧٥ MWh/a
Cooling	١٥٨ MWh/a
Electricity	٦٧٦٣٧٧ MWh/a
Total building types	٦٧٦,٦٦٣ **MWh/a**

Water	Energy consumption MWh/a
Water supply and treatment	٥٥.٧٥٢ MWh/a
Waste water treatment	٥٩,١٧٤ MWh/a
Total water	١١٤,٩٢٦ **MWh/a**

Total	Energy consumption MWh/a
Total building types	٦٧٦,٦٦٣ MWh/a
Total Water	١١٤,٩٢٦ MWh/a
Grand total energy consumption	٦٧٦,٧٧٧,٩ **MWh/a**

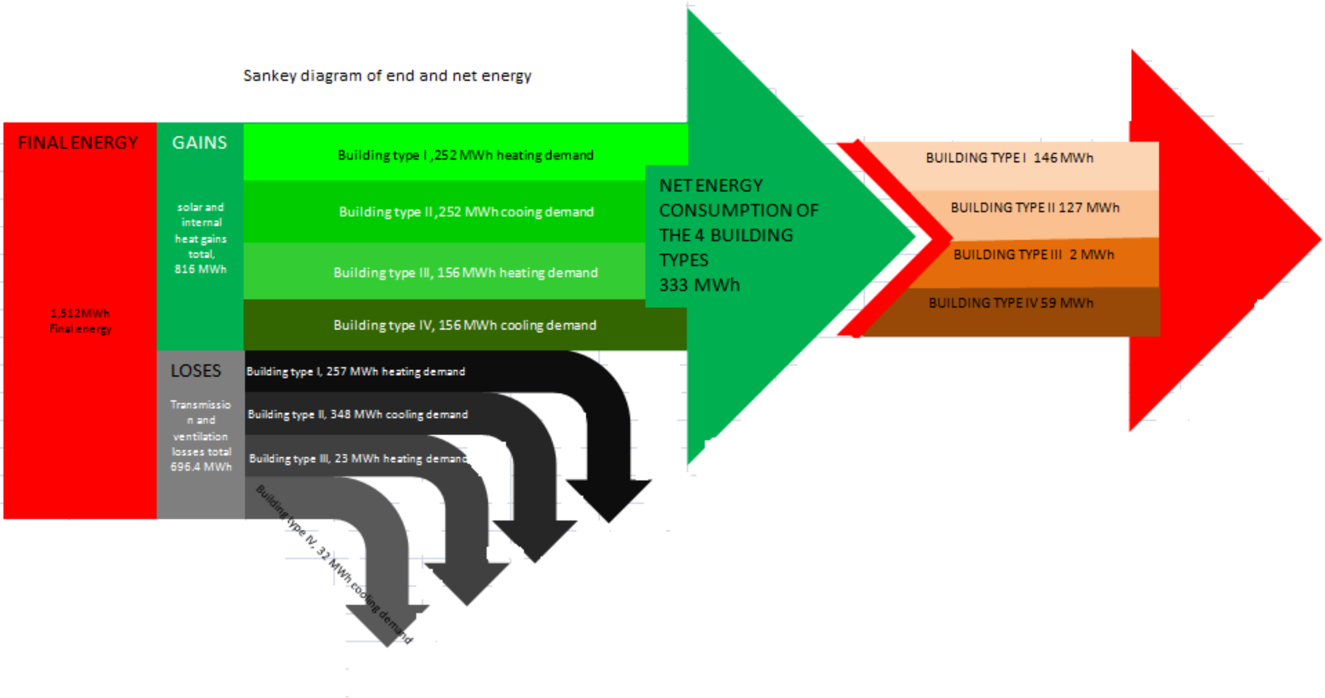
Online calculation source: - http://www.rapidtables.com/convert/power/kw-to-megaw.htm

[٤] *Germany's Population by* ٢٠٦٠ https://www.destatis.de/EN/Publications/Specialized/Population/GermanyPopulation٢٠٦٠.pdf?__blob=publicationFile

[٥] *Statistische Ämter der läander,census* ٢٠١١https://www.zensus٢٠١١.de/SharedDocs/Downloads/DE/Publikationen/Aufsaetze/٢٠١٣_٠٩_Nord_Metropolregion_Hamburg.pdf;jsessionid=EDA٧٤٣ACD٣٠٣٥١A٢٤CB١٠٥٥٩F٦٢٩٧A٥٧,٢_cid٣٢٣?__blob=publicationFile&v=٣

Sankey diagram

Figure ١٠: Diagram of end and energy consumption



Source: student

The diagram above represent the net energy of the four building types (٣٣٣ MWh/a), the final energy demand represented by gains and losses of total heating and cooling demand (see figure ٣ above or attached excel file).

The analysis shows in building type I and II has more loses(٢٥٧ MWh/a) than it gains from the internal and solar (٢٥٢ MWh/a) which is as a result of the U-values (٠,٦٤ W/m²) for heating demand, for cooling, it has the same gains from solar and internal sources(٢٥٢ MWh/a) but losses of transmission and ventilation by ٣٤٨ MWh/a, applicably to the building type III and IV on heating, it gains ١٥٦MWh/a and loses ٢٣MWh/a as a result of its U-values ٠,١٠ which has more bearing capacity to prevent losses, for cooling ١٥٦ MWh/a and losing ٣٢ MWh/a.

Comparatively, the net energy (٣٣٣MWh) and the final energy indicates that building I and II with respect to when they were constructed (١٩٦٠) has more losses than it gains due to transmission, ventilation and surface area of the building, in relation to building III and IV, has less loses as a result of its U- values ٠,١٠ and ٠,١٧ respectively.

Finally from the analysis, the building types I and II loses from ventilation and transmission ٢٥٢ MWh/a for heating demand and ٣٤٨ MWh/a on cooling, indicated that more resources for heating and cooling used on the building.

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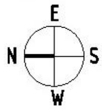
Appendix I

Description of building envelop

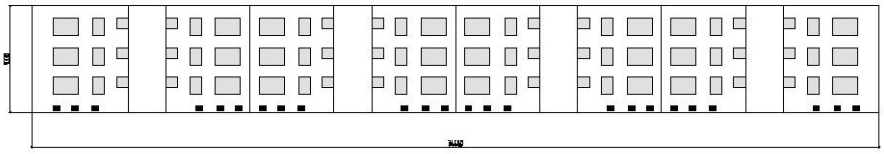
Type 1- Multi Story Residential House

Year of construction: 1960

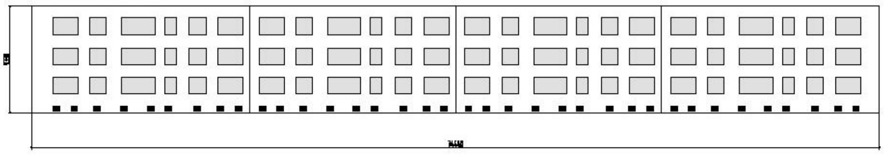
Building orientation to the cardinal direction:



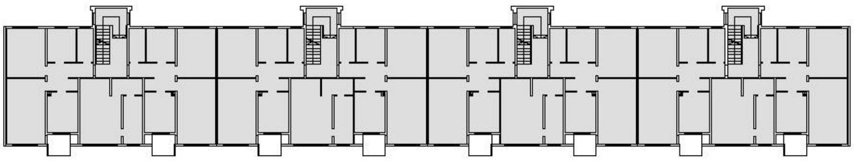
EAST ELEVATION



WEST ELEVATION



STANDARD FLOOR PLAN



No. OF PERSONS:	96
FLOOR AREA:	2097 m2
ROOF AREA:	780 m2
BASEMENT AREA:	780 m2
NORTH SIDE WINDOWS:	0 m2
WEST SIDE WINDOWS:	211 m2
EAST SIDE WINDOWS:	144 m2
SOUTH SIDE WINDOWS:	0 m2
NORTH SIDE WALL:	9.34 x 10.5 m2
WEST SIDE WALL:	9.34 x 74.4 m2
EAST SIDE WALL:	9.34 x 74.4 m2
SOUTH SIDE WALL:	9.34 x 10.5 m2

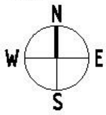
number of floors:	3
roof:	unheated
basement:	unheated
surface A:	3 148 m²
heated volume Ve:	5 550 m³
U - value:	
External wall	0.64 W/ m2K
Flat roof	0.31 W/ m2K
Windows (Double insulated glazing 24 mm with argon filling)	1.1 W/ m2K

Type 2-

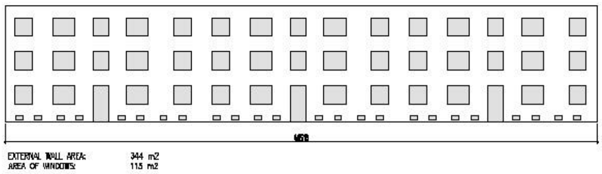
Multi Story Residential House

Year of construction: 1960

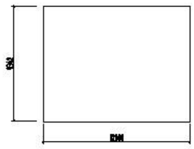
Building orientation to the cardinal direction:



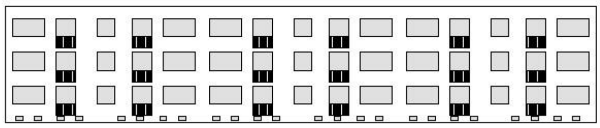
NORTH ELEVATION



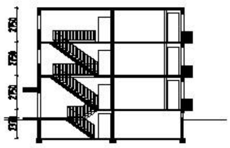
WEST / EAST ELEVATION



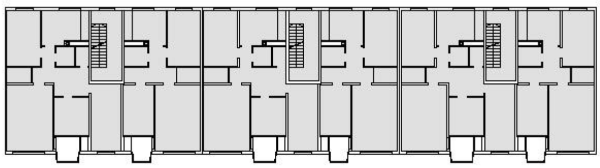
SOUTH ELEVATION



SEC TION A-A



STANDARD FLOOR PLAN



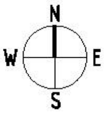
No. OF PERSONS:	63
FLOOR AREA:	1482 m2
ROOF AREA:	582 m2
BASEMENT AREA:	582 m2
NORTH SIDE WINDOWS:	115 m2
WEST SIDE WINDOWS:	0 m2
EAST SIDE WINDOWS:	0 m2
SOUTH SIDE WINDOWS:	139 m2
NORTH SIDE WALL:	9.34 x 48.51 m2
WEST SIDE WALL:	9.34 x 12.0 m2
EAST SIDE WALL:	9.34 x 12.0 m2
SOUTH SIDE WALL:	9.34 x 48.51 m2

number of floors:	3
roof:	unheated
basement:	unheated
surface A:	2 294 m²
heated volume Ve:	3 927 m³
U - value:	
External wall	0.64 W/ m2K
Flat roof	0.31 W/ m2K
Windows (Double insulated glazing 24 mm with argon filling)	1.1 W/ m2K

Type 3- Single-family house

Year of construction: 2011

Building orientation to the cardinal direction:



STANDARD FLOOR PLAN

No. OF PERSONS: 5
FLOOR AREA: 270 m2
ROOF AREA: 115.8 m2

NORTH SIDE WINDOWS: 16.5 m2
WEST SIDE WINDOWS: 13.5 m2
EAST SIDE WINDOWS: 8.5 m2
SOUTH SIDE WINDOWS: 20 m2

NORTH SIDE WALL: 6.11 x 10.25 m2
WEST SIDE WALL: 6.11 x 11.3 m2
EAST SIDE WALL: 6.11 x 11.3 m2
SOUTH SIDE WALL: 6.83 x 10.25 m2

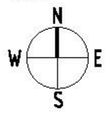
number of floors: 2
roof: unheated
basement: unheated
surface A: 502 m²
heated volume Ve: 641 m³

U - value:
External wall 0.106 W/ m2K
Flat roof 0.116 W/ m2K
Windows
(Triple insulated glazing
44 mm with argon filling) 0.6 W/m2K

Type 4- Multi Story Residential House

Year of construction: 2003

Building orientation to the cardinal direction:



BUILDING TYPE 1,2
Flat roof U-value (0,31 W/ m2K)

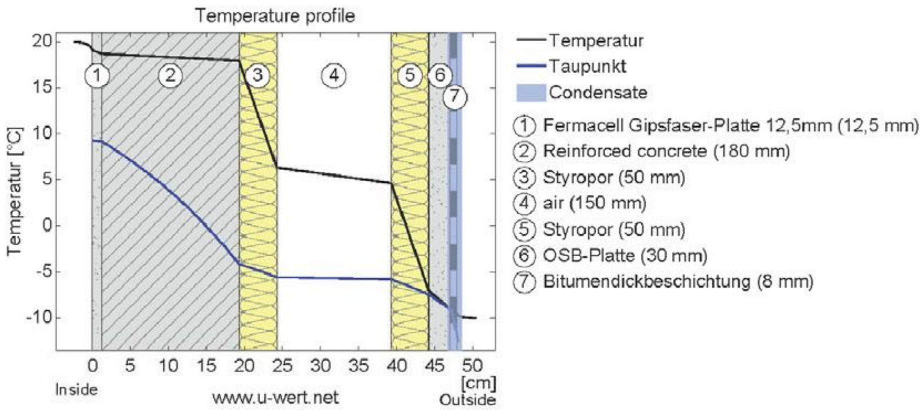
u-wert.net

Alle Angaben ohne Gewähr

Housing : Flat roof, U=0,31 W/m²K (erstellt am 5.8.2013 19:47)

U = 0,31 W/m²K (Wärmedämmung)	Trocknet nicht (Moisture proofing)	TA-Dämpfung: 90.1 (Heat protection)
0 EnEV Bestand*: U<0,2 W/m²K 0.5	0 Drying (Days) 100 48 g/m² (0.2%) Dries in 121 days	Temperature amplitude attenuation: 90.1 Phase shift: 9.3h
Raumluft: 20°C / 50%	Condensate: 0.05 kg/m²	Weight: 458 kg/m²
Außenluft: -10°C / 80%	sd-value: 417.6 m	Thickness: 48.05 cm

Temperaturverlauf / Tauwasserzone



Verlauf von Temperatur und Taupunkt innerhalb des Bauteils. Der Taupunkt kennzeichnet die Temperatur, bei der Wasserdampf kondensieren und Tauwasser entstehen würde. Solange die Temperatur der Konstruktion an jeder Stelle über der Taupunkttemperatur liegt, entsteht kein Tauwasser. Falls sich die beiden Kurven berühren, fällt an den Berührungspunkten Tauwasser aus.

Layers (from inside to outside)

Folgende Tabelle enthält die wichtigsten Daten aller Schichten der Konstruktion:

#		Material	λ [W/mK]	R [m²K/W]	Temperatur [°C] min	Temperatur [°C] max	Weight [kg/m²]	Condensate [Gew%]
		Thermal contact resistance		0,100	19,1	20,0		
1	1,25 cm	Fermacell Gipsfaser-Platte 12,5mm	0,320	0,039	18,7	19,1	14,4	0,0
2	18 cm	Reinforced concrete (1%)	2,300	0,078	18,0	18,7	414,0	0,0
3	5 cm	Styropor	0,040	1,250	6,3	18,0	1,0	0,0
4	15 cm	air (unventilated layer)	0,833	0,180	4,6	6,3	0,0	
5	5 cm	Styropor	0,040	1,250	-7,0	4,6	1,0	0,0
6	3 cm	OSB-Platte (DIN EN ISO 10456)	0,130	0,231	-9,2	-7,0	19,5	0,2
7	0,8 cm	Bitumendickbeschichtung	0,170	0,047	-9,6	-9,2	8,4	0,0
		Thermal contact resistance		0,040	-10,0	-9,6		
	48,05 cm	Whole component		3,215			458,3	

BUILDING TYPE 3
External wall U-value (0,106 W/ m2K)

u-wert.net

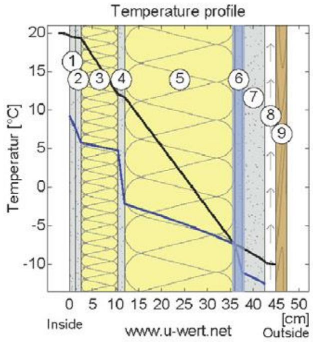
Alle Angaben ohne Gewähr

Housing : Exterior wall, U=0,106 W/m²K

(erstellt am 5.8.2013 17:44)

U = 0,106 W/m²K (Wärmedämmung)	Viel Tauwasser (Moisture proofing)	TA-Dämpfung: 113.6 (Heat protection)
0 EnEV Bestand*: U<0,24 W/m²K 0.5	0% Weight-% 10% 0.63 kg/m² (13.2%) Dries in 51 days	Temperature amplitude attenuation: 113.6 Phase shift: 16.7h
Raumluft: 20°C / 50%	Condensate: 0.63 kg/m²	Weight: 93 kg/m²
Außenluft: -10°C / 80%	sd-value: 2.1 m	Thickness: 47.4 cm

Temperaturverlauf / Tauwasserzone



— Temperatur
— Taupunkt
Condensate

1. Fermacell Gipsfaser-Platte 12,5mm (12,5 mm)
2. Fermacell Gipsfaser-Platte 12,5mm (12,5 mm)
3. Knauf Insulation Fassaden-Dämmplatte FPL-035 (80 mm)
4. OSB-Platte (15 mm)
5. Glaswolle WLG040 (240 mm)
6. MDF (16 mm)
7. Wood-wool board (50 mm)
8. Air (24 mm)
9. Larch (24 mm)

Verlauf von Temperatur und Taupunkt innerhalb des Bauteils. Der Taupunkt kennzeichnet die Temperatur, bei der Wasserdampf kondensieren und Tauwasser entstehen würde. Solange die Temperatur der Konstruktion an jeder Stelle über der Taupunkttemperatur liegt, entsteht kein Tauwasser. Falls sich die beiden Kurven berühren, fällt an den Berührungspunkten Tauwasser aus.

Layers (from inside to outside)

Folgende Tabelle enthält die wichtigsten Daten aller Schichten der Konstruktion:

#		Material	λ	R	Temperatur [°C]		Weight	Condensate
			[W/mK]	[m²K/W]	min	max	[kg/m²]	[Gew%]
		Thermal contact resistance		0,130	19,6	20,0		
1	1,25 cm	Fermacell Gipsfaser-Platte 12,5mm	0,320	0,039	19,5	19,6	14,4	0,0
2	1,25 cm	Fermacell Gipsfaser-Platte 12,5mm	0,320	0,039	19,3	19,5	14,4	0,0
3	8 cm	Knauf Insulation Fassaden-Dämmplatte FPL-035	0,035	2,286	12,1	19,3	4,0	0,0
4	1,5 cm	OSB-Platte (DIN EN ISO 10456)	0,130	0,115	11,7	12,1	9,8	0,0
5	24 cm	Glaswolle WLG040	0,040	6,000	-7,4	11,7	4,8	13
6	1,6 cm	MDF (750kg/m³)	0,130	0,123	-7,8	-7,4	12,0	5,3
7	5 cm	Wood-wool board (mineral bound)	0,090	0,556	-9,6	-7,8	23,0	0,0
		Thermal contact resistance		0,130	-10,0	-9,6		
8	2,4 cm	Air (ventilated layer)			-10,0	-10,0	0,0	
9	2,4 cm	Larch			-10,0	-10,0	11,0	
	47,4 cm	Whole component		9,416			93,3	

BUILDING TYPE 3,4
Flat roof U-value (0,116 W/ m2K)

u-wert.net

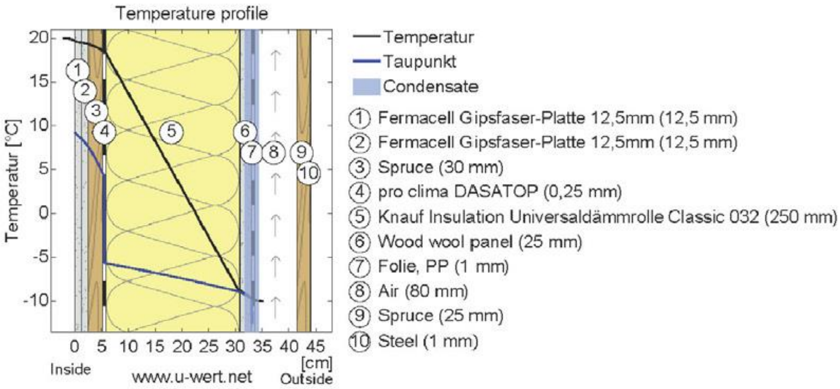
Alle Angaben ohne Gewähr

Housing : Flat roof, U=0,116 W/m²K

(erstellt am 5.8.2013 17:05)

U = 0,116 W/m²K (Wärmedämmung)	Viel Tauwasser (Moisture proofing)	TA-Dämpfung: 37.6 (Heat protection)
0 EnEV Bestand*: U<0,2 W/m²K 0.5	0 Condensate (kg) 1 350 g/m² (3.0%) Dries in 70 days	Temperature amplitude attenuation: 37.6 Phase shift: 10.0h
Raumluft: 20°C / 50%	Condensate: 0.35 kg/m²	Weight: 81 kg/m²
Außenluft: -10°C / 80%	sd-value: 12.4 m	Thickness: 43.725 cm

Temperaturverlauf / Tauwasserzone



Verlauf von Temperatur und Taupunkt innerhalb des Bauteils. Der Taupunkt kennzeichnet die Temperatur, bei der Wasserdampf kondensieren und Tauwasser entstehen würde. Solange die Temperatur der Konstruktion an jeder Stelle über der Taupunkttemperatur liegt, entsteht kein Tauwasser. Falls sich die beiden Kurven berühren, fällt an den Berührungspunkten Tauwasser aus.

Layers (from inside to outside)

Folgende Tabelle enthält die wichtigsten Daten aller Schichten der Konstruktion:

#		Material	λ [W/mK]	R [m²K/W]	Temperatur [°C] min	Temperatur [°C] max	Weight [kg/m²]	Condensate [Gew%]
		Thermal contact resistance		0,100	19,7	20,0		
1	1,25 cm	Fermacell Gipsfaser-Platte 12,5mm	0,320	0,039	19,5	19,7	14,4	0,0
2	1,25 cm	Fermacell Gipsfaser-Platte 12,5mm	0,320	0,039	19,4	19,5	14,4	0,0
3	3 cm	Spruce	0,130	0,231	18,6	19,4	13,5	0,0
4	0,025 cm	pro clima DASATOP	0,170	0,001	18,6	18,6	0,1	0,0
5	25 cm	Knauf Insulation Universaldämmrolle Classic 032	0,032	7,812	-8,7	18,6	7,5	0,0
6	2,5 cm	Wood wool panel (25mm)	0,090	0,278	-9,6	-8,7	11,5	3,0
7	0,1 cm	Folie, PP	0,220	0,005	-9,7	-9,6	0,9	0,0
		Thermal contact resistance		0,100	-10,0	-9,7		
8	8 cm	Air (ventilated layer)			-10,0	-10,0	0,0	
9	2,5 cm	Spruce			-10,0	-10,0	11,2	
10	0,1 cm	Steel			-10,0	-10,0	7,8	
	43,725 cm	Whole component		8,606			81,4	

BUILDING TYPE 4
External wall U-value (0,170 W/ m2K)

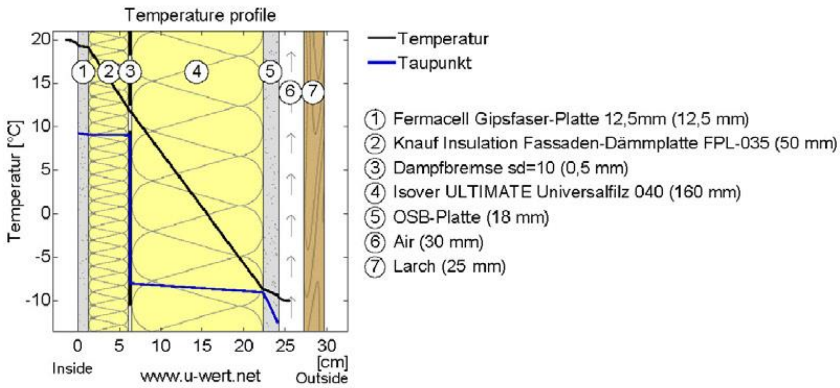
u-wert.net

Alle Angaben ohne Gewähr

Housing Complex Spinnereistrasse_wall: Exterior wall, U=0,170 W/m²K (erstellt am 3.8.2013 0:10)

U = 0,170 W/m²K (Wärmedämmung)	Kein Tauwasser (Moisture proofing)	TA-Dämpfung: 8.0 (Heat protection)
0 EnEV Bestand*: U<0,24 W/m²K 0.5	0 Condensate (kg) 1 No condensate	Temperature amplitude attenuation: 8.0 Phase shift: 7.5h
Raumluft: 20°C / 50%	Condensate: 0.00 kg/m²	Weight: 45 kg/m²
Außenluft: -10°C / 80%	sd-value: 11.4 m	Thickness: 29.6 cm

Temperaturverlauf / Tauwasserzone



Verlauf von Temperatur und Taupunkt innerhalb des Bauteils. Der Taupunkt kennzeichnet die Temperatur, bei der Wasserdampf kondensieren und Tauwasser entstehen würde. Solange die Temperatur der Konstruktion an jeder Stelle über der Taupunkttemperatur liegt, entsteht kein Tauwasser. Falls sich die beiden Kurven berühren, fällt an den Berührungspunkten Tauwasser aus.

Layers (from inside to outside)

Folgende Tabelle enthält die wichtigsten Daten aller Schichten der Konstruktion:

#		Material	λ [W/mK]	R [m²K/W]	Temperatur [°C] min	Temperatur [°C] max	Weight [kg/m²]	Condensate [Gew%]
		Thermal contact resistance		0,130	19,3	20,0		
1	1,25 cm	Fermacell Gipsfaser-Platte 12,5mm	0,320	0,039	19,1	19,3	14,4	0,0
2	5 cm	Knauf Insulation Fassaden-Dämmplatte FPL-035	0,035	1,429	11,8	19,1	2,5	0,0
3	0,05 cm	Dampfbremse sd=10	0,220	0,002	11,8	11,8	0,1	0,0
4	16 cm	Isover ULTIMATE Universalfilz 040	0,040	4,000	-8,6	11,8	4,8	0,0
5	1,8 cm	OSB-Platte (DIN EN ISO 10456)	0,130	0,138	-9,3	-8,6	11,7	0,0
		Thermal contact resistance		0,130	-10,0	-9,3		
6	3 cm	Air (ventilated layer)			-10,0	-10,0	0,0	
7	2,5 cm	Larch			-10,0	-10,0	11,5	
	29,6 cm	Whole component		5,869			45,0	

Appendix II

Analysis of results

Water supply

Per capita consumption ١٢٢ liters per day

Population ١٠١,٠٠٠ inhabitants

Calculations

١٢٢*١٠١,٠٠٠ =١٢,٣٢٢,٠٠٠ liters per day

Per Annual

١٢,٣٢٢,٠٠٠ *٣٦٥ = ٤٤٣,٥٩٢,٠٠٠ liters

Convert to m^3 = ٤,٤٩٧,٥٣٠ **m^3**

Waste water

Based on ١٢٢ liters per capita per day, the percentage of waste water analyzed as follows

٣١٪ Toilet flushing = ٣٧,٨ liters

٣٠٪ Bath and shower = ٣٦,٦ liters

١٢٪ Washing machine = ١٤,٦ liters

٨ % Cleaning = ٩,٧ liters

٦ % plate washing = ٧,٣ liters

Total waste water ١٠٦ liters per capita per day

Calculations

١٠٦ * ١٠١,٠٠٠ = ١٠,٧٠٦,٠٠٠ liters per capita per day

Per Annual

١٠,٧٠٦,٠٠٠ * ٣٦٥ days = ٣٩٠,٧٦٩,٠٠٠

Convert to m^3 = ٣,٩٠٦,٠٠٠ **m^3**

Appendix III

Energy consumption for water supply and treatment

Assumptions

Energy consumption for water supply and treatment = ١،٠١ kWh/m^3 (from source)

Assume ١٥ hours of pumping per day

٨ months in a year has ٣١ days

٤ months in a year has ٣٠ days

Calculations

١٥ hours * ٣١ days = ٤٦٥ **hours**

٤٦٥ hours * ٨ months = ٣,٧٢٠ **hours**

١٥ hours * ٤ months = ١٨٠٠ **hours**

Sum total = ٥,٥٢٠ **hours per year**

Energy consumption for water supply and treatment

١,٠١KWh/m^3 * ٥,٥٢٠ = ٥,٥٧٥,٢ **kWh/m^3 per year**

Convert to megawatts =٥,٥٧٥,٢/١٠٠٠ =

Energy consumption for wastewater treatment

Assumptions

Energy consumption for waste water treatment = ٠،٦٧ KWh/m^3 (from source)

Assumed ٢٤ hours per day for waste water treatment

٨ months in a year has ٣١ days

٤ months in a year has ٣٠ days

٢٤ hours * ٣١ days = ٧٤٤ **hours per month**

٧٤٤ hours * ٨ months = ٥٩٥٢ **hours**

٢٤ hours * ٣٠ days = ٧٢٠ **hours per month**

٧٢٠ hours * ٤ months = ٢٨٨٠ **hours**

Sum total = ٥,٩٥٢ +٢٨٨٠ = ٨,٨٣٢ **hours per year**

Energy consumption for waste water treatment

٠,٦٧ kWh/m³ * ٨,٨٣٢ = ٥,٩١٧,٤٤ **kWh/m³ per year**

Appendix IV

Analysis of gains and losses of heat and cooling demand of the four types of building

End and Net energy

End energy

Building types

Building type ١ = ٥٠٠

Building type ٢ = ٤٠٠

Building type ٣ = ٨٠

Building type ٤ = ٤٨٠

Based on that we merged building ١ and ٢ = ٩٠٠ and building types ٣ and ٤ ٥٦٠

Assumptions

- Same solar energy because the houses are on the same area
- For building type ٣ and ٤, we made it same U- values though ٠,١٠ and ٠,١٧
- ١٥ percent transmission and ventilation loses of building type ٣ and ٤

Note :-(١٥ percent assumption is based on the U-values of the buildings ٠,١٠ / ٠,٦٤ * ١٠٠ = ١٥٪)

Heating demand building type I and II

Gains

Solar gains =٨٢,٠٤٦ kWh/a

Internal heat gains = ١٩٨,٣ kWh/a

Calculation: ٨٢,٠٤٦ kWh/a + ١٩٨,٣ kWh/a = ٢٨٠ Kwh/a

٢٨٠.٣ kWh/a * ٩٠٠ buildings = ٢٥٢,٢٧٠ kWh/a or ٢٥٢ **MW h/a**

Loses

Transmission =١٨١,١ kWh/a

Ventilation = ١٠٤,٥ kWh/a

Calculation: ١٨١,١ kWh/a + ١٠٤,٥ kWh/a =٢٨٦ kwh/a

٢٨٦ * ٩٠٠ buildings = ٢٥٧,٤٠٠ kWh/a or ٢٥٧,٤ **MWh/a**

Cooling demand building type I and II

Gains

Solar gains =٨٢,٠٤٦ kWh/a

Internal heat gains = ١٩٨,٣ kWh/a

Calculation: ٨٢,٠٤٦ kWh/a + ١٩٨,٣ kWh/a = ٢٨٠ Kwh/a

٢٨٠.٣ kWh/a * ٩٠٠ buildings = ٢٥٢,٢٧٠ kWh/a or ٢٥٢ **MWh/a**

Losses

Transmission = ٢٤٥,٣ kWh/a

Ventilation = ١٤١,٦ kWh/a

Calculation: ٢٤٥,٣ + ١٤١,٦ =٣٨٦,٩ kWh/a = ٣٨٦,٩ kWh/a

٣٨٦,٩ * ٩٠٠ =٣٤٨,٢١٠ kWh/a or ٣٤٨ **MWh/a**

Heating demand building type III and IV

Gains

Solar gains =٨٢,٠٤٦ kWh/a

Internal heat gains = ١٩٨,٣ kWh/a

Calculation: ٨٢,٠٤٦ kWh/a + ١٩٨,٣ kWh/a = ٢٨٠ kWh/a

٢٨٠ * ٥٦٠ buildings = ١٥٦,٠٠٠ kWh/a or ١٥٦ **MWh**

Losses

Transmission = ٢٧,١ kWh/a

Ventilation = ١٥,٦ kWh/a

Calculation: ٢٧,١ + ١٥,٦ =٤٢,٧ kWh/a

٤٢,٧ * ٥٦٠ =٢٣,٩١٢ kWh/a or ٢٣ **MWh/a**

Cooling demand building type III and IV

Gains

Solar gains =٨٢,٠٤٦ kWh/a

Internal heat gains = ١٩٨,٣ kWh/a

Calculation: ٨٢,٠٤٦ kWh/a + ١٩٨,٣ kWh/a = ٢٨٠ kWh/a

٢٨٠ * ٥٦٠ buildings = ١٥٦,٠٠٠ kWh/a or ١٥٦ **MWh**

Losses

Transmission = ٣٦,٧ kWh/a

Ventilation = ٢١,٢ kWh/a

Calculation: ٣٦,٧ + ٢١,٢ = ٥٧,٩ kWh/a

٥٧,٩ * ٥٦٠ =٣٢,٤٢٤ kWh/a or ٣٢ **MWh/a**

Net energy

Heating demand = ١٧٥ MWh/a

Cooling demand = ١٥٨ MWh/a