Project Documentation
Gebäude-Dokumentation

Abstract | Zusammenfassung

2 Residential Passive House Towers in Tianjin Eco-City (Bldg. #4) ID: 6119

Data of building | Gebäudedaten - #4

Year of construction Baujahr	2019	**Space heating Heizwärmebedarf**	**14** **kWh/(m²a)**
U-value external wall U-Wert Außenwand	0,138 W/(m²K)		
U-value basement U-Wert Kellerdecke	0,135 W/(m²K)	Primary Energy Renewable (PER) Erneuerbare Primärenergie (PER)	62 kWh/(m²a)
U-value roof U-Wert Dach	0,144 W/(m²K)	Generation of renewable Energy Erzeugung erneuerb. Energie	34 kWh/(m²a)
U-value window U-Wert Fenster	0,81 W/(m²K)	Non-renewable Primary Energy (PE) Nicht erneuerbare Primärenergie (PE)	104 kWh/(m²a)
Heat recovery Wärmerückgewinnung	85 %	Pressurization test n_{50} Drucktest n_{50}	0,24 h^{-1}
Special features Besonderheiten	Split air-cooled heat pump as cold and heat source; Air-cooled heat pump with re-circulation air for each dwelling; Solar hot water 80%.		

Project Documentation
Gebäude-Dokumentation

Abstract | Zusammenfassung

2 Residential Passive House Towers in Tianjin Eco-City (Bldg. #5) ID: 6121

Data of building | Gebäudedaten - #5

Year of construction Baujahr	2019	**Space heating Heizwärmebedarf**	**12 kWh/(m²a)**
U-value external wall U-Wert Außenwand	0,138 W/(m²K)		
U-value basement U-Wert Kellerdecke	0,135 W/(m²K)	Primary Energy Renewable (PER) Erneuerbare Primärenergie (PER)	62 kWh/(m²a)
U-value roof U-Wert Dach	0,144 W/(m²K)	Generation of renewable Energy Erzeugung erneuerb. Energie	43 kWh/(m²a)
U-value window U-Wert Fenster	0,81 W/(m²K)	Non-renewable Primary Energy (PE) Nicht erneuerbare Primärenergie (PE)	104 kWh/(m²a)
Heat recovery Wärmerückgewinnung	85 %	Pressurization test n_{50} Drucktest n_{50}	0,24 h^{-1}
Special features Besonderheiten	Split air-cooled heat pump as cold and heat source; Air-cooled heat pump with re-circulation air for each dwelling; Solar hot water 80%.		

Brief Description

Residential Passive House Towers in Tianjin Eco-City, China

Two residential high-rise buildings of 18 floors within a larger master plan development in Tianjin’s Sino-Singapore Eco-City. The project is initiated by the local government of Tianjin Eco-City with the support of SoftGrid (Shanghai) and the Passive House Institute (PHI), Darmstadt. The treated Floor Area according to PHPP is 4227 m2 for project ID: 6119 and 5021 m2 for project ID: 6121.
The idea behind the project is to integrate the passive house standard into a pilot project of a standard residential building and thus to develop the base for a local passive house standard to be mass replicated in future in the region of Tianjin.
The process consisted of optimizing the architectural layout, changing all construction details so that they can comply with the requirements of the PH standard, rethinking the building services and all technical equipment.
The used construction products are predominantly local, imported solutions were only used where there was no local alternative on the market.
The construction costs are estimated at 1020 €/m^2 Treated Floor Area (Costs of group 200-700).

Kurzbeschreibung

Passivhaus Wohnhochhäuser in Tianjin Eco-City, China

Zwei 18-stöckige Wohnhochhäuser in einem größeren Masterplan in Tianjins Öko-Stadt Sino-Singapur. Das Projekt wird von der lokalen Regierung von Tianjin Eco-City mit Unterstützung von SoftGrid (Shanghai) und dem Passivhaus-Institut (PHI) in Darmstadt initiiert.
Die nach PHPP behandelte Grundfläche beträgt 4227 m2 für Projekt-ID: 6119 und 5021 m2 für Projekt-ID: 6121.
Die Grundidee hinter dem Projekt ist es, den Passivhausstandard in ein Pilotprojekt eines Standardwohngebäudes zu integrieren und damit die Basis für einen lokalen Passivhausstandard zu entwickeln, der in Zukunft in der Region Tianjin massenrepliziert werden kann. Während der Planung wurde das architektonische Layout optimiert, alle Konstruktionsdetails wurden geändert und verbessert, damit sie den Anforderungen des PH-Standards entsprechen, die Gebäudetechnik und die gesamte technische Ausstattung wurden auch angepasst. Die verwendeten Bauprodukte sind überwiegend lokal, importierte Lösungen wurden nur dort eingesetzt, wo es keine lokale Alternative auf dem Markt gab.
Die Baukosten wurden auf 1020 € / m2 geschätzt (Kostengruppe 200-700).

Responsible project participants
Verantwortliche Projektbeteiligte

Architect Entwurfsverfasser	Tianjin Architectural Design Institute (LDI)
Implementation planning Ausführungsplanung	Tianjin Architectural Design Institute (LDI)
Building systems Haustechnik	Tianjin Architectural Design Institute (LDI)
Structural engineering Baustatik	Tianjin Architectural Design Institute (LDI)
Building physics Bauphysik	Tianjin Architectural Design Institute (LDI)
Passive House project planning Passivhaus-Projektierung	SoftGrid (Shanghai) Co., Ltd. www.soft-grid.com
Construction management Bauleitung	China Construction Third Engineering Bureau Co., Ltd.

Certifying body
Zertifizierungsstelle

Passivhaus Institut Darmstadt
www.passiv.de

Certification ID
Zertifizierungs ID

6119 **6121**	Project-ID (www.passivehouse-database.org) Projekt-ID (www.passivhausprojekte.de)

Author of project documentation
Verfasser der Gebäude-Dokumentation

Passivhaus Institut Darmstadt
www.passiv.de

Date Datum	Signature Unterschrift
19.11.2021	

1.a. Exterior Photos

Compound park

1.b. Typical Interior Photos

Passive House Multimedia Showroom

Typical Apartment

1.c. Building Envelope

Building envelope is designed as a typical punch-hole façade without functional balconies. Support slabs for HVAC split units produce the most decisive thermal bridges within the building skin. Basic envelope specifications are:

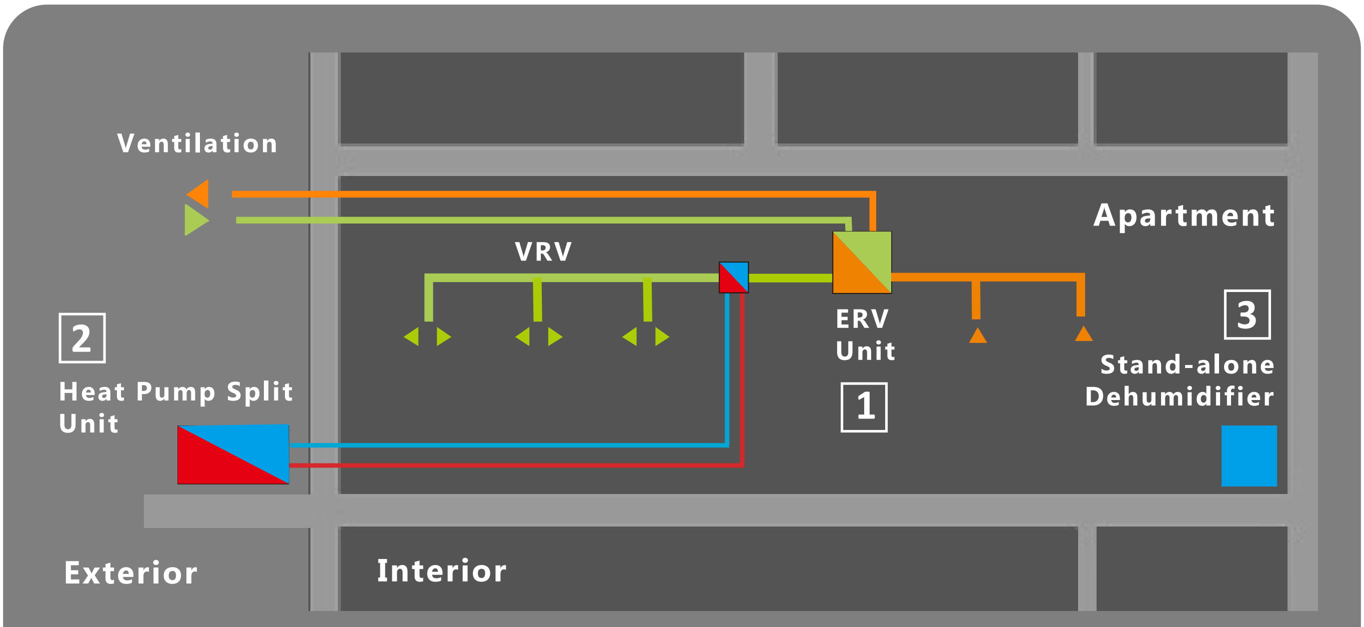
U-Value Window:	0.67 W/m^{2}K
g-Value Window:	0.48
	Triple-glazing PH windows, roller shutters
U-Value Roof:	0.13 / 0.14 W/m^{2}K
	150mm Concrete, 240mm EPS
U-Value Walls:	0.13 W/m^{2}K
	200mm concrete / masonry, 240mm mineral wool / EPS
U-Value Baseplate:	0.13 / 0.14 W/m^{2}K
	90mm combined screed, 120mm concrete, 200mm XPS

All envelope materials and components were sourced 100% in China!

1.d. Technical Systems

The design of the HVAC system addressed the local climate by integrating a split unit heat pump with ERV ventilation system for winter heating as well as summer cooling and dehumidification. However, since the anticipated temperature difference limits the amount of dehumidification considerably, a stand-alone dehumidifier was provided as an additional “safety net” for the hottest and most humid of summer days.

Active system components were all 100% sourced locally in China!



HVAC System Diagram

Tailor-Made combination of components with ERV to provide ventilation with heat recovery and VRV for heating, cooling and dehumidification integrated into the ventilation system. Additional stand-alone dehumidifier.

1 Integrated ERV Unit
Vaillant recoVAIR 260/4E

2 Integrated VRV Unit
Toshiba - RAS-16S3AV-C

3 Stand-alone Dehumidifier

2. Monitoring Concept: Overview

The project was completed as one of Asia's tallest Passive House projects to date in late 2019. Since early 2020, three flats on ground floor have been in full operation for a complete 12-month cycle.

Being a residential building with multiple ownership of individual apartments, it is clear to see how the project's success highly depends on the efficient integration of user behaviour in the overall strategy.

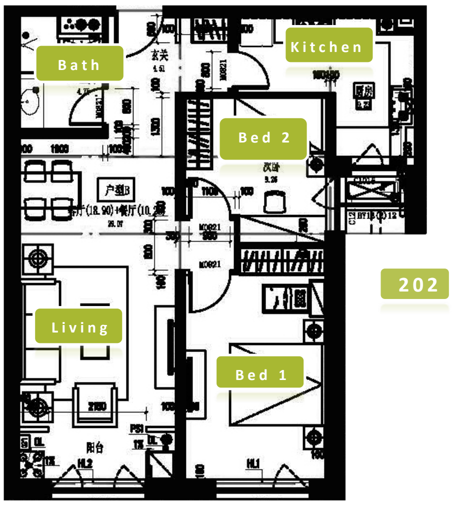
A long term monitoring process has been established, providing data on environmental factors such as temperature, humidity, CO_2 and PM2.5 as well as a structured break-down of energy usage and behavioral factors such as window opening times for all apartments on GF, 8F and top floor.

Dedicated Monitoring Floors:

Current "Test Apartments" 201 / 202 / 203 have been selected since these constitute the "worst case" for heating period because of unconditioned parking basement below.

GF Plan:

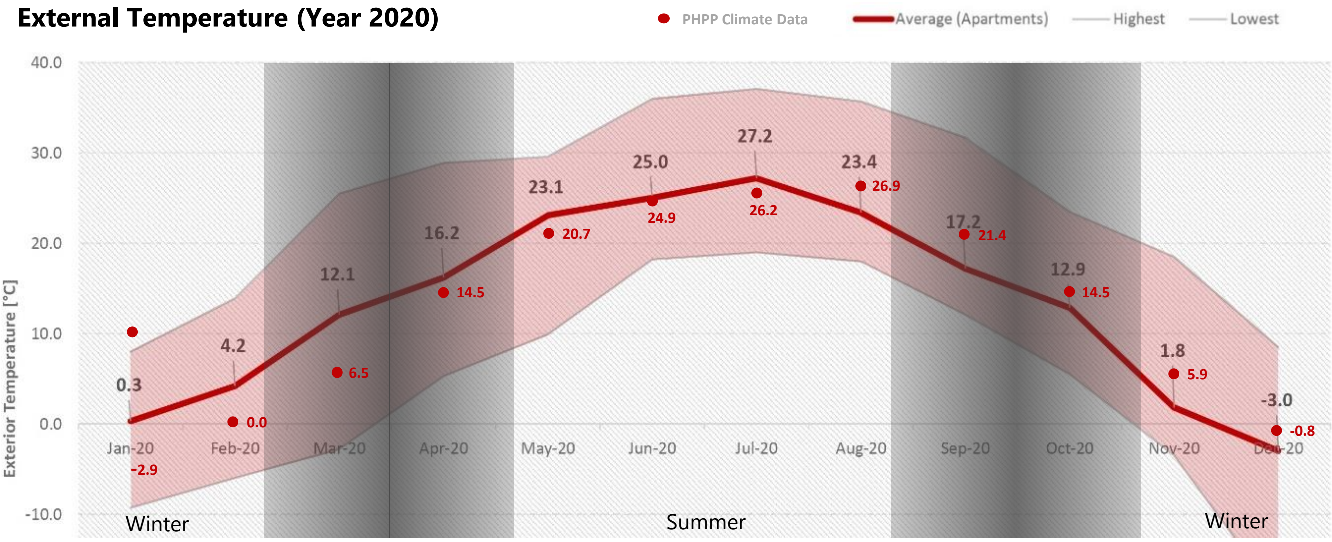
Typical Apartment 202.

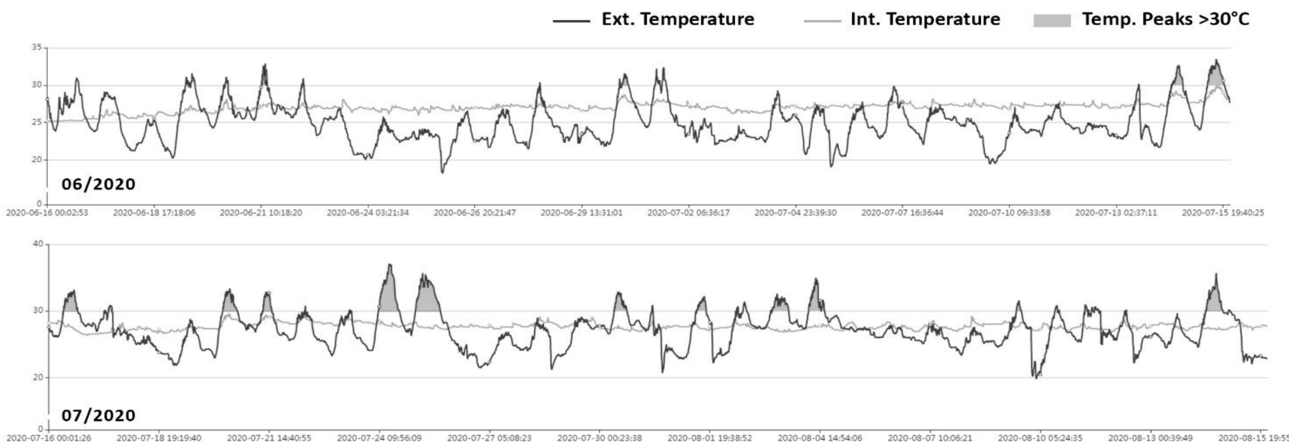


3. Monitoring Context: Tianjin Climate Patterns

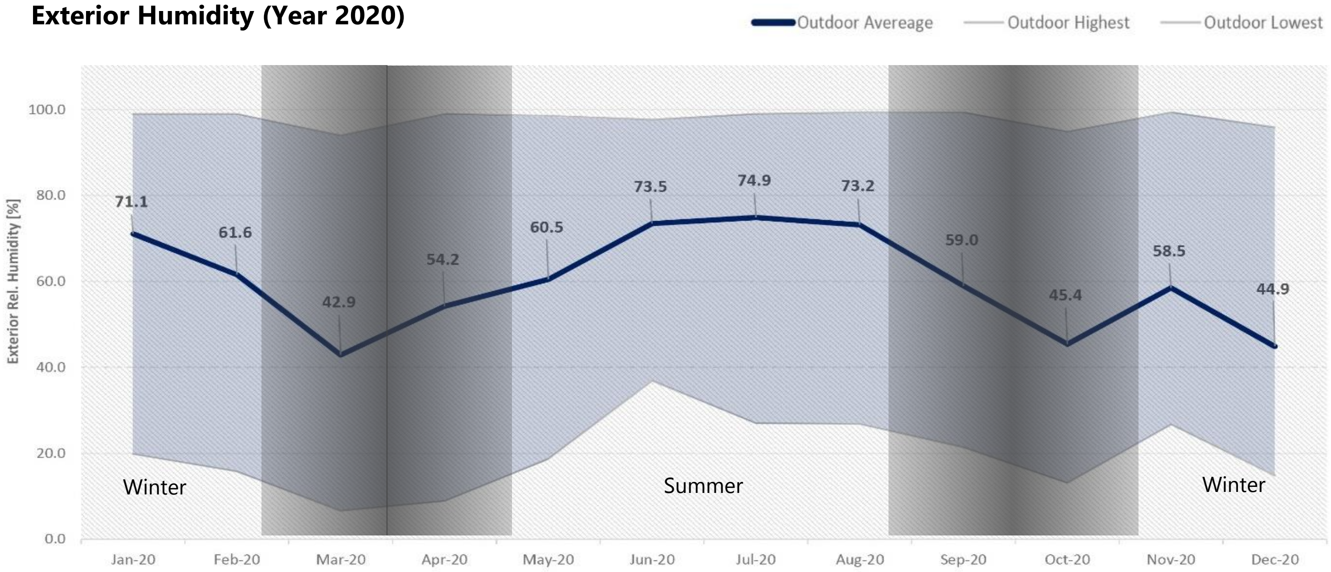
The 2020 testing cycle fell into a typical Tianjin annual climate pattern - with no exceptional incidents like heatwave, extremely low temperature or else – suggesting a need for considerable heating during winter and cooling as well as dehumidification during summer months.

External Temperature (Year 2020)





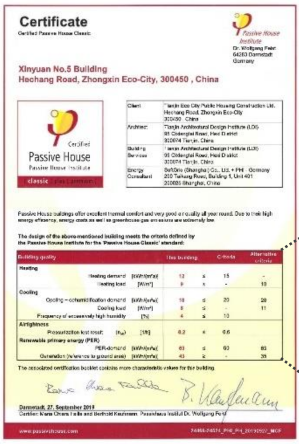
Exterior Humidity (Year 2020)



4. Monitoring Results: Energy Consumption

Sizes of monitored apartments are 79m^2 (201, 203) and 88m^2 (202) respectively, occupied by families of different sizes including children, babies and elderly.

The certified PHPP for Building 5 anticipates a heating demand of 12 and a cooling and dehumidification demand of 18 kWh/m2a.


Certificate

Xinyuan No.5 Building
Hechang Road, Zhongxin Eco-City, 300450 , China

Comparison PHPP and Monitoring Data Result:

"Test Apartments" 201 / 202 / 203 consume on average 3% less energy for heating / cooling + dehumidification than anticipated according to PHPP calculation.

Building quality		This building		Criteria	Alternative criteria
Heating					
Heating demand	[kWh/(m²a)]	12	≤	15	-
Heating load	[W/m²]	9	≤	-	10
Cooling					
Cooling + dehumidification demand	[kWh/(m²a)]	18	≤	20	20
Cooling load	[W/m²]	8	≤	-	11
Frequency of excessively high humidity	[%]	4	≤	10	

Multiplied by the TFA of the test apartments, the predicted energy consumption is roughly 7.370 kWh/a for all apartments combined.

Monitoring Data - Energy Demand Heating / Cooling

Apartments	Energy Demand - Yearly Summary		
Unit Nr.	Total measured	Total predicted (PHPP)	Perecent
201	2,098.39 kWh/a	2,369.30 kWh/a	88.6 %
202	2,507.80 kWh/a	2,369.30 kWh/a	105.8 %
203	2,528.89 kWh/a	2,630.10 kWh/a	96.2 %
All Units	**7,135.08 kWh/a**	**7,368.69 kWh/a**	**96.8 %**

As a result, the actual monitored energy demand is approx. 3% lower than anticipated in PHPP.

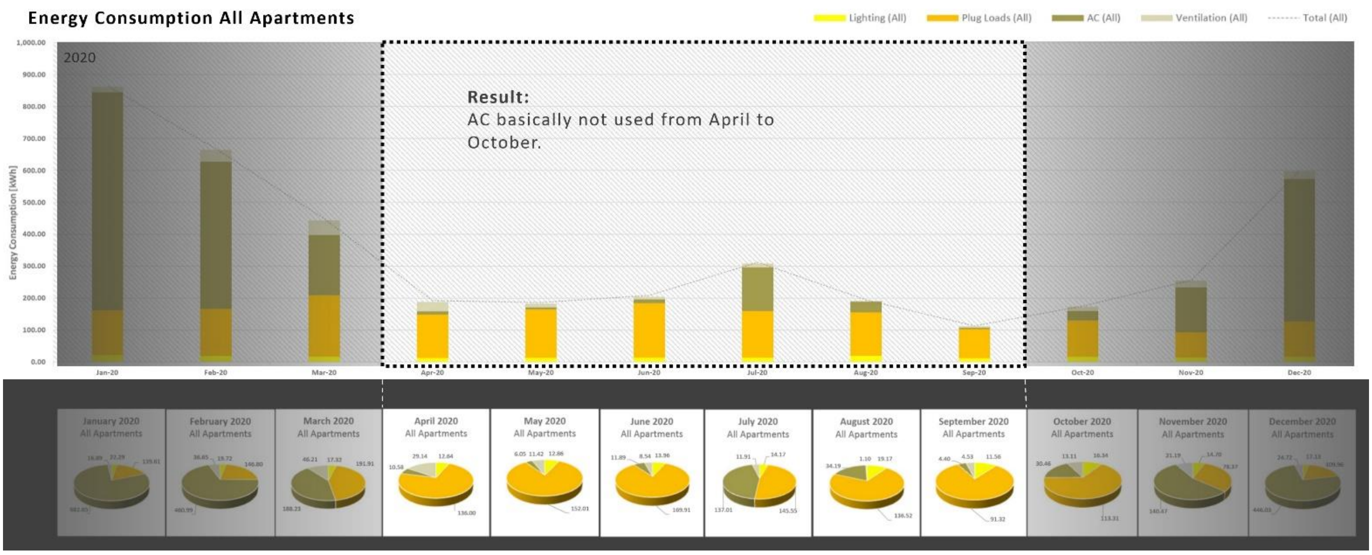
5. Monitoring Results: Summer

Occupant Feedback - Summer

Despite comfort criteria not matching up to the Passive House standard targets – interior temperatures up to 28°C and rel. humidity over 70% - residents perceived their summer in a passive house apartment as extremely comfortable.

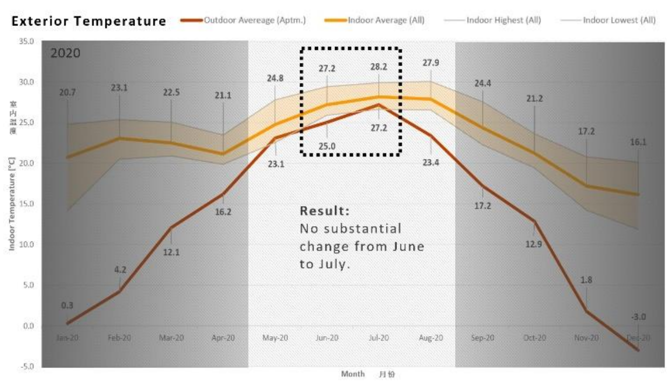
Drivers for Energy Consumption and Use of AC

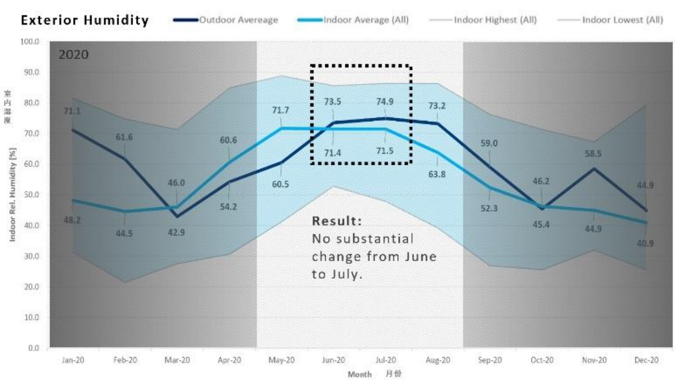
AC System was barely used over the shoulder period / summer months between April and September 2020. Only exception is the month of July 2020.



Corresponding Results for Interior Climate

Temperature and Relative Humidity (see charts below) however did not respond to use of AC as expected, namely by reducing temperature and humidity.

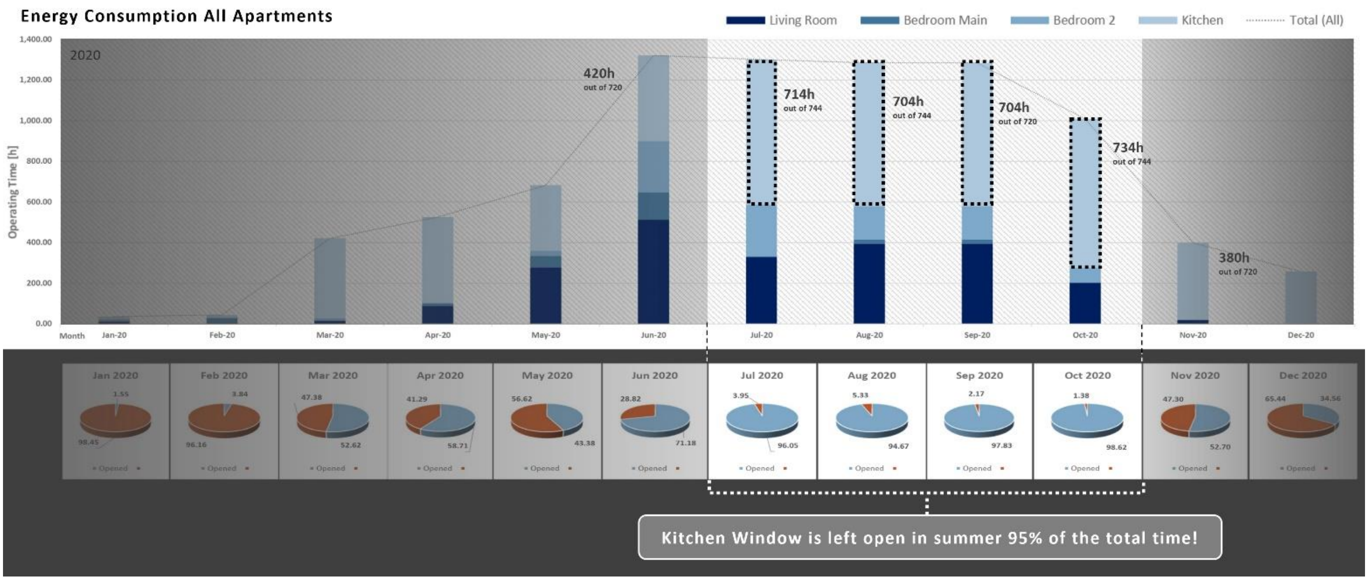




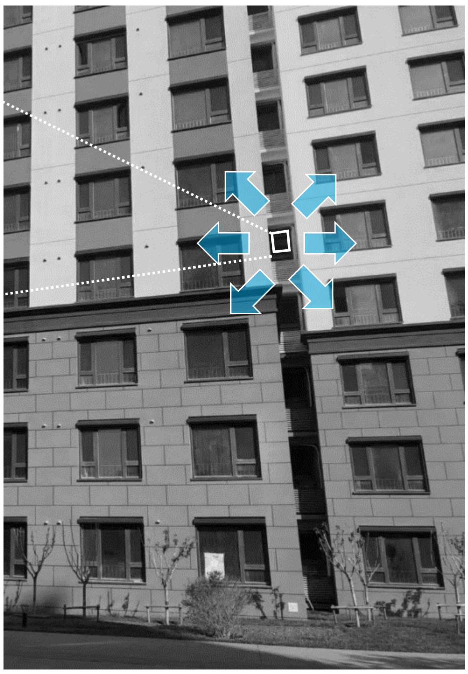
6. Monitoring Results: User Behavior

User Behavior

Monitoring of the times windows were opened reveals, that over hot and humid summer months kitchen windows were left open 95% of the time.



Effect of typical user behavior illustrated on real-life images of kitchen interior and façade: creation of an approx. 1m2 permanent gap in each apartments' air-tightness envelope.



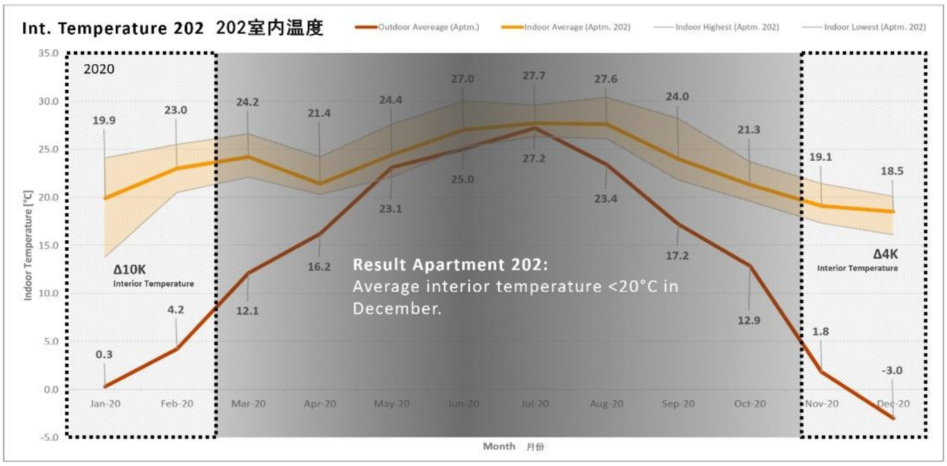
7. Monitoring Results: Winter

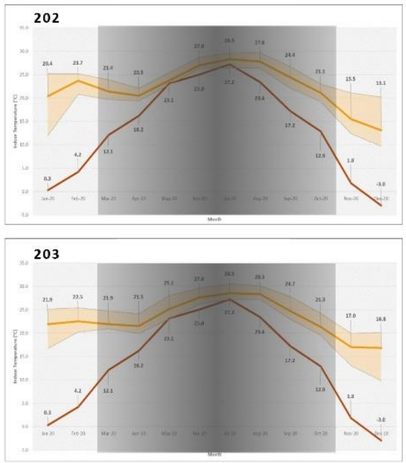
Occupant Feedback – Winter

Users reported this period as "very comfortable", although the average interior temperature fell below 20°C in December 2020.

Interior Temperature

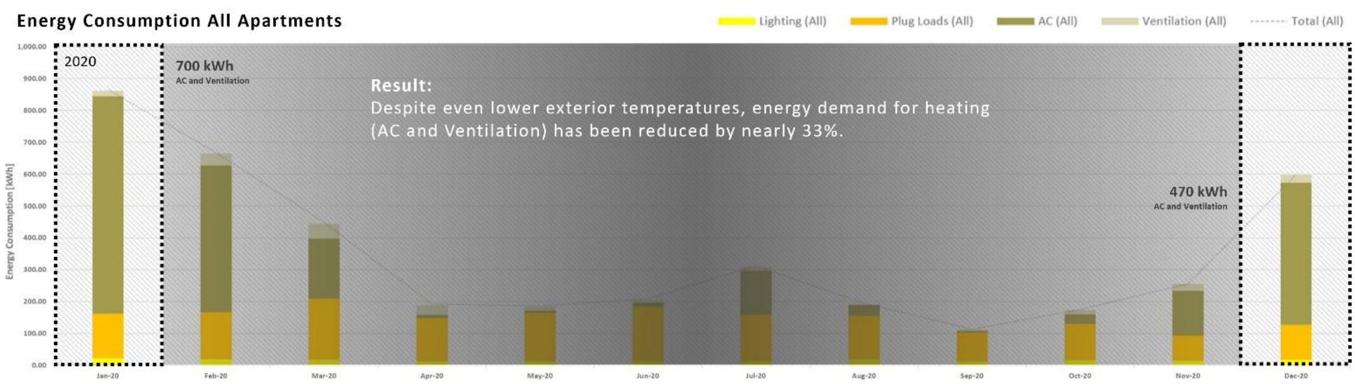
Low temperatures in December 2020 can be explained by ongoing construction work throughout the building (apartments sold and occupants moving in): GC crews left front door open for easier access.





Energy Consumption

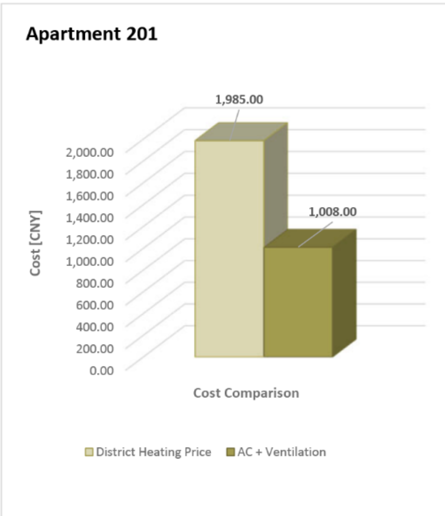
In December 2020 nearly 33% less energy was consumed for heating than in January 2020 (despite December being the colder month). Reasons include a generally better understanding and control of users of HVAC system (see also the tighter temperature curve above) but also the "break-in" period in January 2020, when the entire thermal envelope of the tower first had to be conditioned.

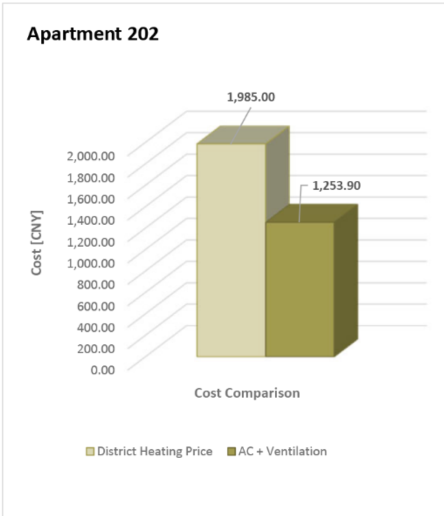


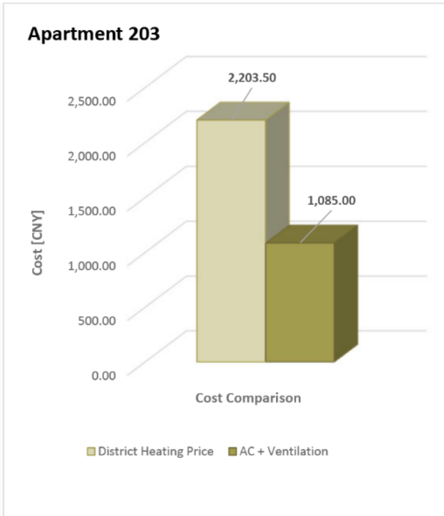
8. Monitoring Results: Cost Savings

The performance of the building envelope alone seems to provide a subjectively high comfort even when not formally matching the PH thermal comfort targets. Passive measures result in a drastically reduced overall cooling period.

In winter, the current savings can already be quantified and exemplify the success story of the Eco-City passive house project. When compared to the grid-supplied central heating residential buildings, as they are typical for Tianjin, related operation costs for energy were reduced 35-50% in the Eco-City Passive House Apartments in winter, more than 45% savings on average over all three test apartments.

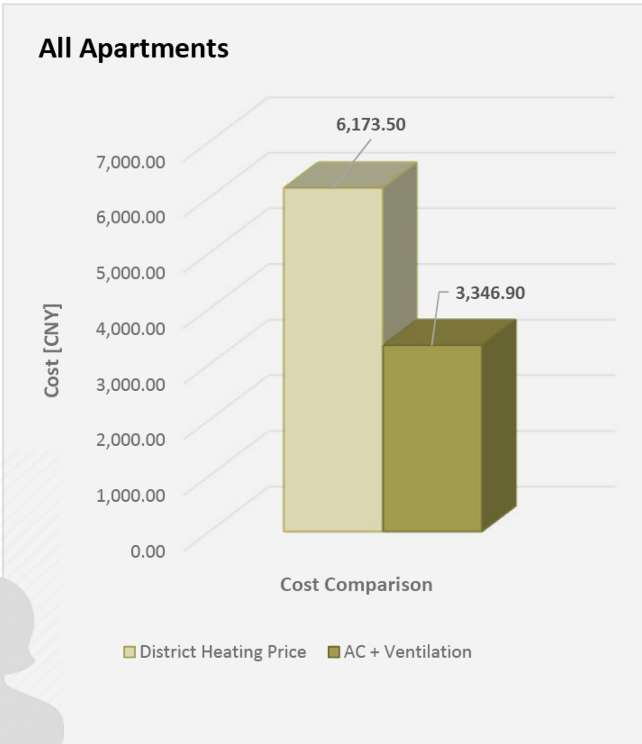






Result:

Operational Cost Savings for heating of >45% in Winter



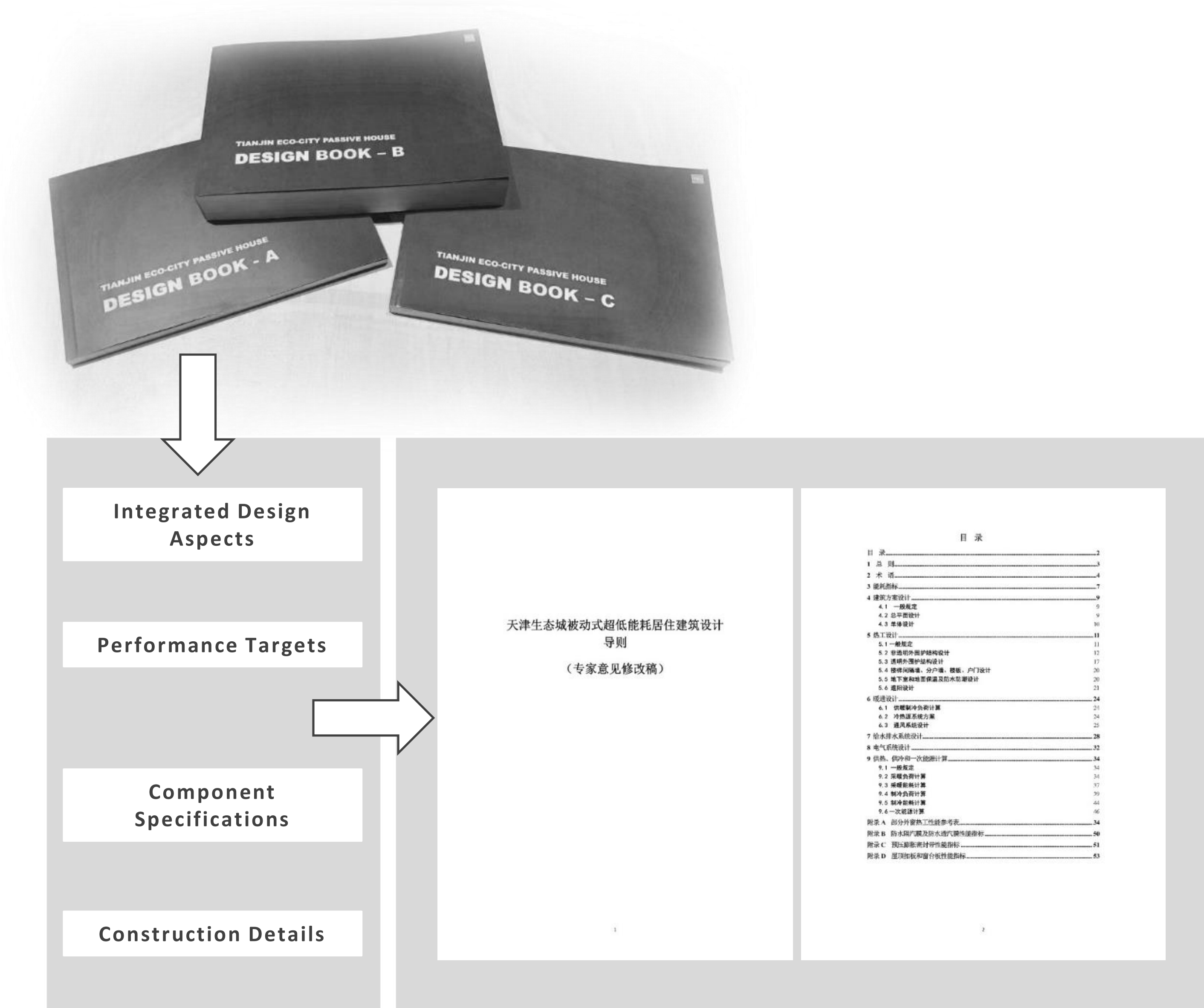
9. Replicability: Eco-City Guideline

Construction details, components and performance aspects developed in this project have formed the basis for the “Eco-City Green Building Guideline”. This will act as a best practice catalogue for up to 25 million square meters GFA still to be developed in the Eco-City.

A key point the guideline makes is that any actual, concrete project proposal should be based on an integrated design approach, taking into account smart design decisions balancing technical performance and construction cost.

While the guideline follows the principal intent and logic of the Passive House, key definitions of building critical construction elements (e.g. thermal bridges) are based on already available Chinese standards (e.g. 《Passive Way and Low Energy Green Building Guideline（Trial）》) .

The guideline extends to both, new-built and retro-fit projects focusing – but not limited to – the Tianjin Eco-City development area.



10. Replicability: Eco-City Guideline Specifications

While the guideline sets best practice standards for envelope components derived from the Tianjin Passive House Towers specifications, it also emphasizes the lessons learned in the process of design and realization, namely:

- Advocating "Performance Based Design" stressing optimization of cost neutral design parameters such as building geometry, AV ration, window/wall ratio and shading
- Setting-up an Integrated Consulting Team, communication structure and decision-making process
- Conducting variant comparisons and quantifiable calculation / simulation starting at earliest design stage
- Avoiding unnecessary complexity: keep a neat geometry and allow floor-to-floor height of 3m for technical systems

Building Component	Project	Eco-City Guideline		
Annual Heating Demand [kWh/m²a]	12.51	≤15		
Annual Cooling Demand [kWh/m²a]	17.51	≤16.25		
Building Air-Tightness [n50]	0.20	≤0.6		
G-Value	0.48	East/West ≤0.35	South 0.4-0.7	North ≤0.3
U-Value Windows [W/m²K]	0.67	≤ 1.00		
U-Value Walls [W/m²K]	0.13	0.15 to 0.25		
U-Value Roof [W/m²K]	0.13 / 0.14	0.15 to 0.25		
U-Value Baseplate [W/m²K]	0.13 / 0.14	0.15 to 0.25		
Insulation Layer	240mm, λ=0,32	High Quality, low λ-Value, no gaps		
Thermal Bridges	Slab Separation	Manage by slab separation or wrap		
Windows	PH Standard	In Insulation pane, air-tight class 8, shading		
Shading	designPH	Consider / quantify natural shading		
Parametric Design	PHPP/designPH	Use simulations to quantify during design		

11.a. PHPP-Results Building #4

Passive House Verification

Building:	Xinyuan No.4 Building
Street:	Hechang Road, Zhongxin Eco-City
Postcode/City:	300450
Province/Country:	Tianjin / CN-China
Building type:	Residential High-rise
Climate data set:	CN0013a-Tianjin
Climate zone:	3: Cool-temperate — Altitude of location: 5 m
Home owner / Client:	Tianjin Eco City Public Housing Construction Ltd.
Street:	Hechang Road, Zhongxin Eco-City
Postcode/City:	300450
Province/Country:	Tianjin / CN-China

Architecture:	Tianjin Architectural Design Institute (LDI)	Mechanical engineer:	Tianjin Architectural Design Institute (LDI)
Street:	95 Qixiangtai Road, Hexi District	Street:	95 Qixiangtai Road, Hexi District
Postcode/City:	300074 Tianjin	Postcode/City:	300074 Tianjin
Province/Country:	Tianjin CN-China	Province/Country:	Tianjin CN-China
Energy consultancy:	SoftGrid (Shanghai) Co., Ltd. + PHI - Germany	Certification:	Passivhaus Institut Dr. Wolfgang Feist
Street:	200 Taikang Road, Building 1, Unit 401	Street:	Rheinstr. 44/46
Postcode/City:	200025 Shanghai	Postcode/City:	64283 Darmstadt
Province/Country:	Shanhgai CN-China	Province/Country:	Hessen DE-Germany

Year of construction:	2019	Interior temperature winter [°C]:	20,0	Interior temp. summer [°C]:	25,0
No. of dwelling units:	44	Internal heat gains (IHG) heating case [W/m²]:	2,6	IHG cooling case [W/m²]:	2,6
No. of occupants:	102,0	Specific capacity [Wh/K per m² TFA]:	180	Mechanical cooling:	x

Specific building characteristics with reference to the treated floor area

					Criteria	Alternative criteria	Fullfilled?[2]
	Treated floor area	m²	4227				
Space heating	Heating demand	kWh/(m²a)	14	≤	15	-	yes
	Heating load	W/m²	10	≤	-	10	
Space cooling	Cooling & dehum. demand	kWh/(m²a)	18	≤	20	20	yes
	Cooling load	W/m²	8	≤	-	11	
	Frequency of overheating (> 25 °C)	%	-	≤	-		-
	Frequency of excessively high humidity (> 12 g/kg)	%	4	≤	10		yes
Airtightness	Pressurization test result n_{50}	1/h	0,24	≤	0,6		yes
Non-renewable Primary Energy (PE)	PE demand	kWh/(m²a)	104	≤	-		-
Primary Energy Renewable (PER)	PER demand	kWh/(m²a)	62	≤	60	62	yes
	Generation of renewable energy (in relation to projected building footprint area)	kWh/(m²a)	34	≥	-	21	

[2] Empty field: Data missing; '-': No requirement

I confirm that the values given herein have been determined following the PHPP methodology and based on the characteristic values of the building. The PHPP calculations are attached to this verification.

Passive House Classic? yes

Task:	First name:	Surname:	Signature:
2-Certifier	Maria Chiara	Failla	

Certificate ID	Issued on:	City:
24422-24465_PHI_PH_20190927_MCF	27.09.19	Darmstadt

Building #4

11.b. PHPP-Results Building #5

Passive House Verification

Building:	Xinyuan No.5 Building
Street:	Hechang Road, Zhongxin Eco-City
Postcode/City:	300450
Province/Country:	Tianjin / CN-China
Building type:	Residential High-rise
Climate data set:	CN0013a-Tianjin
Climate zone:	3: Cool-temperate — Altitude of location: 5 m
Home owner / Client:	Tianjin Eco City Public Housing Construction Ltd.
Street:	Hechang Road, Zhongxin Eco-City
Postcode/City:	300450
Province/Country:	Tianjin / CN-China

Architecture:	Tianjin Architectural Design Institute (LDI)	**Mechanical engineer:**	Tianjin Architectural Design Institute (LDI)
Street:	95 Qixiangtai Road, Hexi District	Street:	95 Qixiangtai Road, Hexi District
Postcode/City:	300074 Tianjin	Postcode/City:	300074 Tianjin
Province/Country:	Tianjin / CN-China	Province/Country:	Tianjin / CN-China
Energy consultancy:	SoftGrid (Shanghai) Co., Ltd. + PHI - Germany	**Certification:**	Passivhaus Institut Dr. Wolfgang Feist
Street:	200 Taikang Road, Building 1, Unit 401	Street:	Rheinstr. 44/46
Postcode/City:	200025 Shanghai	Postcode/City:	64283 Darmstadt
Province/Country:	Shanghai / CN-China	Province/Country:	Hessen / DE-Germany

Year of construction:	2019	Interior temperature winter [°C]:	20,0	Interior temp. summer [°C]:	25,0
No. of dwelling units:	59	Internal heat gains (IHG) heating case [W/m²]:	2,7	IHG cooling case [W/m²]:	2,7
No. of occupants:	125,4	Specific capacity [Wh/K per m² TFA]:	180	Mechanical cooling:	x

Specific building characteristics with reference to the treated floor area

		Unit	Value		Criteria	Alternative criteria	Fullfilled?[2]
	Treated floor area	m²	5021				
Space heating	Heating demand	kWh/(m²a)	12	≤	15	-	yes
	Heating load	W/m²	9	≤	-	10	
Space cooling	Cooling & dehum. demand	kWh/(m²a)	18	≤	20	20	yes
	Cooling load	W/m²	8	≤	-	11	
	Frequency of overheating (> 25 °C)	%	-	≤	-		-
	Frequency of excessively high humidity (> 12 g/kg)	%	4	≤	10		yes
Airtightness	Pressurization test result n_{50}	1/h	0,2	≤	0,6		yes
Non-renewable Primary Energy (PE)	PE demand	kWh/(m²a)	104	≤	-		-
Primary Energy Renewable (PER)	PER demand	kWh/(m²a)	63	≤	60	63	yes
	Generation of renewable energy (in relation to projected building footprint area)	kWh/(m²a)	43	≥	-	35	

[2] Empty field: Data missing; '-': No requirement

I confirm that the values given herein have been determined following the PHPP methodology and based on the characteristic values of the building. The PHPP calculations are attached to this verification.

Passive House Classic? yes

Task:	First name:	Surname:	Signature:
2-Certifier	Maria Chiara	Failla	
Certificate ID	**Issued on:**	**City:**	
24466-24524_PHI_PH_20190927_MCF	27.09.19	Darmstadt	

Building #5