ANNEX 80

EBC
Energy in Building and Communities Programme

International Energy Agency

Resilient Cooling of Buildings – Midterm Report (Annex 80)

Energy in Buildings and Communities Technology Collaboration Programme

April 2024

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Published by Institute of Building Research & Innovation ZT GmbH, Wipplingerstraße 23/3, 1010 Vienna Austria.

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DOI: 10.52776/MLGU9719

Participating countries in the EBC TCP: Australia, Austria, Belgium, Brazil, Canada, P.R. China, Czech Republic, Denmark, Finland, France, Germany, Ireland, Italy, Japan, Republic of Korea, the Netherlands, New Zealand, Norway, Portugal, Singapore, Spain, Sweden, Switzerland, Turkey, United Kingdom and the United States of America.

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Preface

The International Energy Agency

The International Energy Agency (IEA) was established in 1974 within the framework of the Organisation for Economic Co-operation and Development (OECD) to implement an international energy programme. A basic aim of the IEA is to foster international co-operation among the 30 IEA participating countries and to increase energy security through energy research, development and demonstration in the fields of technologies for energy efficiency and renewable energy sources.

The IEA Energy in Buildings and Communities Programme

The IEA co-ordinates international energy research and development (R&D) activities through a comprehensive portfolio of Technology Collaboration Programmes (TCPs). The mission of the IEA Energy in Buildings and Communities (IEA EBC) TCP is to support the acceleration of the transformation of the built environment towards more energy efficient and sustainable buildings and communities, by the development and dissemination of knowledge, technologies and processes and other solutions through international collaborative research and open innovation. (Until 2013, the IEA EBC Programme was known as the IEA Energy Conservation in Buildings and Community Systems Programme, ECBCS.)
The high priority research themes in the EBC Strategic Plan 2019-2024 are based on research drivers, national programmes within the EBC participating countries, the Future Buildings Forum (FBF) Think Tank Workshop held in Singapore in October 2017 and a Strategy Planning Workshop held at the EBC Executive Committee Meeting in November 2017. The research themes represent a collective input of the Executive Committee members and Operating Agents to exploit technological and other opportunities to save energy in the buildings sector, and to remove technical obstacles to market penetration of new energy technologies, systems and processes. Future EBC collaborative research and innovation work should have its focus on these themes.
At the Strategy Planning Workshop in 2017, some 40 research themes were developed. From those 40 themes, 10 themes of special high priority have been extracted, taking into consideration a score that was given to each theme at the workshop. The 10 high priority themes can be separated in two types namely 'Objectives' and 'Means'. These two groups are distinguished for a better understanding of the different themes.

Objectives - The strategic objectives of the EBC TCP are as follows:

- reinforcing the technical and economic basis for refurbishment of existing buildings, including financing, engagement of stakeholders and promotion of co-benefits;
- improvement of planning, construction and management processes to reduce the performance gap between design stage assessments and real-world operation;
- the creation of 'low tech', robust and affordable technologies;
- the further development of energy efficient cooling in hot and humid, or dry climates, avoiding mechanical cooling if possible;
- the creation of holistic solution sets for district level systems taking into account energy grids, overall performance, business models, engagement of stakeholders, and transport energy system implications.

Means - The strategic objectives of the EBC TCP will be achieved by the means listed below:

- the creation of tools for supporting design and construction through to operations and maintenance, including building energy standards and life cycle analysis (LCA);
- benefitting from 'living labs' to provide experience of and overcome barriers to adoption of energy efficiency measures;
- improving smart control of building services technical installations, including occupant and operator interfaces;
- addressing data issues in buildings, including non-intrusive and secure data collection;
- the development of building information modelling (BIM) as a game changer, from design and construction through to operations and maintenance.

The themes in both groups can be the subject for new Annexes, but what distinguishes them is that the 'objectives' themes are final goals or solutions (or part of) for an energy efficient built environment, while the 'means' themes are instruments or enablers to reach such a goal. These themes are explained in more detail in the EBC Strategic Plan 2019-2024.

The Executive Committee

Overall control of the IEA EBC Programme is maintained by an Executive Committee, which not only monitors existing projects, but also identifies new strategic areas in which collaborative efforts may be beneficial. As the Programme is based on a contract with the IEA, the projects are legally established as Annexes to the IEA EBC Implementing Agreement. At the present time, the following

projects have been initiated by the IEA EBC Executive Committee, with completed projects identified by (*) and joint projects with the IEA Solar Heating and Cooling Technology Collaboration Programme by (☼):

Annex 1: Load Energy Determination of Buildings (*)
Annex 2: Ekistics and Advanced Community Energy Systems (*)
Annex 3: Energy Conservation in Residential Buildings (*)
Annex 4: Glasgow Commercial Building Monitoring (*)
Annex 5: Air Infiltration and Ventilation Centre
Annex 6: Energy Systems and Design of Communities (*)
Annex 7: Local Government Energy Planning (*)
Annex 8: Inhabitants Behaviour with Regard to Ventilation (*)
Annex 9: Minimum Ventilation Rates (*)
Annex 10: Building HVAC System Simulation (*)
Annex 11: Energy Auditing (*)
Annex 12: Windows and Fenestration (*)
Annex 13: Energy Management in Hospitals (*)
Annex 14: Condensation and Energy (*)
Annex 15: Energy Efficiency in Schools (*)
Annex 16: BEMS 1- User Interfaces and System Integration (*)
Annex 17: BEMS 2- Evaluation and Emulation Techniques (*)
Annex 18: Demand Controlled Ventilation Systems (*)
Annex 19: Low Slope Roof Systems (*)
Annex 20: Air Flow Patterns within Buildings (*)
Annex 21: Thermal Modelling (*)
Annex 22: Energy Efficient Communities (*)
Annex 23: Multi Zone Air Flow Modelling (COMIS) (*)
Annex 24: Heat, Air and Moisture Transfer in Envelopes (*)
Annex 25: Real time HVAC Simulation (*)
Annex 26: Energy Efficient Ventilation of Large Enclosures (*)
Annex 27: Evaluation and Demonstration of Domestic Ventilation Systems (*)
Annex 28: Low Energy Cooling Systems (*)
Annex 29: ☼ Daylight in Buildings (*)
Annex 30: Bringing Simulation to Application (*)
Annex 31: Energy-Related Environmental Impact of Buildings (*)
Annex 32: Integral Building Envelope Performance Assessment (*)
Annex 33: Advanced Local Energy Planning (*)
Annex 34: Computer-Aided Evaluation of HVAC System Performance (*)
Annex 35: Design of Energy Efficient Hybrid Ventilation (HYBVENT) (*)
Annex 36: Retrofitting of Educational Buildings (*)
Annex 37: Low Exergy Systems for Heating and Cooling of Buildings (LowEx) (*)
Annex 38: ☼ Solar Sustainable Housing (*)
Annex 39: High Performance Insulation Systems (*)
Annex 40: Building Commissioning to Improve Energy Performance (*)
Annex 41: Whole Building Heat, Air and Moisture Response (MOIST-ENG) (*)
Annex 42: The Simulation of Building-Integrated Fuel Cell and Other Cogeneration Systems (FC+COGEN-SIM) (*)
Annex 43: ☼ Testing and Validation of Building Energy Simulation Tools (*)
Annex 44: Integrating Environmentally Responsive Elements in Buildings (*)
Annex 45: Energy Efficient Electric Lighting for Buildings (*)
Annex 46: Holistic Assessment Tool-kit on Energy Efficient Retrofit Measures for Government Buildings (EnERGo) (*)
Annex 47: Cost-Effective Commissioning for Existing and Low Energy Buildings (*)
Annex 48: Heat Pumping and Reversible Air Conditioning (*)
Annex 49: Low Exergy Systems for High Performance Buildings and Communities (*)
Annex 50: Prefabricated Systems for Low Energy Renovation of Residential Buildings (*)
Annex 51: Energy Efficient Communities (*)
Annex 52: ☼ Towards Net Zero Energy Solar Buildings (*)
Annex 53: Total Energy Use in Buildings: Analysis and Evaluation Methods (*)
Annex 54: Integration of Micro-Generation and Related Energy Technologies in Buildings (*)
Annex 55: Reliability of Energy Efficient Building Retrofitting - Probability Assessment of Performance and Cost (RAP-RETRO) (*)
Annex 56: Cost Effective Energy and CO2 Emissions Optimization in Building Renovation (*)
Annex 57: Evaluation of Embodied Energy and CO2 Equivalent Emissions for Building Construction (*)

Annex 58: Reliable Building Energy Performance Characterisation Based on Full Scale Dynamic Measurements (*)
Annex 59: High Temperature Cooling and Low Temperature Heating in Buildings (*)
Annex 60: New Generation Computational Tools for Building and Community Energy Systems (*)
Annex 61: Business and Technical Concepts for Deep Energy Retrofit of Public Buildings (*)
Annex 62: Ventilative Cooling (*)
Annex 63: Implementation of Energy Strategies in Communities (*)
Annex 64: LowEx Communities - Optimised Performance of Energy Supply Systems with Exergy Principles (*)
Annex 65: Long-Term Performance of Super-Insulating Materials in Building Components and Systems (*)
Annex 66: Definition and Simulation of Occupant Behavior in Buildings (*)
Annex 67: Energy Flexible Buildings (*)
Annex 68: Indoor Air Quality Design and Control in Low Energy Residential Buildings (*)
Annex 69: Strategy and Practice of Adaptive Thermal Comfort in Low Energy Buildings
Annex 70: Energy Epidemiology: Analysis of Real Building Energy Use at Scale
Annex 71: Building Energy Performance Assessment Based on In-situ Measurements
Annex 72: Assessing Life Cycle Related Environmental Impacts Caused by Buildings
Annex 73: Towards Net Zero Energy Resilient Public Communities
Annex 74: Competition and Living Lab Platform
Annex 75: Cost-effective Building Renovation at District Level Combining Energy Efficiency and Renewables
Annex 76: ☼ Deep Renovation of Historic Buildings Towards Lowest Possible Energy Demand and CO_2 Emissions
Annex 77: ☼ Integrated Solutions for Daylight and Electric Lighting
Annex 78: Supplementing Ventilation with Gas-phase Air Cleaning, Implementation and Energy Implications
Annex 79: Occupant-Centric Building Design and Operation
Annex 80: Resilient Cooling
Annex 81: Data-Driven Smart Buildings
Annex 82: Energy Flexible Buildings Towards Resilient Low Carbon Energy Systems
Annex 83: Positive Energy Districts
Annex 84: Demand Management of Buildings in Thermal Networks
Annex 85: Indirect Evaporative Cooling
Annex 86: Energy Efficient Indoor Air Quality Management in Residential Buildings
Annex 87: Energy and Indoor Environmental Quality Performance of Personalised Environmental Control Systems
Annex 88: Evaluation and Demonstration of Actual Energy Efficiency of Heat Pump Systems in Buildings
Annex 89: Ways to Implement Net-zero Whole Life Carbon Buildings
Annex 90: EBC Annex 90 / SHC Task 70 Low Carbon, High Comfort Integrated Lighting
Annex 91: Open BIM for Energy Efficient Buildings
Annex 92: Smart Materials for Energy-Efficient Heating, Cooling and IAQ Control in Residential Buildings

Working Group - Energy Efficiency in Educational Buildings (*)
Working Group - Indicators of Energy Efficiency in Cold Climate Buildings (*)
Working Group - Annex 36 Extension: The Energy Concept Adviser (*)
Working Group - HVAC Energy Calculation Methodologies for Non-residential Buildings (*)
Working Group - Cities and Communities
Working Group - Building Energy Codes

Introduction and Summary

This midterm report sums up the developments of Annex 80 between October 2019 and July 2021. Commencing with an initial Expert Meeting held in person in Vienna, Austria, subsequent work efforts by the Operating Agent (OA) and its team included conference calls and the second through fourth Expert Meetings which were held online due to the COVID-19 pandemic. 75 participants from 17 countries and 36 institutions actively took part in the fourth Expert Meeting. 22 institutions confirmed their participation with official letters in the first half of the Annex working phase.

The formation of a common understanding of concepts and definitions of resilience was the focus of the group during the first period of the Annex. Members with different scientific backgrounds developed an understanding of and discussed various approaches to resilience in relation to the cooling of buildings. They published their findings in three peer reviewed journal papers: (1) “Resilient cooling of buildings to protect against heat waves and power outages: Key concepts and definition” by Attia et al., (2) “Conceptualising a resilient cooling system: A socio-technical approach” et al. and (3) “Resilient cooling strategies – A critical review and qualitative assessment” by Zhang et al. . Another focus of the Annex to date has been the development of a framework for assessing cooling technologies (the production of such a framework is a core objective of the Annex generally). The team of experts have thus far established a central question of “Resilience against what?” as a guide the in the creation of this framework. Execution on the development of the framework will be a focus of the remaining project period.

Annex members have investigated several disruptions and shocks that are addressed by resilience. The group identified two major threats for the cooling of buildings: extreme heat events and power outages. Others such as extreme rain events, flooding, landslides, or storms influence the built environment too but are not as strongly connected to the cooling of buildings and therefore, Annex members have decided not to address these disruptions. This identification of threats consequently led to the development of a concrete and consistent groundwork for further evaluation. Different task groups were set up to define thermal boundary conditions, to generate future weather files and to compile key performance indicators for the assessment of cooling technologies through dynamic simulations. This division of work was successful in fostering cooperation between scientists across subtasks and produced outcomes viable for further research. Each subtask’s activities are presented in the following paragraphs. The groups summarized their results and published short technical reports. The weather data task group are planning to publish their methodology and results as scientific paper (which takes more time and effort than a technical report and will therefore come in the future).

Subtask Descriptions

Subtask A Fundamentals defines resilience for building cooling by assessing a wide range of disciplines, strategies of disaster risk management and resilience measures. Appropriate KPIs are developed within Subtask A to evaluate the resilience of cooling systems using a holistic approach. This holistic approach includes economic and technical criteria (e.g. life cycle cost effectiveness, technical life span, energy efficiency), environmental impacts (e.g. effects on urban heat islands, local air pollution), cultural and social aspects (e.g. affordability, usability, availability) and ecological impacts (e.g. carbon intensity, climate warming potential. A key aspect of this work assembles and synthesises current knowledge and evidence bases and involves intensive collaboration and exchange of information between the participating institutions and countries. The subtask is divided into three research activities and strongly involved in the task groups “Resilient Cooling Definition Task Group”, “Thermal Conditions” and “Key Performance Indicators”

which have been established. At the second Expert Meeting, a discussion was had on renaming Subtask A “Fundamentals” instead of its original name “Impact Assessment”. A broad consensus was found that this new wording reflects the subtask’s work better. The adaptations and resulting shifts of responsibilities amongst the subtask are reported in more detail throughout this report.

Subtask B Solutions systematically assesses the benefits, limitations, and performance indicators of various resilient cooling solutions. Identifying barriers as well as conducive conditions for the implementation of the proposed solutions is also within the subtasks scope of work. The subtask provides guidelines for the integration of resilient cooling systems in existing and new energy performance calculation methods as well as indoor comfort prediction methods. Subtask B carries out specific R&D towards new development and improvement of resilient cooling/overheating protection solutions. It extends the boundaries of existing low energy and low carbon cooling solutions and develops new solutions, combinations of technologies and applications. Subtask B is integrated with specific national R&D projects whose work includes methodological approaches such as numeric modelling and measurements on lab scale and prototype scale. Given that many countries have specific climatic and other contextual interests, Subtask B covers research topics that are both internationally relevant and nationally specific. It covers a broad variety of research topics and research methodologies, leveraging the specific research priorities and capabilities of the Annex participants. Its findings shall be published in scientific journals such as Energy and Buildings’ special issue on Building Cooling for Sustainable Societies. Preliminary results will be published in the State-of-the-Art-Review (SOTAR). Furthermore, Subtask B is coordinating more than 40 national research projects in several countries that are all relevant to the improvement of cooling systems. Furthermore, the findings are documented in Technology Profiles, which were originally intended for Subtask A but were then shifted to Subtask B.

Subtask C Field Studies showcases the opportunities and benefits of resilient cooling through analysis and evaluation of well-documented applications of low energy and low carbon resilient cooling technologies. Field studies are used to analyse and monitor examples of specific technologies and solutions. The subtask examines the quoted performance gap of existing cooling applications as well as their real performance in situ, with special attention paid to socio-technological interactions and control strategies. The outcomes of Subtask C will illustrate and support the Technology Profiles developed in Subtask B. Subtask C is strongly involved in the work of the “Key Performance Indicators Task Group”. Furthermore, Subtask C is coordinating around 15 case study projects that are related to the monitoring of cooling systems. A draft of its final report format has been presented at the second Expert Meeting in April 2020.

Subtask D Policy Actions deals with policy related endeavours to promote energy efficiency and resilience in cooling. This subtask analyses product labelling programmes, AC minimum energy performance standards (MEPs), building regulations, standard and compliance requirements, and identification of international best practice examples and potential barriers. The main goal of Subtask D is to develop recommendations for future regulatory policies to support the implementation and mainstreaming of resilient cooling systems on a national, European, and international levels. In that sense, Subtask D strives to represent a toehold for international programmes. One of the initial objectives of Subtask D was to set frameworks for Demand Side Management (DSM) which proved to not be feasible without extensive basic research that exceeded the scope of this Annex. At the end of October 2020, management and lead of Subtask D were taken over by the Annex attending team from Lawrence Berkeley National Laboratory, namely Ronnen Levinson and Haley Gilbert. Bjarne Olesen pledged to support the group as a senior advisor and other teams guaranteed their support. A new roadmap for the completion of subtask activities has been set up and is being executed.

Task Group Descriptions and Current Status

The following task groups have been established to work on the above subtask overarching topics of the Annex:

- **Weather Data Task Group**, has created TMY weather files and performed heat wave assessments of three time periods (2001-2021, 2041-2061, 2081-2101). Results will officially be published in a journal paper in the second term half of the Annex.
- **Thermal Conditions Task Group**, has completed its work and published its report on the definition of boundary conditions for cooling technology assessments.

  Attia, S., Rahif, R., Corrado, V., Levinson, R., Laouadi, A., Wang, L., Sodagar, B., Machard, A., Gupta, R., Olesen, B., Zinzi, M., & Hamdy, M. (2021). Framework to evaluate the resilience of different cooling technologies. Liege, Belgium: Sustainable Building Design Lab. doi:10.13140/RG.2.2.33998.59208
- **Key Performance Indicators Task Group**, has created a basic set of KPIs relevant for resilient cooling technologies. It will include metrics for IEQ, energy, HVAC and the supply Grid.
- **Resilience Definition Task Group**, has completed its task and is currently on stand-by. In order to create a definition of resilience in the context of the Annex, which will also be used as the starting point for all considerations in the further course of the project, this task group was set up, which strongly supported Subtask A.
- **Dynamic Simulation Task Group** has been established to carry out cooling technology assessment and create technology profiles.

  Zhang, C., Kazanci, O. B., Attia, S., Levinson, R., Lee, S. H., Holzer, P., Salvatif, A., Machard, A., Pourabdollahtootkaboni, M., Gaur, A., Olesen, B. W., & Heiselberg, P. (2021). IEA EBC Annex 80 - Dynamic simulation guideline for the performance testing of resilient cooling strategies. Aalborg University.

Further Notes

The OA launched the Annex 80 Lecture Series to provide a platform to informally exchange knowledge during the time of the pandemic. Once a month, a specific topic is presented by a team of participants and discussed by the group. Recordings are made available on the EBC fileserver (http://files.iea-ebc.org/). The first lecture on borehole heat exchangers, relevant for Natural Heat Sinks, was held by the OA in October 2020.

The Annex text has been updated according to the programme development and has been submitted to the Executive Committee for approval. The State-of-the-Art-Review (SOTAR) has been internally reviewed and submitted to the ExCo.

Together with the Air Infiltration and Ventilation Centre (AIVC) a platform for regular exchange between Annex 80 scientists and practitioners was established. It targets industry, interest groups, and planners, and is designed to both disseminate Annex outcomes and receive feedback from outside the academic world. This “Advisory Board of Practitioners of Resilient Cooling” held its first meeting in March 2021. It had been very well attended and three further meetings have been scheduled.

Publications

Three papers have been published:

1. Miller, W., Machard, A., Bozonnet, E., Yoon, N., Qi, D., Zhang, C., Liu, A., Sengupta, A., Akander, J., Hayati, A., Cehlin, M., Kazanci, O. B., & Levinson, R. (2021). Conceptualising a resilient cooling system: A socio-technical approach. City and Environment Interactions, 11, 100065. https://doi.org/10.1016/j.cacint.2021.100065

2. Attia, S., Levinson, R., Ndongo, E., Holzer, P., Berk Kazanci, O., Homaei, S., Zhang, C., Olesen, B. W., Qi, D., Hamdy, M., & Heiselberg, P. (2021). Resilient cooling of buildings to protect against heat waves and power outages: Key concepts and definition. Energy and Buildings, 239, 110869. https://doi.org/10.1016/j.enbuild.2021.110869

3. Zhang, C., Kazanci, O. B., Levinson, R., Heiselberg, P., Olesen, B. W., Chiesa, G., Sodagar, B., Ai, Z., Selkowitz, S., Zinzi, M., Mahdavi, A., Teufl, H., Kolokotroni, M., Salvati, A., Bozonnet, E., Chtioui, F., Salagnac, P., Rahif, R., Attia, S., … Zhang, G. (2021). Resilient cooling strategies – A critical review and qualitative assessment. Energy and Buildings, 251, 111312. https://doi.org/10.1016/j.enbuild.2021.111312

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Abbreviations

Abbreviations	Meaning
AIVC	Air Infiltration and Ventilation Centre
AWD	Ambient Warmness Degree
DSM	Demand Side Management
ExCo	Executive Committee
IOD	Indoor Overheating Degree
LoN	Letters of National Participation
MEPs	Minimum energy performance standards
NRIs	National Research Items
OA	Operating Agent
SOTAR	State Of The Art Review
STA	Subtask A
STB	Subtask B
STC	Subtask C
STD	Subtask D
STL	Subtaskleader
TMY	Typical Meteorological Years

Project Management

Subtask Leadership and Co-Leadership

Annex 80 Subtask leaders as well as co-leaders have been affirmed as following:
Operating Agent: Peter Holzer (Institute of Building Research & Innovation, Austria)

Subtask A Fundamentals

Lead: Wendy Miller (Queensland University of Technology, Australia)
Co-Lead: Shady Attia (University of Liège, Belgium)

Subtask B Solutions

Lead: Chen Zhang (Aalborg University, Denmark)
Co-Lead: Ongun Kacanzi (Technical University of Denmark)

Subtask C Field Studies

Lead: Dahai Qi (Université de Sherbrooke, Canada)
Co-Lead: Gerhard Hofer (e7 Energie Markt Analyse GmbH, Austria)

Subtask D Policy Actions

Lead: After the 3rd Expert Meeting: Haley Gilbert and Ronnen Levinson (Lawrence Berkeley National Laboratory, USA)
Before: Peter Graham (Global Buildings Performance Network, Australia)

Mailing Lists

Mailing lists have been set up for the general communication:

All participants	Annex80@googlegroups.com
Subtask A (STA) participants	Annex80-subtask-a@googlegroups.com
Subtask B (STB) participants	Annex80-subtask-b@googlegroups.com
Subtask C (STC) participants	Annex80-subtask-c@googlegroups.com
Subtask D (STD) participants	Annex80-subtask-d@googlegroups.com

Data Structure and File Sharing

For the exchange of general and subtask specific files the IEA SHC file server is used. The following rules apply for this service:

1. The ISO code date format (YYYY-MM-DD), e.g.: 2019-10-21, is used as a prefix for all file names. This allows better comprehension of when a file has been created or altered.
2. The following indicators are used to indicate to which subtask the file relates:

   "Annex80" for general documents
   "STA" for Subtask A
   "STB" for Subtask B
   "STC" for Subtask C
   "STD" for Subtask D
3. Content of the file is indicated by a significant title and separated by a dash.

An appropriate title would therefore be: 2019-10-21_STA_Paper1a-Structure

1st Expert Meeting

The first Expert Meeting took place on the 21st and 22nd of October 2019 in Vienna, Austria.

Project Management Updates

The contact person for India's involvement was kept up to date about the proceedings of Annex 80.
The involvement of Mexico in the EBC Annex 80 was pending. Participation was strongly sought by José Roberto Garcia Chavez of Metropolitan Autonomous University Mexico City, Mexico, who repeatedly expressed his willingness to contribute to the Annex.
The involvement of Heriot Watt University Dubai, United Arab Emirates, was pending, but seemed unlikely. Participation through Heriot Watt University Edinburgh was another possibility which has not been advanced by the interested parties.
From Singapore Poh Seng Lee from National University of Singapore, Dep. of Mechanical Engineering has expressed interest earlier that year but has not renewed their interest. The probability of participation was assessed as low.

Discussed General Topics

Alteration of Annex Title

The limitation of the Annex scope to residential and small non-residential buildings has been questioned. The attending experts unanimously agreed on changing the title to discard this limitation. The change has been reported to and must be accepted by the Executive Committee.

Clarification of Resilient Cooling Fields of Technologies

The definition of Resilient Cooling Fields of Technologies as stated in the Annex 80 text has been discussed and clarified by the group of subtask leaders and OA. The new wording has been agreed upon as follows:

I. Reduce heat loads to people and indoor environments (this wording has been chosen to explicitly include thermal mass)
II. Remove sensible heat from indoor environments
III. Enhance personal comfort apart from space cooling
IV. Remove latent heat from indoor environments

Revision of Responsibilities of Subtasks, including Deliverables

The responsibilities of the Subtasks have been discussed and revised as follows:

Subtask A

I. Definition of resilience in terms of cooling
II. Development of resilient cooling qualities, criteria and key performance indicators (KPIs)
III. Interrelate resilient cooling to United Nations Sustainable Development Goals (SDGs)

Subtask B and Subtask C

I. Application of the qualities, criteria and KPIs developed by STA to technologies and system applications
II. Feedback to STA on applicability and possibly necessary revision

Subtask B

I. Systematic technology assessment and authorship of Technology Profile Sheets

Accordingly, the responsibilities for deliverables have been shifted between the Subtasks:

Resilient Cooling criteria set (new):	STA
Technology Profile Sheets:	Changed from STA to STB
Field Studies Report:	STC
Resilient Cooling Design and Operation Guidelines:	Changed from STA to STB and STC
Policy Actions Recommendation Report:	STD

State-of-the-Art-Review (SOTAR)

It was decided that the SOTAR will be published according to the Annex work plan by the end of June 2020. Three Annex papers had been under preparation, paper 1a (from STA), 1b (from STA) and 2 (from STB), which were going to feed into the SOTAR. They included a multidisciplinary review of ‘resilience’ within the context of overheating as well as a technological review of ‘resilient cooling of buildings’. The writing group for the SOTAR was led by the OA.

Weather Data Task Group

It has been discussed that the selection of (future) metrological boundary conditions is crucial for consistent assessments of resilient cooling technologies.
It has been agreed upon that a task group formed by Annex attendants will elaborate suggestions for a co-ordinated methodology/source for climate data sets, to represent/predict the effects of climate change and heat waves.
The following participants formed this task group and had to report their findings and suggestions to the group in the next expert meeting in April 2020:

- Agnese Salvati
- Anais Machard
- Hilde Breesch
- Mamak Tootkaboni
- Ronnen Levinson
- Shady Attia

Topical Sessions at Conferences

It was suggested by Bjarne Olesen that the Annex should seek to hold topical sessions at related conferences to gain valuable input as well as to disseminate Annex 80 findings (as has happened at the AIVC conference in Ghent 2019). The idea was well received. The following possible conferences were identified:

- ASHRAE conference in Austin USA on June 27th to July 1st 2020
- UNEP Conferences

Board of Industries

It has been decided that the Annex 80 should seek to keep a tight link to representatives of the cooling industry and cooling applicants. Therefore, the OA has established and further elaborated a platform for connecting the Annex with interest groups and relevant industry partners. This “board of industry” is intended to form a hub for bilateral exchange. The board allows Annex participants to get access to relevant studies from the industry and allows industry to get priority information about the Annex work and chances to join activities such as webinars. The linkage to partners from resilient cooling related industries was advanced by the OA. So far, institutions like REHVA, ES-SO and Venticool as well as companies such as Velux, Panasonic, Daikin, RENSON, WAREMA and Zehnder Group had already been contacted.

Lecture Series

During the course of Annex 80 a huge amount of knowledge has been generated by its members through international collaboration and national research. Due to the situation with solely remote
Expert Meetings exchange and transfer of knowledge has been limited.
The Annex 80 lecture series has been established to provide a platform for making this knowledge visible and easily accessible to all participants. The first lecture was held on October 7th, 2020, 8:00 pm (UTC).

Sessions are held once every month and take approximately 60 minutes. The dates for the next lectures have been set as following:

- Lecture 02 November 3rd 2020 03:00 am (UTC)
- Lecture 03 December 1st, 2020, 1:00 pm (UTC)
- Lecture 04 January 7th, 2021, 8:00 pm (UTC)
- Lecture 05 February 2nd, 2021, 03:00 pm (UTC)
- Lecture 06 March 2nd, 2021, 01:00 pm (UTC)
- Lecture 07 April 6th, 2021, 08:00 pm (UTC)

Definitions of Resilience / Resilient Buildings / Resilient Cooling

In order to develop a definition of resilience within the framework of the research project, the following existing definitions were presented and discussed.

Definition of Resilience by IPCC (2012)
The definition of Resilience, published by the IPCC in 2012:

"(…) the ability of a system and its component parts to anticipate, absorb, accommodate, or recover from the effects of hazardous events in a timely and efficient manner, including through ensuring the preservation, restoration, or improvement of its essential basic structures and functions."

Definition of Resilience by Bjarne Olesen (2019)
Bjarne Olesen, in his presentation at the international conference "Comfort at the Extremes" (CATE) 2019, Dubai, defined Resilience as either:

- the capacity to recover quickly from difficulties; *toughness*
- the ability of a substance or object to spring back into shape; *elasticity*
- an ability to recover from or adjust easily to misfortune or change
- the ability to be happy, successful, etc. again after something difficult or bad has happened
- the quality of being able to return quickly to a previous good condition after problems
- the ability to endure or bounce back quickly from adverse conditions
- When faced with a tragedy, natural disaster, health concern, relationship, work, or school problem, resilience is how well a person can adapt to the events in their life

Definition of Resilient Buildings by Per Heiselberg (2019)
Per Heiselberg delivered a definition of resilient buildings:

- Resilient buildings are defined as building designs that have a large ability to withstand/recover/mitigate /cope with foreseen and unforeseen changing conditions and maintain a certain service or functionality.
    - For example, future changes in outdoor climate or different building use in a resilient building will not result in large changes in energy use or in poor indoor environmental quality.
- Absorptive Capacity
    - To which degree a building is able to absorb the impacts of system perturbations and minimize consequences with little effort. For example, a heavy mass building can absorb a lot of solar energy on a sunny day and can minimize the temperature increase in the building without any use of cooling energy.
- Adaptive Capacity
    - The ability to adjust to undesirable situations by undergoing some changes. Adaptive capacity is distinguished from absorptive capacity in that adaptive systems change in response to adverse impacts, especially if the absorptive capacity has been exceeded. For example, solar shading in a façade will be activated, when the temperature in the space start to increase because the storage capacity of the thermal mass has been exceeded.
- Restorative Capacity
    - The ability to return to normal or improved operation.
- Recovery Capacity
    - The rapidity of the restorative capacity. For example, night cooling will be able to remove solar energy from the thermal mass during night time depending on the ventilation flow rate and outdoor temperature. A certain time period will be needed (recovery capacity). If conditions are unfavourable the thermal mass might not be cooled completely leading to a lower restorative capacity and the opposite if the weather conditions are favourable

Definition of Resilient Cooling, used in the Annex Text (2019)

Note that this definition was developed by the writing group of the Annex Text and delivered to the ExCo on 28th of May 2019. It therefore formed the basis of the ExCo's positive decision to start the Annex 80. Resilient cooling was defined as:
"The term of "Resilient Cooling" was deliberately chosen as name of the newly proposed Annex:
It centres the development of cooling solutions, which are not only efficient, affordable and climate-protective, but also robust and supportive in cases of extreme occurrences.
In the context of this Annex, Resilient Cooling is used to denote low energy and low carbon cooling solutions that strengthen the ability of individuals and our community as a whole to withstand, and also prevent, thermal and other impacts of changes in global and local climates; particularly with respect to increasing ambient temperatures and the increasing frequency and severity of heat waves."

Definition of Resilient Cooling by Peter Holzer (2019)
Peter Holzer delivered a definition of Resilient Cooling, using elements of Bjarne Olesen's presentation, which was shown by the OA in the Annex 80 presentation to the ExCo at the meeting in Ghent, June 2019.

Resilience definitions:
- Toughness: the capacity to withstand or recover quickly from difficulties
- Elasticity: the ability of a substance or object to spring back into shape

Against the background of:
- climate change, weather extremes, changes of physical outdoor conditions
- grid blackouts, other breakdowns in supply chains
- changes in economic and social conditions

Resilient cooling qualities:
- Reliability & Failure Safety
- Affordability & Accessibility
- Energy Efficiency & Carbon Neutrality
- Social Inclusiveness

Annex 80 Roadmap with Milestones

The Annex 80 Roadmap with milestones has been agreed upon as shown in the next image:

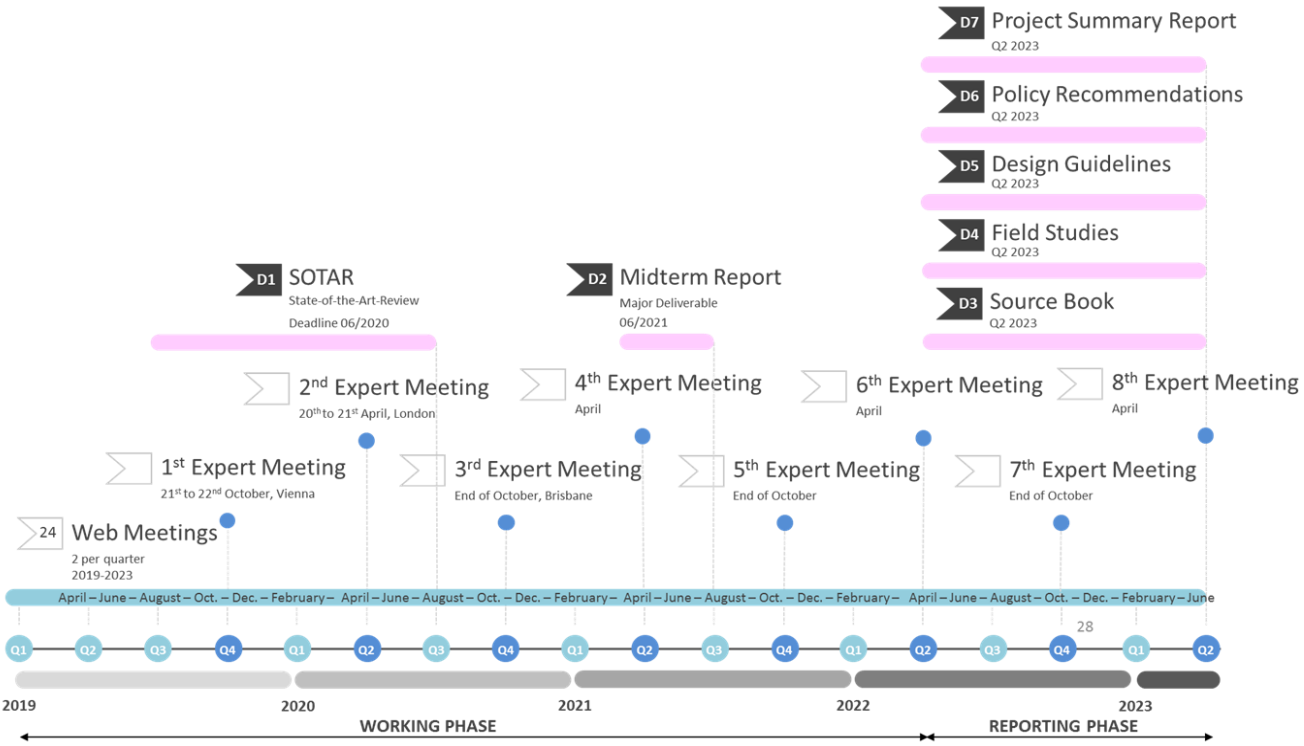

Figure 1: Annex 80 Roadmap with milestones

Subtask A

The work programme for STA was as follows:

A.1 Develop and test a comprehensive list of resilient cooling criteria and KPIs. A deadline was set for December 2019.

A.2 Write the SOTAR together with STB. A deadline was set for June 2020.

A.3 Write the Resilient Cooling Technology Profiles, with specific cooperation with other Technology Collaboration Programmes (TCPs) (SHC, Geothermal, Heat pumps). A deadline was set for June 2021.

Broadly summarized, the focus was laid on finalizing the scope, assigning contributors, establishing the process for the shared library and establishing processes and timelines for research work (collation, review, submission dates, finalisation dates, etc.). Within the STA breakout sessions, the dominating topic of discussion was the coordination of approaches towards a definition of resilience in the context of the Annex. It was agreed that this definition of resilience with regards to cooling is the core contribution of STA to the whole Annex 80, including the development of resilient cooling qualities, criteria and KPIs. A summary of the baseline has been presented by the Subtask A leader (STL-A) and can be found in the STA-presentation for the 1st Expert Meeting, available at the Annex 80 IEA file server.
It was further agreed to structure the work of STA within the development of three review papers. The composition of three papers and their contents has been agreed upon as follows:

Paper 1: Multidisciplinary review of 'resilience' within the context of overheating
This paper investigated definitions of resilience (resilience against …) in a wide range of scientific disciplines. It sought to derive principles, strategies, and patterns to provide resilience to people and communities to stay cool. Participants involved in STA volunteered to contribute according to their fields of expertise. Wendy Miller led the group of authors.
A deadline for contributions was set for December 13th, 2019.

Paper 2: Technological review of 'resilient cooling building' based on initial definition
Participants involved in STA volunteered to contribute according to their fields of expertise. Shady Attia led the group of authors together with a group of PhD students from Université de Liège. The outcome was a test of the initial definition and criteria on a building scale.
The deadline for the paper was set for the end of December 2019.

Paper 3: Resilient cooling definition
This paper delivered a resilient cooling definition (resilience/events) and indicators (descriptive quality, boundary conditions and performance indicators) in range of categories (Triple bottom line/sustainability approach, United Nations SDGs). Wendy Miller led the group of authors.
Contributions had to be submitted to Wendy Miller by the end of January 2020. Web meetings in February and March were held to evaluate and review the paper.
The deadline for the paper was set for the 2nd Expert Meeting in April 2020.

Subtask B

The work programme for STB were as follows:

B.1 Carry out specific research towards the extension of the range of situations where existing resilient cooling technologies and systems may be applied (e.g. with regard to building type, climate zones, occupancy characteristics, etc.), and develop new solutions, combinations of technologies and applications.

B.2 Examine user interaction issues and system control issues, including the impact of user behaviour on system performance.

Within the STB breakout sessions, the dominating topic of discussion was the coordination of the National Research Items (NRIs), of which 28 have been proposed up to this point. The NRIs have been structured according to the Resilient Cooling Fields of Technologies.
In accordance with this, it has been discussed and agreed upon that the generation of "Technology Profiles", formerly included in STA, be carried out by STB.
It was further agreed to structure the next steps of STB within the development of one review paper, "Resilient Cooling Solutions". Participants involved in STB volunteered to contribute according to their fields of expertise. 4 group leaders have been assigned to 4 technology groups. Chen Zhang and Ongun Kazanci led the group of authors.

The following schedule was set:

- Submission of KPIs to STBL by every participant, until November 30th, 2019
- Technology group leaders receive contributions (date was determined by group leaders)
- STBL receive compiled contributions until February 29th, 2020
- 1st draft until March 15th, 2020
- Final submission on June 30th, 2020

Subtask C

Within the STC breakout sessions, the dominating topic of discussion was the coordination of the case studies amongst the National Research Items (NRIs).
It was agreed to send a call for registration to the Annex attendants to name case studies, incorporated in the NRIs.
The following schedule was discussed and agreed upon.

- Registration forms by October 31st, 2019
- Sending proposals for KPIs (derived from expected monitoring data) for resilient cooling technologies to STLA and STLB by October 31st, 2019
- Definition of monitoring requirements for field studies until November 30th, 2019
- Overview of field studies and applied resilient cooling technologies until December 31st, 2019
- Development of questionnaire for building owners, facility managers, etc. The draft was scheduled by February 29th, 2020, the final version for end of May 2020.
- Start of analysis of case study projects on July 31st, 2020

Further steps decided upon by STC were the identification of performance gaps, writing the case studies report for this subtask and pass on experiences from the case studies to the guideline development in STB.

Subtask D

The Work Programme for STD was as follows:

D.1 Identify and spread best practice / worst failure in policy actions supportive to resilient cooling. The deadline was set for June 2022.
D.2 Cooperate with Mission Innovation #7. The deadline was set for June 2022.
D.3 Cooperate with KIGALI cooling efficiency programme. The deadline was set for June 2022.

The Subtask Leader of STD, Peter Graham, was not able to attend the Expert Meeting. The agenda of STD has thus only been briefly discussed.
It has been agreed that STD will host all Annex activities of cooperation with international programs.
At this point some have been identified and partly already approached:

- KIGALI-Cooling Efficiency Programme
- Sustainable Energy for All (SEforALL) organisation
- IEA EBC Working Group on standardisation (led by Takao Sawachi)

Peter Graham kept up these endeavours and reported at the next Expert Meeting.

Further Schedule

The next dates were scheduled as follows:

Meeting type	Location	Date	Recipients
STL Web Meeting 04	Web Meeting	2019-12-12, 22:00-23:00 (CET)	STL + Interested Parties
STL Web Meeting 05	Web Meeting	2020-02-06, 22:00-23:00 (CET)	STL + Interested Parties

Preparative Expert Web Meeting 03	Web Meeting	2020-04-14, 07:00–08:00 (CEST)	Those who cannot attend Expert Meeting
2nd Expert Meeting	Brunel University London (GBR)	2020-04-20/21	All participants

2nd Expert Meeting

The second Expert Meeting took place on the 20th and 21st of April 2020 as a remote meeting. Meeting in person at Brunel University, London (GBR) as scheduled was not possible due to the pandemic outbreak.

Project Management Updates

From National University of Singapore, Poh Seng Lee from the department of mechanical engineering renewed their interest to participate during a web meeting with the OA, initializing the process of Singapore becoming official Annex 80 member.

Mailing List

Invitations for mail lists have been sent out to concerned participants. Additionally, to the already existing mail lists the following mail lists have been set up:

Weather Data Task Group:	Annex80-tg-weatherdata@googlegroups.com
Thermal Conditions Task Group:	Annex80-tg-thermal-conditions@googlegroups.com
Criteria and KPI Task Group:	Annex80-tg-kpi@googlegroups.com

Reference Management

It was decided to use the free, cross-platform Zotero reference manager (https://zotero.org) to cite references in the manuscripts.

Discussed General Topics

Alteration of Subtask A Title to "Fundamentals"

During the first year of the Annex working phase the character of STA has changed. Its former core activity of systematic technology assessment has been shifted to STB. In exchange STA took over numerous activities forming the basis for the other subtasks, such as identifying criteria and defining resilience in the context of cooling. Thus, the initial title of "Impact Assessment" did not reflect its full scope anymore. The change of title to "Fundamentals" has been discussed and agreed upon. The change was reported to and accepted by the Executive Committee.

Alteration of Deliverables

The deliverables have changed according to the following table, which was reported to and accepted by the Executive Committee. The following table gives an overview of the adjusted deliverables:

Deliverable	Name	Audience	Responsibility
D1	State-of-the-Art-Review	- Research community and associates - Real Estate developers - Urban planning experts	OA, STA, STB, STC, STD

		- Policy makers	
D2	Midterm Report	- Research community and associates - IEA and EBC Programme	OA, STA, STB, STC, STD
D3	Technology Profiles	- Building component developers and manufacturers - Architects and design agencies - Engineering offices and consultants	STB
D4	Field Studies	- Building component developers and manufacturers - Architects and design agencies - Engineering offices and consultants - Real Estate developers	STC
D5	Design and Operation Guidelines	- Architects and design agencies - Engineering offices and consultants - Real Estate developers	STA, STB, STC
D6	Recommendations for policy actions, legislation, and standards	- Policy makers - Legal interest groups - Experts involved in building energy performance standards and regulation	STD
D7	Project Summary Report	- Research community and associates - IEA and EBC Programme - Real Estate developers - Policy makers	OA, STA, STB, STC, STD

State-of-the-Art-Review (SOTAR)

The SOTAR shall be published according to the Annex work plan by the end of June 2020. The OA presented its structure and scope as well as the team of authors:

Team Lead

- Peter Holzer, Institute of Building Research & Innovation

Team Members

- Zhengtao Ai, Hunan University
- Giacomo Chiesa, Politecnico Torino
- Per Heiselberg, Aalborg University5

- Ongun Kazanci, Technical University of Denmark
- Ronnen Levinson, Lawrence Berkeley National Laboratory
- Wendy Miller, Queensland University of Technology
- Behzad Sodagar, School of Architecture and the Built Environment Lincoln
- Philipp Stern, Institute of Building Research & Innovation
- Chen Zhang, Aalborg University

Structure

1 Preface, 2 pages, Peter Holzer Institute of Building Research & Innovation
2 Executive Summary, 5 pages, Peter Holzer Institute of Building Research & Innovation
3 The Cooling Challenge, 20 pages, Peter Holzer Institute of Building Research & Innovation
4 The Resilient Cooling Framework, 40 pages, Wendy Miller, Queensland University of Technology
5 Existing Technologies/Solutions of Resilient Cooling, 60 pages, Chen Zhang, Aalborg University, and Ongun Kazanci, Technical University of Denmark
6 Research and Development Needs, 20 pages, Per Heiselberg, Aalborg University
7 Acknowledgements, Peter and Philipp Stern, Institute of Building Research & Innovation
8 Annex Participants, Peter and Philipp Stern, Institute of Building Research & Innovation
9 Annex Description, Peter and Philipp Stern, Institute of Building Research & Innovation

Weather Data Task Group

Since the last expert meeting in October 2019 the group has been extended and several participants joined. It has been discussed and agreed upon to also implement the effects of urban heat islands which was taken on by a group of specialists of the task group. The following participants form this task group and reported to the group until the next expert meeting in November 2020.

Team Lead

- Anaïs Machard, La Rochelle Université
- Mamak Pourabdollahtootkaboni, Politecnico di Turino
- Agnese Salvati, Brunel University

Team Members

- Shady Attia, Liège University
- Ramin Rahif, Liège University
- Hilde Breesch, KU Leuven
- Delphine Ramon, KU Leuven
- Peter Holzer, Institute of Building Research & Innovation
- Philipp Stern, Institute of Building Research & Innovation
- Ronnen Levinson, Lawrence Berkeley National Laboratory
- Tianzhen Hong, Lawrence Berkeley National Laboratory
- Vincenzo Corrado, Politecnico di Torino
- Emmanuel Bozonnet, La Rochelle Université
- Afshin Afshari, Fraunhofer Institute of Building Physics IBP

Invitations

- Haider Taha, Altostratus Inc.
- Abdelaziz Laouadi, Natural Research Council of Canada
- Abhishek Gaur, Natural Research Council of Canada

Objectives

1. Produce sets of weather data of characteristic climate zones and representative cities
   - Typical meteorological year (hourly resolution - present & future)
   - Characteristic heat waves (hourly resolution - present & future)
   - Cooling design conditions

2. Develop a set of charts and spreadsheets illustrating climate characteristics relevant to resilient cooling
3. Define a methodology, sources, and minimum quality levels for deriving individual weather data sets within Annex 80

The ASHARE climate zones were used to select representative cities for each climate region (Developed by Standing Standards Project Committee 169: Climatic Data for Building Design Standards. Defined in ANSI/ASHRAE Standard 169). The selection of the representative cities will favour cities of high population density and growth (in accordance with IPCC).

Launch of New Task Groups

The formation of three new Task Groups has been proposed by the OA and agreed upon by the group.

Thermal Conditions Task Group

The following participants form this task group:

- Shady Attia, Liège University (Team Lead)
- Mohamed Hamdy, Norwegian University of Science and Technology (Team Lead)
- Bjarne Olesen, Technical University of Denmark
- Anaïs Machard, La Rochelle Université
- Hua Ge, Concordia University, Montreal
- Rajat Gupta, Oxford Brookes University
- Behzad Sodagar, School of Architecture and the Built Environment Lincoln
- Peter Holzer, Institute of Building Research & Innovation
- Vincenzo Corrado, Politecnico di Torino

Invitations:

- Abdelaziz Laouadi, Natural Research Council of Canada
- Abhishek Gaur, Natural Research Council of Canada

Criteria and KPI Task Group

The following participants form this task group:

- Wendy Miller, Queensland University of Technology (Team Lead)
- Amanda Krelling, Federal University of Santa Catarina
- Dahai Qi, Université de Sherbrooke
- Feryal Chtioui, La Rochelle Université
- Gerhard Hofer, e7 Energie Markt Analyse GmbH
- Haohan Sha, Université de Sherbrooke
- Letícia Eli, Federal University of Santa Catarina
- Marcelo Olinger, Federal University of Santa Catarina
- Peter Holzer, Institute of Building Research & Innovation
- Philipp Stern, Institute of Building Research & Innovation
- Roberto, Lamberts, Federal University of Santa Catarina
- Ronnen Levinson, Lawrence Berkeley National Laboratory

Resilience Definition Task Group

Work for this task was already being carried out by Wendy Miller and Shady Attia through the composition of Paper 1 and 2.

Lecture Series

Through the work composing Annex 80, a huge amount of knowledge is generated by its members through international collaboration and national research. Due to the situation with solely remote
Expert Meetings, exchange and transfer of knowledge is limited. The Annex 80 lecture series has therefore been established to provide a platform for making this knowledge visible and easily accessible to all participants. The first seven lectures were already held.

Sessions are held once every month and take approx. 60 min. The dates for the next lectures have been set as following:

- Lecture 08 May 4th, 2021, 05:00 pm (UTC)
- Lecture 09 June 1st, 2021, 01:00 pm (UTC)
- Lecture 10 July 6th, 2021, 08:00 pm (UTC+1)
- Lecture 11 September 1st, 2021, 08:00 pm (UTC+1)
- Lecture 12 October 6th, 2021, 08:00 pm (UTC+1)
- Lecture 13 November 3rd, 2021, 08:00 pm (UTC)

Subtask A

As stated above the activities of STA shifted. The assessment of technologies has been relocated to STB whereas STA worked on the identification and definition of criteria and performance indicators of resilience in the realm of cooling.
After the STA status reports of Wendy Miller and Shady Attia, papers 1 and 2 have been discussed and worked on in the STA break-out sessions. Paper 2 has been presented by Shady and openly discussed by the group of contributors. Suggestions were taken on to further develop the paper before its submission.

Paper 1: - A review and evaluation of resilience frameworks and criteria

Wendy Miller presented paper 1 “How can we define and measure ‘resilient cooling’? - A review and evaluation of resilience frameworks and criteria” which has been submitted to the journal Applied Energy and is currently under review.
A summary of the reviewed qualities, indicators and KPIs has been summed up as follows, taken from the STA-presentation at the 2nd Expert Meeting:

Buildings	**Cooling solutions**	**Power systems**
Building heat performance index	Availability (capability of functioning)	Average interruption frequency
Building resilience	Stabilisation time	Average interruption duration
Comfort models	Recovery time	Loss of load frequency / expectation
Constants of proportionality	Cumulative disruption and recovery curve	% of load restored
Gain utilisation factor (GUF)		Energy index of unreliability
Passive survivability / habitability	COP / EER? – at what °C?	Consequence matrix
Hours of safety metric	Peak demand / Power Factor	Functional redundancy score
Thermal autonomy	Demand control mechanism	Rapidity in recovery phase
Overheating escalation factor	Noise	Recovery ability
CDD 24°C? CDD 30°C? ...		Resilience indicator

Paper 2: Resilient cooling of buildings: A review of definition and assessment criteria
Shady Attia presented the progress of paper 2 “Resilient cooling of buildings: A review of definition and assessment criteria”.

Content
- Definition of Resilience in other fields
- Disruptions in Buildings
- Definition of Resilience of Buildings
- Criteria of Cooling Technologies
- Discussion and Conclusion

A summary of the resilient cooling criteria was presented as follows, taken from the STA-presentation at the 2nd Expert Meeting:

Figure 2: Summary of resilient cooling criteria

Paper 3: Resilient cooling definition

It has been decided that the formerly proposed Paper 3 “Resilient cooling definition“ will not be composed. The definition of resilient cooling was further elaborated in the synthesis of Paper 1 and 2 and in the SOTAR. The Resilience Definition Task Group has been specifically created for this purpose.

Subtask B

The progress of STB has been presented by Chen Zhang and Ongun Berk Kazanci and discussed by the group. Prior to the Expert Meeting, 30 NRIs have been proposed. The NRIs have been structured according to the Resilient Cooling Fields of Technologies. New participants were asked to submit their NRI description as soon as possible. Further, the integration of contributions to Paper 4, SOTAR and Technology Profile sheets was discussed.
During the break-out sessions the progress of Paper 4 as well as the composition of (new) Paper 5: “Literature Review of KPI of Cooling Technologies which address resilience” were discussed.

The objectives of the new proposed paper were:

- Identifying KPIs could address resiliency
- Identify universal KPI for all/most technologies

- The universal KPI for systematic evaluation of different technologies (technology profile sheet activity)

Paper 4: Aspects of Resilience in existing Cooling Solutions
The progress of paper 4 has been discussed openly and a lack of reviews on active cooling technology has been identified.

The following action list and schedule was set:

- Update NRI (include project from new participants)
- Paper 4:
    - Confirm contribution to unedited chapters
    - Technology group leaders send integrated review to STB leaders by 15th of May 2020
    - STB leaders contact STA about the characteristic of resilient technology, to be used for qualitative evaluation in Paper 4, chapter 5
    - Final submission by the end of August 2020
- Work on Paper 5
- Finish SOTAR by the end of June 2020
- Technology profile sheet:
    - Develop a template (after August 2020, when the paper 4 and SOTAR are finished until circa April 2022)
    - Send out template to potential participants

Subtask C

The progress of STC has been presented by Dahai Qi and Gerhard Hofer and discussed by the group. Within the STC breakout sessions the coordination of the field studies, the concept for Resilient Cooling Performance Evaluation as well as the overall Structure of Case Study description have been discussed. At that point 17 cases studies have been registered.

The following action list and schedule was set:

- Concept for Resilient Cooling Performance Evaluation, based on works in STA and STB. Deadline: 30th June 2020
- Overall Structure of Case Study description
    - Containing: technical parameters of the building, KPIs, Information about operation, energy performance details, comfort parameters, other information about resilience
    - Development of detail chapters in Case Study description
- Case studies should include information about operation
    - Development of questionnaire for building owner/facility manager/operators and buildings users
- KPI List: Definition of which indicators are obligatory (if resilient cooling technology is in place) and which are optional - request feedback by partner. Deadline April 30th, 2020

- Feedback to revised KPI list until 30th of May 2020
- Questionnaire
    - Feedback to existing draft with focus on operation of resilient cooling technologies until 20th of May 2020
    - Analysis of resilient cooling definition for any other qualitative questions until 30th of June 2020

Subtask D

The Subtask Leader of STD, Peter Graham, was not able to attend the Expert Meeting. The agenda of STD has thus only been briefly discussed.
In accordance with the last meeting, it has been agreed upon that STD will host all Annex activities of cooperation with international programs.
At that point some have been identified and partly already approached:

- KIGALI-Cooling Efficiency Programme
- Sustainable Energy for All (SEforALL) organisation
- IEA EBC Working Group on standardisation (led by Takao Sawachi)

The time until the next Expert Meeting was used to enforce STD activities.

Further Schedule

The next dates were scheduled as follows:

Meeting type	Location	Date	Recipients
STL Web Meeting 06	Web Meeting	2020 June 23rd	STL + Interested Parties
STL Web Meeting 07	Web Meeting	2020 Aug 26th	STL + Interested Parties
STL Web Meeting 08	Web Meeting	2020 Oct 28th	STL + Interested Parties
3rd Expert Meeting	Remote Meeting	2020 Nov 05/06	All participants

3rd Expert Meeting

The third Expert Meeting took place on the 5th and 6th of November 2020 as a remote meeting. Meeting in person was not possible due to the pandemic outbreak.

Project Management Updates

Just at the end of October 2020, the Annex attending team from Lawrence Berkeley National Laboratory, Ronnen Levinson and Haley Gilbert, decided to take the vacant position and lead STC moving forward. Six other teams already guaranteed their support. Bjarne Olesen pledged to support the group as senior advisor.

Adaptations and shifts of responsibilities between the Subtasks have already been reported to the ExCo in the last meeting and have been reflected in an updated version of the Annex 80 Text.

Discussed general topics

Status Report

The number of countries which have officially confirmed their participation by Letters of National Participation (LoN) increased to 15. The countries of Singapore, Brazil and Turkey joined the group. Overall, 33 institutions are involved in the Annex up to this point however only 22 institutions have confirmed their participation by submitting official letters.

State-of-the-Art-Review (SOTAR)

The SOTAR has been briefly presented. It is scheduled to be submitted to the ExCo for review at the end of November 2020.

Status Reports of Task Groups

Weather Data Task Group

The progress of the weather data task group has been discussed and reported. Before the Expert Meeting, the group held a workshop to generate Typical Meteorological Years (TMY) as well as heat wave events for future periods (2050s, 2090s). Twenty-five cities were selected to cover each climate zone from the ASHRAE classification (ANSI/ASHRAE Standard 169). Next steps addressed inclusion of urban heat island effects.

Thermal Conditions Task Group

Three meetings have been held since the last Expert Meeting to define the thermal comfort conditions and benchmark model for the assessment of cooling technologies. It has been decided to refer to the thermal comfort model as described in ASHRAE 55 and EN 16798 / ISO 17772 and ISO 7730 for the design and minimum thermal condition.

It has also been decided to:

- Quantify the severity of foreseeable events (i.e., heat wave and electricity cut). The Ambient Warmness Degree (AWD) index should be referred to for this.
- Quantify the impact of foreseeable events. The Indoor Overheating Degree (IOD) index should be referred to for this.
- Further a calculation of the escalation factor shall be performed (IOD/AWD).

The next meeting of the Thermal Conditions Task Group was scheduled for November 17th, 2020.

Criteria and KPI Task Group
KPIs which have already been collected by different subtasks were reviewed and systematically described to create a glossary.
It has been proposed to investigate a combination of KPIs to define resilience in regards to cooling, rather than to find one specific indicator.

More details on the proceedings of this task group can be found on the IEA file server (Annex80_3rd-Expert-Meeting_master-slides_2020-11-06.pdf)

Resilience Definition Task Group
The definition of resilience in terms of cooling is ongoing. Wendy Miller proposed ten questions to guide further related research.

Lecture Series

Through the work composing Annex 80, a huge amount of knowledge is generated by its members through international collaboration and national research. Due to the situation with solely remote
Expert Meetings, exchange and transfer of knowledge is limited. The Annex 80 lecture series has therefore been established to provide a platform for making this knowledge visible and easily accessible to all participants. 14 lectures were already held.
During Annex 80 a huge amount of knowledge is generated by its members through
international collaboration and national research. Due to the situation with solely remote
Expert Meetings exchange and transfer of knowledge is limited.
The Annex 80 lecture series has been established to provide a platform for making this knowledge visible and easily accessible to all participants. 14 lectures were already held.

Sessions are held once every month and take approximately 60 minutes. The dates for the next lectures have been set as following:

- Lecture 14 December 1st, 2021, 08:00 pm (UTC)
- Lecture 15 January 5th, 2022, 08:00 pm (UTC)
- Lecture 16 February 2nd, 2022, 08:00 pm (UTC)

Subtask A

Wendy Miller and Shady Attia gave the STA status report. Paper 1 has been submitted to Applied Energy and Paper 2 to Energy and Buildings.

Resilient Cooling Framework
Wendy Miller presented the outline of the SOTAR's chapter 4 "The Quality of Resilience in Cooling" giving an overview of the two approaches to assess the quality of resilience (broadly social and broadly technical). She posed ten questions, which were key for the Resilience Definition Task Group and to further guide Annex related research.

Definition of Resilient Cooling
Shady Attia presented the main points of Paper 2 "Resilient cooling of buildings to protect against heat waves and power outages: key concepts and definition". The definition was limited to building scale, heat waves and power outages. Resilient Cooling Characteristics and Risk Factors were defined.

Subtask B

The progress of STB has been presented by Chen Zhang and Ongun Berk Kazanci and discussed by the group. Prior to the Expert Meeting, 40 NRIs have been proposed so far. The NRIs have been structured according to the Resilient Cooling Fields of Technologies. Changes of NRI should be reported.

Paper 4: Resilient Cooling Solutions-Review
A qualitative approach for the evaluation of cooling technologies according to four capacities (absorptive, adaptive, restorative, recovery capacity) has been presented. Energy and Buildings and Renewable & Sustainable Energy were identified as target journals. Contributions should be sent to STB leaders by the 1st of December 2020. Submission to the journals was estimated for end of December 2020 or January 2021.

Technology Profile Sheets
Following technology performance testing procedures were introduced:

- Cooperate with weather data task group: present and future weather for representative climate zones
- Cooperate with thermal condition task group: reference buildings (different building typologies) and thermal conditions
- Dynamic simulation of various cooling technologies/solutions
- Building simulation software
- Performance evaluation (select KPIs to address resilient characteristics)

The following schedule was set for technology performance testing:

- Weather data available by 31st of December 2020
- Reference cases available by 31st of December 2020
- KPI for evaluation available by 31st of December 2020
- Simulation and individual analysis finished by 30th of April 2021
- Combined analysis finished by 30th of June 2021

- Paper submission until 30th of Sep 2021

Subtask C

Dahai Qi and Gerhard Hofer presented the monitoring concept for the case studies and the structure for the case study documents as well as first results from monitoring conducted in summer 2020.
STC called for projects that are using cool materials, double skin façades / ventilated façades, high performance compression chillers, including split and multiple split and VRV units, high performance absorption chillers, including desiccant cooling, micro-cooling / personal comfort control. Furthermore, STC is coordinating more than 15 case study projects, relevant to monitoring of cooling systems.

Subtask D

Haley Gilbert and Ronnen Levinson, assigned as the new leaders of STD, recaptured the objectives and targets for the remaining working phase. Annex 80 members were invited to join the upcoming web meeting to get involved in STD. The following members assured their support:

- Feryal Chtioui, La Rochelle Université
- Vincenzo Corrado, Politecnico Torino
- Ezilda Costanza, ENEA Italian National Agency
- Peter Holzer, Institute of Building Research & Innovation
- Roberto Lamberts, Federal University of Santa Catarina
- Anais Machard, La Rochelle Université
- Bjarne Olesen, Technical University of Denmark
- Behzad Sodagar, School of Architecture and the Built Environment Lincoln
- Yin Wei, Hunan University of Science and Technology
- Michele Zinzi, ENEA Italian National Agency

Contact and cooperation with the following programmes and organisations was carried on:

- KIGALI-Cooling Efficiency Programme
- Sustainable Energy for All (SEforALL) organisation
- IEA EBC Working Group on standardisation (led by Takao Sawachi)
-

Further Schedule

The next dates were scheduled as follows:

Meeting type	Location	Date	Recipients
Subtask D Meeting	Web Meeting	November 16th 2020	Interested Parties
TG Thermal Conditions	Web Meeting	November 17th 2020	TG Members
Annex Lecture Series 03	Web Meeting	December 1st 2020, 13:00 UTC	Interested Parties
STL Web Meeting 06	Web Meeting	December 15th 2020	STL + Interested Parties
Annex 80 Board of Professionals	Kick-Off Meeting	February 4th 2020	OA + Industry Partners
STL Web Meeting 07	Web Meeting	February 18th 2021	STL + Interested Parties
STL Web Meeting 08	Web Meeting	April 8th 2021	STL + Interested Parties
4th Expert Meeting	Web Meeting	April 15th + 16th 2021	All participants

4th Expert Meeting

The fourth Expert Meeting took place on the 15th and 16th of April 2021 as a remote meeting. Meeting in person was not possible due to the pandemic outbreak.

Project Management Updates

The Annex text has been updated and submitted to the Executive Committee for approval.
The SOTAR has been internally reviewed and shall be submitted to the ExCo.

Discussed General Topics

Status Report

35 institutions from 15 countries were taking part in this Annex 80 meeting.
The progress of the last 1.5 years of the working phase has been evaluated and future steps identified. Especially the generation of Annex deliverables has been discussed intensively during the plenary sessions.

Update on Deliverables

The group collectively discussed D3 “Technology Profiles” and defined next steps:

- Research and review precedent documents of short technical sheets addressed at planners/consultants/policymakers.
- Define content and integration of simulation results.
- Distribute workload and start composing.

Deliverable	Name	Status	Responsibility
D1	State-of-the-Art-Review	- two chapters missing - internal review finished → submission to ExCo	OA, STA, STB, STC, STD
D2	Midterm Report	- in progress, submission to ExCo for meeting in June 2021	OA, STA, STB, STC, STD
D3	Technology Profiles	- technology review finished - simulations to start soon after this meeting	STB
D4	Field Studies	- measurements in progress - report layout in progress	STC
D5	Design and Operation Guidelines	- not started at that moment, to be composed	STA, STB, STC

		after technology assessment	
D6	Recommendations for policy actions, legislation, and standards	- not started at that moment, will be composed after policy assessment	STD
D7	Project Summary Report	- will be written at the end of the project	OA, STA, STB, STC, STD

Status Reports of Task Groups

Weather Data Task Group

The generation of TMY future weather files for at least two cities of each climate zone of the ASHRAE classification and the three time periods, 2001-2020, 2041-2060 and 2081-2100, has been widely completed. Generating of data for remaining cities and concurrent testing of the data sets was continued. The results and final data sets are intended to be published by the end of June 2021.

The modelling of effects of urban canopy (heat island effects) has not been elaborated further since the last expert meeting. A small group of experts took on this task after the generation of weather files was completed.

The following schedule was set for the next simulations:

- Building Simulations to be completed by September 2021
- Heatwave EPW files ready for the first group of cities by Mid-May 2021
- Test of the first group of cities with building simulations and KPIs by May/June 2021
- Heatwave EPW files ready for the remaining cities by end of June 2021

It was decided to publish the datasets via MDPI or Elsevier. Authorization by the IEA executive committee for publishing these datasets was obtained. Two options for the publication plan were agreed upon, either 15th of June 2021 or July/August 2021.

Thermal Conditions Task Group

The definition of boundary conditions for the evaluation of cooling technologies through thermal simulations has been published in the report “Framework to evaluate the resilience of different cooling technologies”. This task has been completed and is closed until further requirement.

Criteria and KPI Task Group

A selection of basic KPIs was formed on the basis of an extensive collection from different task groups and discussed in the group. They included:

- IEQ / thermal comfort metrics
- Energy metrics
- HVAC
- Grid Metrics

Not included, and had to be specifically assigned:

- Technology specific KPIs

Resilience Definition Task Group
This task has been completed and there were no reported actions since the last meeting.

Simulation Task Group
The programme for this group was subject to extensive discussion with different points of view. The following was agreed upon:

1. Participants may choose the technology which they want to simulate themselves. There will, however, be the endeavour of a joint simulation activity lead by Shady Attia, University of Liège.
2. All evaluated technologies shall be referenced against a standard air driven HVAC system.
3. Simulations shall include two types of shocks: hight temperatures (heat waves) and power outage.

Details were to be specified in a written guideline which was under preparation and released in the following weeks.

Subtask A

Wendy Miller and Shady Attia presented the STA status report. STA has contributed to the SOTAR, Paper 1 has been submitted to Applied Energy and Paper 2 to Energy and Buildings.

Subtask B

STB has produced a collection of KPIs and submitted an extensive review of cooling technologies for the SOTAR. It is currently working on a review paper evaluating existing cooling technologies and their aspects of resilience. A first draft has been internally submitted to the group and the final paper will be published (potentially in Energy and Buildings' special issue on Building Cooling for Sustainable Societies). Furthermore, STB is coordinating numerous national research projects, relevant to the improvement of cooling systems, see also chapter **Fehler! Verweisquelle konnte nicht gefunden werden. Fehler! Verweisquelle konnte nicht gefunden werden.**.
Chen Zhang and Ongun Kazanci reported on the submission of Paper 4 "Resilient cooling strategies- a critical review and qualitative assessment" as well the upcoming dynamic simulation task.

The following schedule was set for the dynamic simulation:

- Guideline for methodology ready: postponed from Mid-March 2021 to Mid-April 2021
- Simulation and individual analysis finished: postponed from 30th of June 2021 to end of Sep 2021
- Combined analysis completion: postponed from 30th of Sep 2021 to end of Dec 2021

The plan for further publication was scheduled as follows:

- Paper 2 of STB: quantitative assessment based on KPIs (existing and new ones to be developed), led by Ongun Kazanci
    - Submission is aimed for end of 2021

- Paper 3 of STB: Passive technologies, simulation results to be evaluated using the methodology of Paper 1 and Paper 2
    - Submission date undefined
- Paper 4 of STB: Active technologies, simulation results to be evaluated using the methodology of Paper 1 and Paper 2
    - Submission date undefined

Subtask C

STC is coordinating more than 15 case study projects monitoring resilient cooling systems. Dahai Qi and Gerhard Hofer reported on the ongoing field studies and presented a template for reports.

The following task list was set regarding next steps:

Task description	Deadline	Responsibility
Performance evaluation: Analysis how Resilient Cooling Criteria could be used for Performance Evaluation; data selection	30th June 2021	Gerhard, Dahai
KPI List: Definition which indicators are obligatory (if resilient cooling technology is in place) and which are optional; request feedback from partner	30th June 2021	Dahai
KPI List: Feedback to revised KPI list	30th May 2021	All
Questionnaire: Analysis of resilient cooling definition for any other qualitative questions; the topic evaluation criteria and indicators for resilient cooling	30th June 2021	All
Overall Case Study description: proposal for structure and chapters/subchapters of document (draft is completed)	30th June 2021	Gerhard, Dahai

Subtask D

Haley Gilbert and Ronnen Levinson reported on the current status of policy collection and planned future steps:

- November 2020 - April 2021: Policy collection
- May 2021 – October 2021: Policy review & comparison
- November 2021 - April 2022: Recommendations
- May 2022 - June 2023: Write-up

The scope of collecting resilient cooling related policies was too broad and overlapped with other similar efforts. Therefore, the scope was narrowed, and the cross comparison focused on major national or regional policies. For the evaluation of policies “guides”, who share a common understanding of a country’s, or region’s policy framework, were to be identified. Further the execution of policy reviews was to be taken on by a bigger group of participants, so called “hikers”. Annex participants were asked to volunteer for this task, especially for geographical regions not yet covered.

Publications

The following table gives an update about publications associated with Annex 80.

Paper	Title	Authors	Publisher/Submission Date
01	“Developing an understanding of resilient cooling: a socio-technical approach City and Environment Interactions”	Wendy Miller et al	Elsevier City and Environment (accepted)
02	“Resilient cooling of buildings to protect against heat waves and power outages: key concepts and definition”	Shady Attia et al	Energy & Buildings (published)
03	“Resilient cooling definition“		Discarded
04	“Resilient cooling strategies - a critical review and qualitative assessment”	Chen Zhang et al	Energy & Buildings (under review)
05	“Resilient cooling strategies – evaluation of metrics and quantitative assessment”		Submission end of 2021
06	Passive technologies, simulation results to be evaluated		Planned
07	Active technologies, simulation results to be evaluated		Planned
	Methodology and future weather data sets	TG Weather Data	Submission June 2021

Further Schedule

The next dates were scheduled as follows:

Meeting type	Location	Date	Recipients

Annex Lecture 08	Web Meeting	4th May 4 2021, 17:00 UTC+1	Interested Parties
Annex Lecture 09	Web Meeting	1st June 2021, 13:00 UTC+1	Interested Parties
Annex 80 Advisory Board of Practitioners	2nd Web Meeting	9th June 2021, 14:00 UTC+1	Interested Parties + Industry Partners
STL Web Meeting	9th Web Meeting	16th June 2021, 21:00 UTC+1	STL + Interested Parties
STL Web Meeting	10th Web Meeting	18th August 2021, 21:00 UTC+1	STL + Interested Parties
Annex 80 Advisory Board of Practitioners	2nd Web Meeting	29th September 14:00 UTC+1	Interested Parties + Industry Partners
5th Expert Meeting	Politecnico di Torino (ITA)	14th & 15th October 2021	All participants

National Research Items

The following NRI are carried out, none have been omitted. The comprehensive list of items below:

Institution	Country	Title of National Research Item
Aalborg University	Denmark	Efficiency of night-time ventilation for passive cooling of office buildings
Aalborg University	Denmark	EUDP House 2020 with high indoor environmental quality and user comfort
Aalborg University	Denmark	Control strategies of mixed-mode cooling for apartment in hot-humid climate zones
BBRI & Thomas More Kempen	Belgium	SCOOL
Belgian Building Research Institute	Belgium	Sustainable Cooling Solutions
Brunel University	United Kingdom	Resilience of Cooling Retrofit Solutions for Residential Buildings
Brunel University	United Kingdom	Urban Albedo and Microclimatic Modifications to Enable Resilient Cooling in Residential Buildings
Chalmers University of Technology	Sweden	Direct-Ground Cooling Systems for Office Buildings: Design and Control Considerations
Concordia University	Canada	Assessment and mitigation of summertime overheating in vulnerable buildings of urban agglomerations
EURAC – Europäische Akademie Bozen	Italy	Solar window block with ventilation unit
Eurac Research	Italy	Assessment of cooling resilience of technologies
Eurac Research	Italy	Plus energy multi-family building in Bologna Italy
Eurac Research	Italy	Smart air movement for thermal comfort
Federal University of Santa Catarina	Brazil	Analysis of the Brazilian bioclimatic potential for single family housing in the face of climate change
Federal University of Santa Catarina	Brazil	Assessing elevated air movement indoors under hot and humid conditions in Brazil
Federal University of Santa Catarina	Brazil	Demand-side management strategies in the urban scale

Federal University of Santa Catarina	Brazil	Development of a global method of climatic zoning that takes into account the urban microclimate: A study directed to the energy performance of buildings
Federal University of Santa Catarina	Brazil	Passive cooling of office buildings in Brazilian climates
Federal University of Santa Catarina	Brazil	Personal conditioning systems implementation in shared offices during summer
Federal University of Santa Catarina	Brazil	The impact of occupant behavior modeling on the thermal performance of Brazilian residential building
Fraunhofer IBP	Germany	Urban Physics Modelling
Gebze Technical University	Turkey	The numerical simulation of an adsorption chiller working with waste heat of the system
Hunan University	China	Energy-efficient ventilation of residential buildings in hot summer and cold winter regions: potential
Hunan University	China	Energy-efficient ventilation of residential buildings in hot summer and cold winter regions: strategy
Hunan University of Science and Technology	China	Wind-pressure distribution on a building interfered by surrounding buildings
Institute of Building Research & Innovation	Austria	Cooling for existing care centres for elderly people
Katholieke Universiteit Leuven	Belgium	Development of a multi-criteria assessment methodology for integrated resilient cooling strategies
La Rochelle Université	France	Design of Buildings under the effect of Climate Change
La Rochelle Université	France	Optimal design and control methods of ventilative cooling in residential buildings
Lawrence Berkeley National Laboratory	USA	Best Suite of Passive/Low-Energy Cooling Solutions for U.S. Climates
Lincoln University	United Kingdom	Climate Responsive Cooling Technologies
Oxford Brookes University	United Kingdom	Zero Plus project on near zero energy buildings
Politecnico di Milano	Italy	eERG*
Politecnico di Torino	Italy	KPI to evaluate the geo-climatic applicability of passive/hybrid cooling technologies
Politecnico di Torino	Italy	Towards energy efficient and heat-wave resilient buildings
SONY Corporation	Japan	REON Pocket

Technical University Denmark	Denmark	Intelligent comfort control development
Technical University Denmark	Denmark	Personalized Environmental Control Systems (PECS)
Technical University Denmark	Denmark	Model Predictive Control and Innovative System Integration of GEOTABS in Hybrid Low Grade Thermal Energy Systems
Technical University Denmark	Denmark	Solar CHP & Cooling for Commercial Buildings
Technical University Denmark	Denmark	IEA EBC Annex 69 – Strategy and Practice of Adaptive Thermal Comfort in Low Energy Buildings
Thomas More Kempen	Belgium	Sustainable Cooling Solutions
Université de Liège	Belgium	Advanced shading design and control for cooling demand reduction
University of Gävle	Sweden	Space Cooling in new City Districts in Nordic Climates

Additional Annex Activities

In addition to the recurring Expert Meetings, the following meetings, activities, or actions have taken place:

- Jul 9th, 2018: Presentation at UNEP Workshop on “Energy efficiency opportunities while phasing-down hydrofluorocarbons” (HFCs)
- Aug 6th, 2018: Annex 80 homepage went online
- Aug 27th, 2018: Resilient Cooling Newsletter No.1
- Sep 12th, 2018: Joined Scientific Committee of CATE Conference
- Sep 18th, 2018: Topical session on Annex 80 at 39th AIVC, Juan-les-Pins
- Oct 10th, 2018: National IEA Network Meeting
- Oct 11th, 2018: Mission Innovation National Kick Off
- Oct 16th, 2018: Resilient Cooling Newsletter No.2
- Oct 24th, 2018: Invitation to “Board of Industries” for interested companies
- Oct 25th, 2018: Web Meeting with Venticool steering committee
- Nov 19th, 2018: Presentation at NEEC Sydney
- Apr 10th, 2019: Resilient Cooling Workshop at CATE Conference, Dubai
- Jul 4th, 2019: National IEA Network Meeting
- Sep 25th-26th, 2019: National IEA Network Meeting
- Oct 10th, 2019: Preparative Web Expert Meeting
- Oct 15th, 2019: Topical session on Resilient Cooling at 40th AIVC, Ghent
- Apr 29th, 2020: Venticool Steering Committee web meeting
- May 5th, 2020: AIVC board meeting
- Jun 30th, 2020: Web meeting with Poh Seng Lee National University of Singapore
- Aug 12th, 2020: Web meeting with Prof. Lamberts’ team, University of Santa Catarina, Brazil
- Sep 14th, 2020: AIVC Board Meeting
- Oct 7th, 2020: Venticool Steering Committee web meeting
- Oct 28th, 2020: Web meeting with Gamze Gediz İliş
- Jan 26th, 2021: WDTF Urban Subgroup
- Feb 24th, 2021: Venticool Steering Committee
- Mar 3rd, 2021: Venticool preparation Meeting
- Mar 22nd, 2021: Meeting on future publications of STB
- Mar 22nd, 2021: Meeting with venticool for Advisory Board

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ANNEX 80

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