Means and Ends
of Architecture

'Technology' includes not only the technical building equipment, but the entire building as a technical organism.

by **Hans Drexler**
↪ Founder of DGJ Architektur

Architects love the idea of low-tech buildings: Simple, self-sufficient structure, that requires little in terms of technology or explanation. The discipline cultivates the myth of simplicity and identity between design and construction.

Architects hate technical building equipment[1]: Machines, wires, pipes, pumps, and little grey boxes everywhere. Worst of all: Engineers going on about necessities and regulations, polluting formerly clean and organised drawings with coloured lines, asking for holes in walls, ceilings, exhaust pipe on facades, and spending a third of the building's budget. This technical equipment does not fit into this clean and pretty picture of architecture. It is a world beyond the control and for the most part beyond the understanding of architects. The job of the architect is not to plan or design building technology, but to hide it from view as best as they can. Mark Wigley describes this difficult relationship between the architects and the world of the pipes[2], explaining that all contemporary buildings just don't work without all the pipes and machines, but on the time, building technology is hardly ever subject of the architectural discourse. Whereas structural engineering and construction are regarded as an integral part of the architectural design, building technology is disregarded or denied.

→ **[1]** With the exception of a very brief and limited fascination and over-articulation of building technologies during the 'High-Tech'-architecture, which was mostly limited to architects (Rogers, Piano, Foster, Archigram, Ludwig Leo and others) between the seventies and nineties.

→ **[2]** Mark Wigley, Buckminster Fuller Inc. : Architecture in the Age of Radio (Zürich: Lars Müller, 2015).

One problem with building technology is the lack of control. While architects like to pretend, that they are in control of the design, the structure, and the materials of a building (when in reality every aspect of the building is the result of a cooperative process of many participants from clients, engineers, project managers, builders, planners, legislator and many others), the technology is surely beyond architects' control. There can be heated arguments about the sizes, positions and necessities of pipes and cables, but by and large, the cables and the pipes have the upper hand. The last decades have seen a spectacular increase in quantity and complexity of technology: More machines, more cables, heating, cooling, sanitary equipment, and most of all electronics for the operation of the buildings and the comfort of the inhabitants. In Germany for example the costs for building construction have risen 41% during the period of 2000 and 2018, which corresponds to the general inflation rate. During the same period costs for building technology have increased 146%[3]. That seems not right.
Ten out of ten architects would tell you, that this development is misguided. Probably most clients and engineers would agree. It seems that building technology is an unintended consequence of our lifestyle, not a choice.

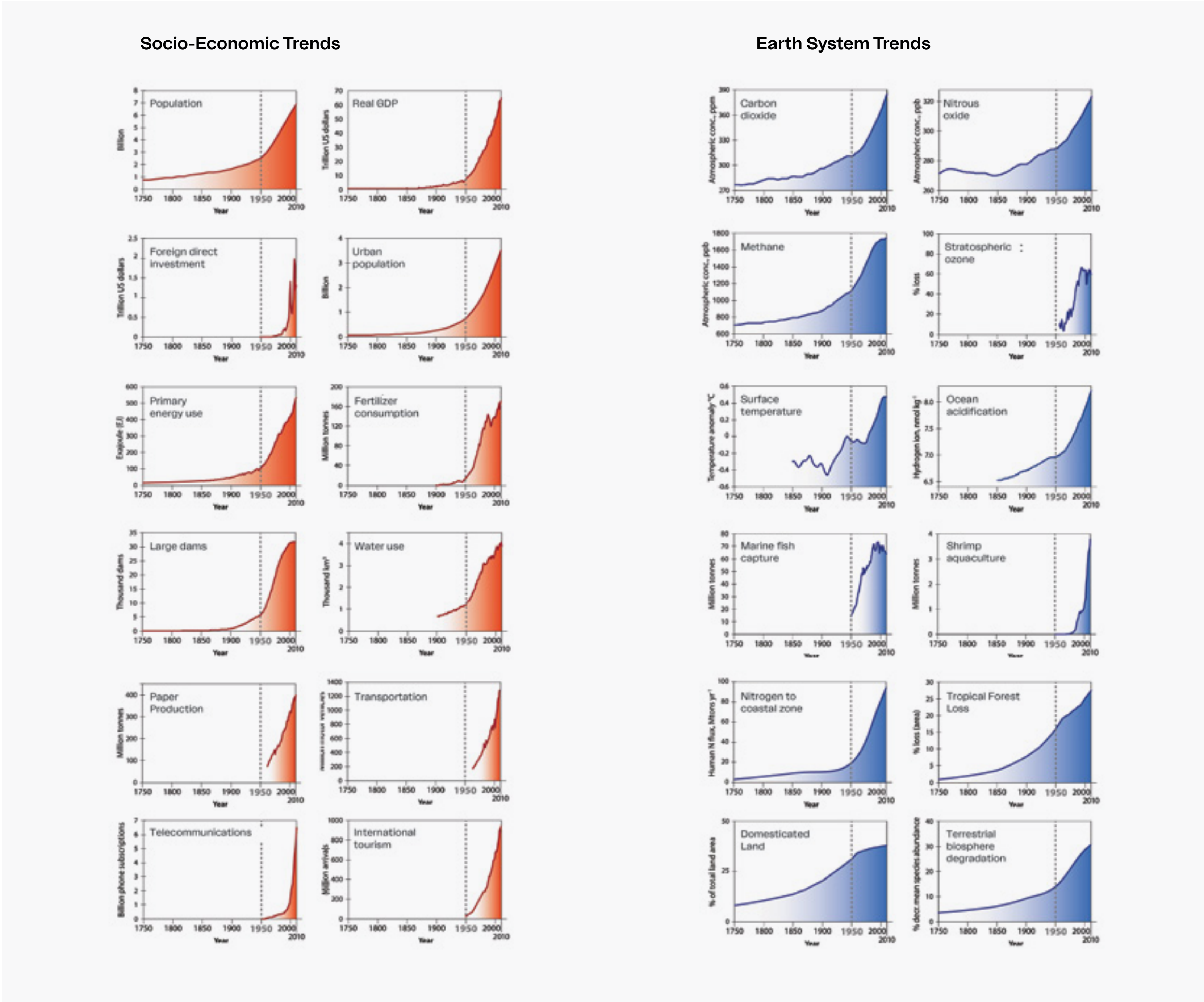
← **[3]** Dietmar Walberg, "Baukosten im Wohnungsbau und standardisiertes Bauen," ed. Arbeitsgemeinschaft für zeitgemäßes Bauen e.V. (München: Detail , 2019).

But why do we use all this technical building equipment? In 1966 Cedric Price in his lecture *"Technology Is The Answer - But What Was The Question?"* [4] (audio-visualised in 1979) hints at one reason: Because we can. Technology seems to have become an end in itself. Therefore, most planning and design revolves around questions of 'how' (the means) rather than 'why' (the ends). We have become so accustomed to technology, that we hardly question its necessity and usefulness. For the building sector technology is also deeply embedded in technical and legal codes, and all attempts to reduce it result in legal risks for architects and engineers involved. But those codes also reflect the expectations of the wider public towards (new) buildings:
We have grown used to the standard that buildings provide an optimal comfort at all times and under all circumstances: Not too hot, never too cold, good lighting and indoor air quality. We want to be protected from noise and fires. So, for the last decades man-kind aimed to realise ever higher standards of living for a growing world population, which resulted in the widespread destruction of habitats and resources. The strategy so far has always been to increase efficiency by using more and ever more complex technology.
The hope has always been, that it might be possible to outrun the increasing demand and expectations by an increase of efficiency and progress of technology. In that sense the problem of technology goes much further than buildings.
Every aspect of life is deeply dependent and interwoven with technology: Work, communication, social relations, agriculture, transport, medicine, art, buildings, and cities. By and large, it could be argued from an ecological point of view that the widespread of technology leads to an increase in resource depletion and emissions. Will Steffens and his co-authors described this in 2015 as the "great acceleration" showing the exponential growth of

← **[4]** Cedric Price, "Technology Is The Answer But What Was The Question? | Cedric Price | Pidgeon Digital" (World Microfilms Publications Ltd, 1979), https://www.pidgeondigital.com/talks/technology-is-the-answer-but-what-was-the-question-/.

→ **[5]** Will Steffen et al., “The Trajectory of the Anthropocene: The Great Acceleration,” Anthropocene Review, April 16, 2015, https://doi.org/10.1177/2053019614564785.

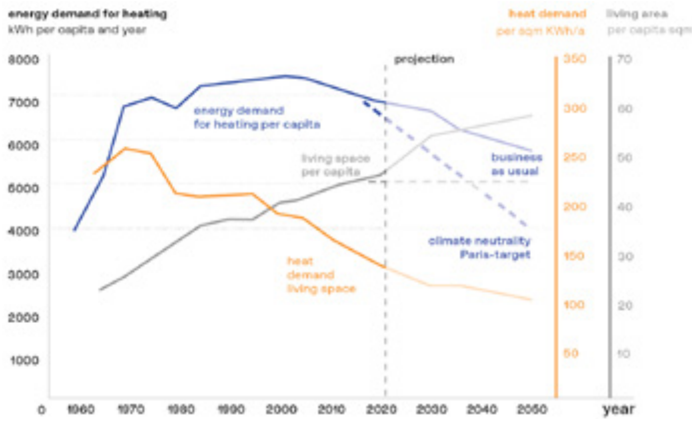
these key socioeconomic indicators (energy consumption, GDP, transport…) leading to exponential growth in CO_2 emissions, loss of natural habitats and biodiversity. [5]



← **[Graphik]** The trajectory of the Anthropocene: The Great Acceleration, Will Steffen, Wendy Broadgate, Lisa Deutsch, Owen Gaffney und Cornelia Ludwig: Trends from 1750 to 2010 in globally aggregated indicators of socio-economic development.

For the building sector, comfort for the inhabitants is also only one part of the equation. The resources used and emissions caused to achieve this comfort have to be balanced against the world's ecosystems to cope with the impact. "Plus-Energy-Buildings", which in their operation produce more energy than they consume, are not only possible but economically feasible and more common. But at the same time, the overall energy consumption and CO2 emissions of energy for the building sector is still rising. How can this phenomenon be explained? The most important effect is the 'rebound effect': The higher efficiency leads to better availability of resources (expressed in lower prices) and in return to higher consumption. In the case of housing that translates to an increased floor area per person and higher comfort standards. For example, in Germany, the average living area has almost doubled from 26,4sqm/person in 1972 to 47,4sqm/person in 2020 (+80,2%)[6]. At the same time the energy consumption of the buildings has been reduced by half, but these gains in efficiency are overcompensated by the increase of area.

→ **[6]** Statistisches Bundesamt, "Wohnungsbestand nach Anzahl und Quadratmeter Wohnfläche," 2019, https://www.destatis.de/DE/Themen/Branchen-Unternehmen/Bauen/Tabellen/wohnungsbestand-deutschland.html.



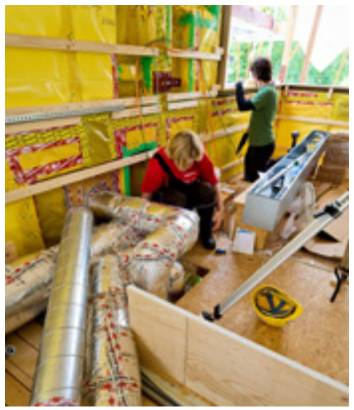
→ **[Graphik]** Space heating requirement in kWh per capita and year: The living space per capita in Germany has been increasing for years (blue line). This makes it difficult to save heat despite, for example, thermal insulation. On the other hand, if the living space per capita were limited (red dashed line), enormous savings could be achieved (red line). Graphik DGJ based on Wuppertal Institute 2015.
Umwelt Wuppertal Institut für Klima, "Kommunale Suffizienzpolitik – Ressourcenschutz vor Ort stärken - Wuppertal Institut für Klima, Umwelt, Energie," April 29, 2016, https://wupperinst.org/a/wi/a/s/ad/3448.

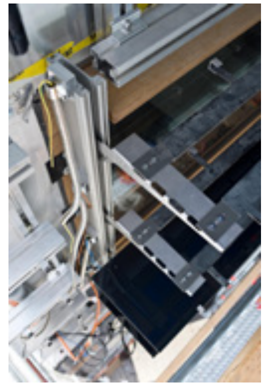
Technical failures and/or a lack of robustness of high-tech buildings in the face of changing demands and circumstances are adding to the problems since many buildings with complex technical systems perform not as good as intended due to technical failures and/or bad maintenance (the so-called 'performance gap'). Finally, the complex technology translates to a shorter life cycle of buildings or at least the technical systems of it, since they are more likely to fail and be replaced, and less likely to be repaired and maintained.

Rebound effects, performance gaps, rising standards as well as population growth and urbanisation overcompensate what could be achieved with better efficiency. The building sector uses more and more energy and resource consumption. What is the way out of this dilemma and what can be the contribution of architecture? The title of the buildPorto-Conference suggests one strategy: 'From high to low tech'. During the past 15 years, DGJ Architecture also went from high-tech to low-tech. In 2007 and 2009 as part of a research project of the TU Darmstadt, Hans Drexler helped to design and build the first Plus-Energy-Buildings in Germany as entries to the Solar-Decathlon competition taking place in Washington D.C. at the time. Those small prototypes, which both won the international competition between 20 universities, were important for demonstrating, that buildings can be designed and built that produce significantly more energy than they use, transforming the buildings into small powerplants rather than polluters.

↓ Solar Decathlon Prototype, Team Germany / TU Darmstadt, 2009. Photo Hans Drexler 2009

↘ **[Construction Photos]**
Solar Decathlon Prototype,
Team Germany / TU Darmstadt,
2009. Photos Thomas Ott 2009





In order to achieve this, the building was equipped with a heat pump, controlled ventilation system, an innovative cooling ceiling using PCMs (phase-changing materials). The façade of the 2009 Solar Decathlon was made from photovoltaics, a new system developed and implemented for the first time in the project. It was a high-tech prototype that could be compared to a Formula-1 car **[←]**.

To transfer this knowledge from the laboratory to real life, 2012 DGJ Architektur designed a Plus-Energy-House for a boarding school, which also produces more energy throughout the year than the operation of the building consumes.

← Plus-Energy-Building Boarding School Geisenheim, 2014. Photo Hans Drexler.

In this project our focus was to reduce complexity and to use the means of architecture and building construction rather than high-tech building equipment. When working on the energy concept we first explore all options, how the building itself with passive technology can reduce the energy demand.

Energy Topics	Design and Construction Passive Means	Building Technology Active Systems
Heating	conserve heat energy collect passively	efficient heating
Cooling	avoid overheating	efficient cooling
Ventilation	ventilate naturally	mechanical ventilation
Lighting	daylight	efficient artificial light
Eletricity	reduce electrical power	energy production

← Source: Energie Atlas , 2007 Manfred Hegger, Matthias Fuchs, Thomas Stark, Martin Zeumer. Manfred Hegger et al., Energie Atlas: Nachhaltige Architektur (München: DE GRUYTER, 2007).

The first idea was to minimize the indoor floor area by putting the circulation in an open corridor. Not only does this space does not require heating or maintenance it also creates an inhabitable balcony for the students to meet and use.

→ Plus-Energy-Building Boarding School Geisenheim, 2014. Photo Hans Drexler.

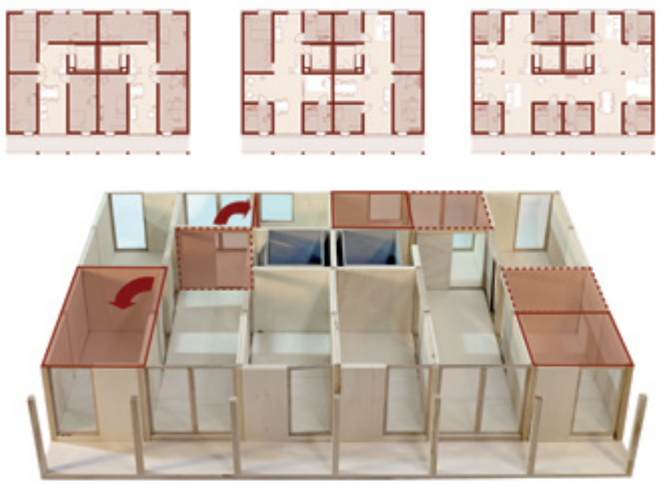
For the cold German winter, a well-insulated and air-tight building envelop (walls, windows, roof, and floor) are very useful to reduce the heating demand but also to prevent overheating in summer. Position and sizes of windows are designed based on the results of the energy simulation, which is one of the reasons why DGJ often does the energy simulation as part of the design process. As a result, the end-energy demand of the building is 17,3 kWh/sqm*a, which is better than the Passivhaus-Standard.

Only after passive means were optimized, the technical equipment was implemented: Mechanical ventilation with heat regain, which reduces heat losses during winter. A heat pump that uses a solar collector in the south façade as a heat source is used for heating and hot water. The roof is covered with PV panels, producing about twice as much energy throughout the year as the building requires, providing the overshoot to the grid.

The building was a model project in a federal research programme for Plus-Energy-Buildings and therefore monitored during the first two years of operation. During the first year, the building displayed all the problems of the high-tech-buildings: The actual energy use was 41,3% high than simulated during planning, due to technical failures, overstrained users and facility managers. The monitoring allowed to identify and correct those problems so that in the second year the over-consumption could be reduced to 17%. But in most of the high-tech buildings neither the time and money is spent on the monitoring nor is the building's equipment being adjusted, so that performance gaps between design and reality are as common as they are significant.

The lesson learned from the first Plus-Energy-Houses was to reduce all active systems in the next such project, a student's housing 'Collegium Academicum' in Heidelberg. The project is conceived by the clients to be a model for affordable housing, which allowed questioning ideas about apartment and room sizes. Reducing the floor area per capita is an important contribution not only to reduce the costs for housing but also energy and resource consumption. The challenge is to achieve a similar or even higher level of comfort on a smaller footprint. The solution tested in the 'Collegium Academicum' is to reduce the individual spaces in the building and provide more shared and common spaces. At the same time, the inhabitants are given choices and the opportunity to change and adapt the appartements according to their needs, roommates and experiences. Within the apartments, each individual room could be either 7sqm or 14sqm. A flexible wall can be placed in two different positions which results in a different layout of the apartment and proportions of shared and individual spaces. For this flexible wall, a new system of sliding doors has been developed, which allows being repositioned within half an hour time and which provides sufficient soundproofing between the rooms.

↑ → DGJ Architektur

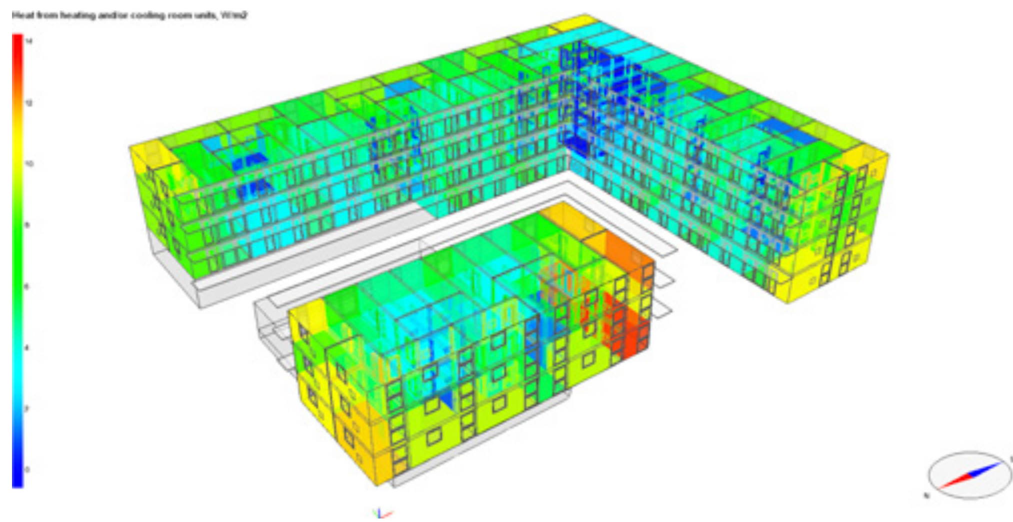


This concept is based on the idea of sufficiency – asking 'how much is enough?'[7]. The involvement of the inhabitants or users of the building is an important part of this strategy. Participation of inhabitants makes reducing the standards an active choice, which can lead to higher user satisfaction. Going on a diet to improve health and looks is a choice, which might make you happy. Not getting enough to eat is starving.

For the student housing in Heidelberg, the well-insulated building construction reduced the heat demand for the building up to the point, that the simulation indicated the building does not require a heating system at all. Heat gains from people, appliances and lighting would be enough to maintain a comfortable temperature. The initial concept, therefore, was to dispense with a heating system and only install small electrical radiators as a kind of parachute that could be used during unfavourable weather. Such a design is only possible by using a dynamic building simulation, which allows predicting the comfort in the building. Conventional, static simulation will always consider the worst of conditions even if they only apply for a very brief period of time during the year and/or are highly unlikely. Those simple planning tools also play an important part in overdesigned building technology.

← **[7]** Robert Skidelsky and Edward Skidelsky, How Much Is Enough?: Money and the Good Life (London: Penguin Books, 2012).

↓ Heat from heating and/ or cooling romm-units. DGJ Architektur: IBA Heidelberg. Source: ina Planungsgesellschaft, Darmstadt (http://www.ina-darmstadt.de/).



In the end, the radical concept to abandon the heating system could not be realised. The reason was, that the client entered into an obligation to connect to the district heating when they bought the land.

When we develop projects at DGJ together with our clients, we try to remind them, that we should go from ends to means and not the other way around. So, when the clients ask us to change the design in one way or another, we ask them to explain what they want to achieve. Ideally, it would be left to the engineers and the design team to figure out how to achieve those ends. For Cedric Price, technology was never an end in itself. His projects were mostly concerned with opening up new social and cultural relationships between people. The most prominent example is his 'Fun Palace Project' for Joan Littlewood 1959 – 1961, which he describes as "a large, mechanised shipyard in which various structures could be built from above by means of gantries, travelling cranes, and intermediate beams; and that these structures would contain the activities as shown, simple in themselves, but would, through their design, be capable of being altered while the building was being occupied." [8]

→ **[8]** Price, "Technology Is The Answer But What Was The Question? | Cedric Price | Pidgeon Digital."

His idea of architecture was that it creates spaces and infrastructure as an everchanging stage set for all kinds of human interaction can take place.

Architecture is not an end in itself. **I like to remind myself, that we create spaces to live in.** We don't build houses to save energy or to save the environment. Architecture creates spaces in which most of our lives take place. Where we live, work, love, where children grow up, and in which we spend most of our time. This is an enormous responsibility, but also the most fantastic job in the world. Even if architects don't have full control of the design team and process, they need to take a more active role in dealing with building technology. If requirements, standards, and technical solutions are not discussed and questioned, the inherent tendency of the design process to reduce risks and therefore to plan for the highest standards and the worst cases will continue to transform buildings into technological systems with high risks of performance gaps and built-in redundancies. But to better understand and prevent those outcomes, architects also need to embrace technology as an integral part of the design of the building.