Energy Efficient Cities Initiative

GOOD PRACTICE IN CITY ENERGY EFFICIENCY

Münster, Germany - Low-energy Building Standards through Sale of City-owned Land

Project title	Low-energy Building Standards through Sale of City-owned Land
Sector	Residential buildings
Type of project	Building Standards
City and country	Münster, Germany
City population	282,718 (2009)
Capital cost/initial investment	€227,600 (from the city)
Annual % energy reduction	13 GWh/year
Project status	Ongoing; started in 1997

Project Summary

By mandating low-energy building standards in sales contracts of city-owned land, the City of Münster (Germany) caused a market transformation that led to 80 percent of all new buildings constructed in 2010, even those not built on city-owned land, to follow the city's energy efficiency requirements. The standard, locally known as Niedrig Energie Haus (NEH), imposes stringent thermal performance requirements for the building envelope which exceed the existing German federal building regulations by 30 percent.

The implementation of NEH led to the construction of over 5,600 low-energy housing units and 85 more energy efficient commercial buildings between 1997 and 2010, saving the city 13 million kWh per year while reducing annual CO_2 emissions by at least 3,400 tons in the residential sector by 2010. The benefit-cost ratio to the city was over 6 to 1 and the estimated incremental cost to homeowners was, on average, about €2,600 per house (about 1.4 percent of construction costs). The transformative outcome and positive market reactions encouraged the City Council to propose a passive house standard in the fall of 2010.[1]

The program was fairly low in cost, less than about a half million Euros, invested by the city to achieve substantial savings. However, some of the conditions were very unique; the city owned about 50 percent of the undeveloped land, city residents were supportive of broad scale climate measures, and homeowners had the financial means to absorb a modest incremental cost for the low-energy houses.

1. Introduction

With more than 280,000 inhabitants, Münster is a medium-sized city located in the northwest part of Germany. The total area of the city is 302 square kilometers, of which agricultural land use accounts for 46 percent while buildings and open spaces accounts for 19.3 percent.[2] Its economy is based mainly on financial and public services (85 percent) and the manufacturing industry (13 percent), with an overall GDP of about €12.25 billion (2007)[3]. Münster's eight colleges and universities have close to 50,000 students, making it one of Germany's largest university cities. It is also the center of the *Westphalia* region, serving as

[1] A passive house is a well-insulated and air-tight building heated primarily by passive solar gain and internal heat gains from people, electrical equipment, etc. Active heat demand threshold for a passive house is 15 kWh/m^2 per year, compared with 50-65 kWh/m^2 required by the NEH.

[2] http://www.Münster.de/stadt/stadtplanung/pdf/Faltblatt_Münster_im_Spiegel_2010_en.pdf

[3] http://www.Münster.de/stadt/stadtplanung/pdf/Jahres-Statistik_2009.pdf

the hub of the area with more than 1.5 million inhabitants. In 2009, Münster's average unemployment rate was only 6.5 percent, lower than the 8.9 percent for the region and the 8.2 percent national average. In 2008, the per capita GDP was a third higher in Münster than the national level.[4]

Münster has a long history of promoting energy efficiency and environmental protection. In 1984, the city's building department issued a report highlighting energy efficiency measures such as the renovation of the public swimming pool, Amelsbüren, for which the city received an award from the German Gas producer association.[5] In 1990, the city council issued a directive to develop a comprehensive climate protection plan. This led to the establishment of an Advisory Council consisting of nationally renowned experts with expertise related to energy and climate. The task of the Advisory Council was to devise specific solutions that would allow Münster to reach the German federal mandate of a 25 percent reduction in CO_2 emissions by the year 2005. The Advisory Council presented its final report on climate and energy in 1995, proposing 38 measures ranging from the transport to the housing sector.[6]

Münster followed this comprehensive plan and initiated a series of programs to renovate the existing building stock, to encourage the use of public transport and bicycling, to install district and localized heat plants, and to launch educational efforts in energy efficient lifestyles and waste reduction. Each of these efforts contributed to the city's overall goal, reducing total CO_2 emission by 21 percent from 2.22 million tons (1990) to 1.76 million tons (2005). This translates to a per capita reduction from 8.1 tons to 6.3 tons per year.[7]

The 2005 climate inventory calculated that Münster reduced its CO_2 emissions by 21 percent during that time period. However, several demographic factors complicated Münster's efforts to curb its energy and emissions reduction strategy. For example, between 1990 and 2006, the residential population of Münster rose from 275,150 to 280,023. During the same period, the number of households grew from 127,465 to 146,802, a 15 percent increase. In addition, the total net living space increased from 9 to 11 million square meters (m^2) (21 percent) and per capita living space grew from 34 to 40 m^2/person. Thus, the number of residents per household dropped from 2.2 to 1.9.[8]

This case study focuses on the city's efforts to promote more efficient residential building construction. However, it is important to understand that these efforts were part of a larger and more holistic approach to climate protection undertaken by Münster for the past two decades.

2. Project Description and Design

As part of Münster's comprehensive plan, the Advisory Council recommended measures in the construction and residential sector concerning building standards. Specifically, the Council proposed using the sales contracts of city-owned land as a lever to tighten the building envelope thermal performance requirements for new buildings. The rationale for the focus on the building envelope was that measures to reduce heat load, such as greater

[4] http://www.insm-regionalranking.de/2009pdf/kreisfreie-stadt-muenster.pdf, Federal Statistical Office, www.destatis.de

[5] See "Umweltbericht 1998 Klima und Energie" Stadtwerke Münster GmbH, Umweltamt, Hochbauamt; p.14

[6] Krasutzki, J , et. al. Endbericht des Beirates für Klima und Energie http://aachen2050.isl.rwth-aachen.de/mediawiki/images/0/09/Stadtwerke_M%C3%BCnster_klima.pdf, p.15-16.

[7] Hübner, Andreas, et. al; Klimaschutzkonzept 2020 für die Stadt Münster, p.21

[8] See p.13, Klimaschutzkonzept 2020 für die Stadt Münster Endbericht hier: Auszug der Energie- und CO2 - Bilanz der Stadt Münster

insulation and higher thermal performance windows, are best implemented when buildings are constructed. This is in contrast to other measures, such as boiler retrofits, which could be done by the homeowners later. To fulfill the CO_2 reductions of 772 tons per year by 2005 through building energy efficient houses, the Advisory Council calculated that, depending on the type of structure, such newly constructed buildings should not exceed an annual heating energy demand of 50-65 kWh/m^2 for a building's living space (Table 1).[9]

Table 1. Maximal Annual Heating Use for New Residential Buildings Set by Münster's NEH, 1997-2010

Type of Building	Maximum Annual Heat Use (kWh/m^2-heated floor area)
One/Two Family House (detached) and End of Row House	65
Row House	60
Apartment Building/Multi-floor Building	50

Source: City Council Directive 1093/96, http://www.muenster.de/stadt/umwelt/pdf/1093-96N.pdf

On December 11, 1996, the Münster City Council passed the Niedrig Energie Haus (NEH) standard, which unlike a building code is not mandatory for all buildings, but only those built on city-owned land.[10] Therefore**,** the land sale contracts specify that buildings constructed on this land must meet minimum technical specifications. However, the city-owned land was sold at market price, so there was no imbedded subsidy in the sale. NEH specifications changed the requirements on the maximal annual heating energy use to take into account the financial impact of these measures, especially for builders of smaller buildings.[11] Developers and builders can attain compliance with the NEH by improving architectural design, using thicker or higher performance insulation materials for the exterior wall and roof, installing windows with lower U-values[12], and paying close attention to prevention of thermal bridges and infiltrations in building design and construction.

Compliance requirements. Since 1997, every buyer of city-owned land is contractually obligated to fulfill the city of Münster's heat insulation standards when constructing a building. Sale contracts include a special provision on this requirement. The contractual agreement also requires the developer or builder to provide a thermal insulation certificate by a licensed assessor to the City Council, proving compliance with the NEH. By signing a contract to build on city-owned land, builders in Münster are legally bound to submit a thermal insulation certificate for the NEH. Builders need to hire a licensed assessor for heat and sound insulation to issue the certificates.[13] If a builder fails to supply the thermal insulation certificate three years after signing the contract, the city council can fine the builder with 100 DM (about €50) per square meter construction floor area, adding about 5

[9] Münster City Council Directive 1659/95, p.7; available at: http://www.Münster.de/stadt/stadtplanung/pdf/Jahres-Statistik_2009.pdf

[10] City Council Directive 1093/96, http://www.muenster.de/stadt/umwelt/pdf/1093-96N.pdf

[11] Since the relationship of outer surface to volume is larger in smaller buildings, the City Council changed the Advisory Council's "one size fits all" standard to distinguish between single family homes, row houses and apartment buildings. Without this change, builders of single family homes would have to use building parts with extremely low k-values (0.1-1.3 W/(m^{2}K)), which would seriously impact the financial feasibility of the NEH houses. See City Council Directive 1093/96, http://www.muenster.de/stadt/umwelt/pdf/1093-96N.pdf, p.2-3.

[12] The u-value, or U-factor, represents the rate of heat loss of a building material, insulation, or window.

[13] This reflected a shift in Germany's building energy code enforcement towards self-enforcement which began in the mid 1990s. Instead of federal inspectors visiting the construction site to ensure compliance, the burden of proof was with the architect and builder.

percent of the construction cost of a single family home.[14] From a technical perspective, the NEH standard was about 30 percent more energy efficient than the 1995 federal heat insulation ordinance, also known as WSVO 1995[15] (Table 2).

Table 2. Maximum Annual Heating Requirements for Residential Buildings as a Function of the Area to Volume Ratio (Germany), 1995-2002

Building Characteristics (A/V in m^{-1})	Maximum Annual Heat Use (Interior Vol-in kWh/m3*a)	Maximum Annual Heat Use (kWh/m2*a)
0.2	17.3	54
0.3	19	59.4
0.4	20.7	64.8
0.5	22.5	70.2
0.6	24.2	75.6
0.7	25.9	81.1
0.8	27.7	86.5
0.9	29.4	91.9
1	31.1	97.3
1.05	32	100

Note: The 1995 federal heat insulation ordinance established several standards for heat energy and total energy use of new buildings. Specifically, it set up a balance of the annual heating demand, applying balance methodology during heating periods, used kWh/(m²*a) as a reference, established annual heating demand "Qh" depending on A/Ve. as well as building envelope tightness, and a certificate in heating demand.
Source: German federal heat insulation ordinance, WSVO 1995.

Institutional and technical support. Implementation of the NEH was overseen by the Climate and Energy Coordination Office (KLENKO), formed in 1997. This office was initially staffed with a manager, two engineers, and an administrative officer. Likewise, it coordinated the different administrative units of the city, the City Council, builders, and buyers of city-owned land. KLENKO supervised several parts of the city's climate protection plan, such as building renovation, transport, and maintaining a general continuity of the city's decade-long emission reduction targets. It also ensured that NEH builders certified their building while buyers' questions regarding the regulations were answered.

The City Council faced several reservations in the planning and execution of the NEH. Given the new regulation, builders feared that houses would be harder to build and difficult to sell because of the new bureaucracy and requirements, such as the thermal insulation certificate. Commercial builders used to standardized designs worried about the financial impacts of changing specifications to comply with the NEH regulation. Further, cultural issues, such as the region's preference for clinker brick-built houses, led to fears that the new houses would not fit the building style of the region.

To address these anxieties, the City Council made calculations of comparable building costs available to builders that illustrated the cost competitiveness and livability of the new energy efficient houses. Furthermore, the city made KLENKO's engineers and experts available to commercial builders during the planning phase to help builders minimize the cost of fulfilling NEH compliance and to transfer their know-how.

[14] Penalties were set at 100 DM/m^2 of a buildings floor surface. A typical single family home in Münster has about 180 m^2 floor surface (120 m^2 living space and 60m^2 storage) and costs about €190,000 to build. Penalties are based on City Council directive 1093/96, p.5.
[15] See p.68 "Evaluierung NEH-Standard Münster – Endbericht," GERTEC / IGBEU, 2003

In 2002, the federal building mandate was revised. The new Federal Energy Saving Ordinance, also known as *EnEV,* aimed at reducing end-use heat energy demand by 30 percent. Compared with WSVO 1995, however, it was a more flexible, performance-based approach. Builders could achieve the improvement by installing more efficient heating equipment. Münster's City Council viewed this as a weakening of mandatory requirements on building envelope thermal performance that could create an incentive to build buildings that were not adequately insulated but still looked energy efficient on paper.

In spite of the new federal mandates that made Münster's envelope-centric approach to energy efficiency look stricter – especially in the field of transmission heat loss – builders and residents still embraced NEH and the share of new buildings in compliance with the NEH continued to grow. By 2010, compliance with the NEH reached 80 percent of new building construction in the city, even though only about 50 percent of the new developments were on city-owned land.[16]

Program evaluation and change in compliance enforcement. In 2003, the city hired an independent engineering office to assess the effectiveness of the NEH program. This evaluation examined a sample of 30 houses built under the NEH program and included an analysis of the building plans, insulation materials used, construction quality, as well as blower door tests to measure the airtightness of the houses. While the evaluation showed that the examined houses were, on average, 5 percent more energy efficient than the NEH standard called for, it highlighted several discrepancies between the construction plans, the compliance certificates, and the measured results. As a result, the City Council passed an ordinance offering every builder a voluntary, subsidized quality assurance inspection to ensure proper design and construction of the NEH houses. This new quality assurance procedure involved independent licensed assessors checking the adequacy of thermal insulation, airtightness, mechanical equipment of the building and the avoidance of thermal bridges during the planning and construction phase. However, since residential owners did not have an incentive to undertake this independent inspection, only about 30 building owners have used this subsidized inspection to date.

3. Cost, Financing, Benefits, and Effects

Project Cost. The mandatory low-energy building standard through sale contracts of city-owned land created additional costs for the city of Münster, the builders, and the residents. For the city, additional costs were incurred for the Advisory Council, KLENKO operations, and the inspection subsidy. However, it should be noted that the Advisory Council and KLENKO worked on the full climate plan, not only the NEH standard. In terms of specific costs, the city spent €200,000 for the services of the Advisory Council, €147,000/year for administrative and advisory services provided by KLENKO, and €550 for the subsidy offered for voluntary quality assurance inspections (Table 3).

For builders, added costs varied considerably depending on the year and type of building. While the 2003 evaluation of the NEH houses showed that 20 percent of the surveyed builders reported higher costs when building the NEH houses, a later cost analysis showed that incremental costs can add up to €4,300. The additional costs resulted, for example, from the use of triple-glazed windows and other highly efficient building materials. In 1997, the

[16] Interview with Heiner Bruns, Department of Green Spaces and Environmental Protection, City of Münster, 2/11/2011.

cost of building a typical detached single family home was about €190,000.[17] With the introduction of the quality assurance in 2006, builders could purchase an independent assessment of the construction plan and execution for a discounted price of €550 (this price includes a 50 percent subsidy from the city).[18]

Table 3. Costs and Benefits to the City of Münster

Costs	Benefits
• **Advisory Council €20,000** (€200,000 for the Council, of which an assumed 10% was for the NEH standard) • **KLENKO €191,100** (€147,000 per year, of which an assumed 10% was for the NEH standard, for a 13-year period) • **Quality Assurance Subsidy €16,500** (€550 per house, of which only about 30 owners have used since it was offered in 2003)	• **CO_2 Savings €470,000** (The NEH reduces CO_2 by ~3,400 tons/year, translating into €47,000 Euro/year, 10 yrs)[19] • **Energy Savings €960,000** (The NEH helped reduce heating energy demand by about 5 GWh/yr by 2003, valued at ~€96,000/yr, 10 yrs)[20], • **Quality of Life €0** (While not quantified, the NEH helped to make the city more livable, transformed construction industry, improved energy security, local air quality, etc.) • **City Recognition €0** (Not quantifiable, but Münster received the European Energy Award in Gold in 2005 and 2009; called the "Most livable city of the world" by the International Awards for Livable Communities; selected as Germany's "Federal Climate Protection Capital" in 1997 and 2006 by Deutsche Umwelthilfe, an NGO.)
Total €227,600	**€1,430,000**

Financing. The costs for the Advisory Council were shared by the city and its utilities. From 1996-1999, the utilities also paid for one of the three positions at KLENKO. After 2000, the city paid for the remaining two positions. Builders and owners could take advantage of several low interest building loans, such as from the German government-owned development bank, KfW, as well as tax credits through a first home buyer allowance. These incentives, however, applied to non-NEH buildings as well.

Results and Benefits. In terms of the public costs and benefits, the program was successful. The project resulted in (a) a reduction of the city's CO_2 emissions, (b) additional energy savings in NEH-compliant buildings, compared with the federal standards of the time, yielding a reduction in energy supply, and (c) increased city recognition and livability. The benefit-cost ratio for the program based on these economic benefits is over 6 to 1.

Energy efficiency improvements in new residential buildings. According to the independent assessment of Münster's NEH standard, energy efficient houses reduced heat energy

[17] Prices for Single family homes have been steady in Germany over the last 15 years; see "Der Grundstücksmarkt In Münster, Umsätze, Preisentwicklung und Preisspiegel," 2006, p. 33.
[18] Price quoted is for a single family home. Costs for apartment buildings vary. http://www.Münster.de/stadt/umwelt/neubau_28091.html
[19] Using the European Energy Exchange's CO_2 spot price. See http://www.eex.com/en/Market%20Data/Trading%20Data/Emission%20Rights/EU%20Emission%20Allowances%20%7C%20Spot
[20] Using a natural gas price of €0.019 as reference.

consumption in the residential sector by an estimated 5.8 GWh/yr in 2003. The estimated savings for the 2003-2010 period were 7.5 GWh/year.[21] (Table 4)

Table 4. Energy Savings in New Residential Buildings from Implementing Münster's NEH, 1997-2010

Time Period	Number of Buildings	Average Savings/Bldg (kWh/year)	Total Savings (kWh/year)
1997 – 2002	2,500	2,341	5,853,000 (2003)
2003 – 2010	2,020	3,705	7,484,100 (2010)

Source: "Evaluierung NEH-Standard Münster – Endbericht," GERTEC/IGBEU, 2003, p.57 for 1997 – 2002; Münster Department of Green Spaces and Environmental Protection for 2003-2010.

The costs and benefits of an NEH house. Since the calculations and modeling of the 2002 federal EnEV legislation gave builders more flexibility to comply with the federally mandated energy efficiency targets, building an NEH house became more expensive. The marginal costs mainly depended on what configuration of space and water heating the builder chose to fulfill the new federal requirements. Additional costs of building an NEH house could add up to 3 percent of construction costs, depending on the design of a comparable house compliant with the federal requirements. For builders of NEH houses constructed after 2002, the efficiency measures reduced annual energy use of an average single family home by 3,705 kWh, or about €220/year. [22]

Builders constructing a typical single family house in compliance with the city's NEH standard face reported incremental costs ranging from €1,300 in the early years of the program, to about €4,300 after 2003, which are passed on to homeowners. However, it is possible that some of the builders did not maintain full accounts of their additional construction costs. This corresponds with payback periods of 6.4 to 20 years, or internal rates of return (IRRs) to the homeowner of about 16 and 3.6 percent, respectively. In order to broadly assess the overall cost-effectiveness, one could assume a weighted average incremental cost of €2,640, which leads to a payback period of about 11 years, with an IRR of 7 percent.[23]

Although the NEH standard was estimated to be about 30 percent more efficient than the federal ordinance, only an 18 percent figure was used for the benefit calculations to be conservative. The 30 percent figure is supported by the thermal insulation certification provided by the builders of NEH houses. However, when a 2003 evaluation, which included blower door tests, was performed on a sample of the NEH buildings, the heat energy used was only about 18 percent less than the stated WSVO levels. The city noted that

[21] Between 1996 and 2003, Münster's environmental administration documented the type of construction and the heat energy requirements of 216 of the NEH buildings. The 2003 evaluation examined 30 additional NEH buildings, growing the sample to 246 buildings, or 10% of Münster's total NEH building stock. These 10% are representative of the type of construction and size of the total NEH residential stock. See p.26 "Evaluierung NEH-Standard Münster – Endbericht," GERTEC/IGBEU, 2003

[22] When the comparable EnEV house is heated with district heating, a model NEH house (786.4 m^3 Space, 186.7 m^2 total area; of that 124.5 m^2 living area) with gas heating costs €4,256 more. If the EnEV house is equipped with solar panels to reach the requirements, the comparable NEH house with gas heating will cost slightly less (~ €300).

[23] Author's calculations of weighted average of incremental costs, based on €1,300 for 1997-2003 and €4,300 for the 2003-2010 period over a 20-year period, based on data submitted by Münster's Department of Green Spaces and Environmental Protection of an average NEH single family home built after 2002 with natural gas heating compared with an EnEV single family home with district heat. If builders chose to add the quality assurance, the numbers change to a payback period of 13.3 years and an IRR of 5%.

performance of the WSVO buildings generally suffer from similar weaknesses, so the 30 percent estimate is a reasonable figure.

Reduction of the city's CO_2 emissions. In 1995, the Advisory Council on Climate and Energy estimated that the mandated low energy building standard could save up to 772 tons of CO_2 per year by 2005. However, the city's assessment in 2003 indicated that by 2002, the city had doubled its target. According to an independent evaluation of 30 NEH standard houses in 2003, 67 percent of examined houses showed that NEH houses exceeded the standard by between 1 and 26 percent in terms of annual heat energy consumption. The remaining third showed heat energy use between 1 and 31 percent above the NEH. (These deviations are due to the fact that these buildings have windows with higher K values and thinner outer insulation.) In the ongoing years, the NEH program further reduced the city's emissions by 1,960 tons of CO_2 per year.[24]

Increased public awareness of energy efficiency in the city and beyond. Münster's mandated low energy building standard has been received positively within and beyond the city. The 2003 survey of builders found that over 80 percent of respondents would recommend building NEH houses.[25] All respondents considered the city's mandate adequate and mentioned the benefits of long-term savings in the face of rising energy prices and general environmental benefits resulting from living in a low-energy house.

Münster's environmental and efficiency measures have contributed to the city being called the "Most livable city of the world" by the International Awards for Livable Communities. The city also received the European Energy Award in Gold in 2005 and 2009. The German NGO Deutsche Umwelthilfe selected Münster as Germany's "Federal Climate Protection Capital" in 1997 and in 2006.[26]

4. Project Innovation

The most innovative feature of Münster's approach to improving energy efficiency in new buildings is the use of municipal-owned land as leverage for stricter requirements on building envelope insulation. With Münster owning close to 50 percent of all land for real estate development in the city, the city realized it could use a "regulation by contract" approach to push local construction to exceed the federal building code requirement for energy use. The city's energy efficient building policy lead to a market transformation resulting in nearly 80 percent of all newly constructed buildings on both publicly- and privately-owned land in Münster being built according to the NEH standard.

Other innovative measures included:

- Development of a holistic approach to climate mitigation and energy savings that not only addressed buildings, but also transportation, district heat and local power plants, waste reduction, and public education in more sustainable living.
- Setting of the standard to require only a few percent incremental cost above the federal standard, which was well within the means of the city residents and did not require substantial subsidies to foster high compliance.

[24] Evaluierung NEH-Standard Münster – Endbericht," GERTEC / IGBEU, 2003; Calculations from Münster Department of Green Spaces and Environmental Protection P. III; CO_2 calculation from Gertec-Evaluation f = 262 g/kWh

[25] P.III Evaluierung NEH-Standard Münster – Endbericht," GERTEC / IGBEU, 2003

[26] Bruns, Heiner; Athens 2009: The City of Münster's Climate Protection Concept, Department of Green Spaces and Environmental Protection, 11/2/2009, p. 22

- Support for builders through the provision of energy efficiency experts during the planning and constructing of buildings helped builders improve compliance and reduce additional costs. Creation of a coordination office, KLENKO, and participation by the city's public utilities also helped lead to a sustained commitment to Münster's energy efficiency measures.

5. Lessons Learned

Because the city of Munster has been implementing the NEH standard for more than a decade, it has gained valuable experiences and lessons learned about such programs. Some of these include:

- *Confronting prejudices*. Providing builders with cost calculations for houses built according to the NEH standard helped to overcome skepticism about the financial and technical feasibility of the mandated energy efficiency standard. This information, along with upfront communication and the provision of expertise to commercial builders before the sale of a plot, helped reduce uncertainty among builders and buyers.
- *Changing construction practices*. The 2003 evaluation discovered that the lightweight structure houses surveyed fulfilled Münster's NEH standard more consistently than the traditional clinker brick solid structure ones. This was due to better insulation characteristics of the construction materials used.[27] These findings led local builders, which in 1990 almost entirely built traditional solid structure houses, to construct more light structure buildings. By 2010, about one-third of all new buildings were designed and built as light structure buildings.[28]
- *Improving compliance support*. There were several barriers to achieving NEH compliance. Builders often did not capture the cost-effective potential of a buildings' heat energy consumption and sometimes provided incorrect heat energy use declarations due to miscalculations of insulation material, windows, material used and volumes and areas measured. The city also faced ongoing deregulation in the building sector which resulted in lower resources to inspect builder compliance with efficiency guidelines. Therefore, the City Council introduced a voluntary quality assurance inspection. During the planning phase and construction of the building, assessors would check thermal insulation, airtightness and technical equipment of the building and make sure that the architects avoid thermal bridges. But even with the city's €550 subsidy of the quality assurance inspection (50 percent of the total cost), few builders or owners actually accepted the city's offer.[29] This was likely due to the lack of incentive to take on this additional step with additional cost, if it was not required.
- *Feasibility of self-enforcement*. Germany's practice of moving the burden of proof of building energy code compliance away from the government building authorities and towards builders and private citizens is rather unique. However, self-enforcement is a model that most likely would not work in countries with weaker governance structures. Using federal (or municipal) inspectors to check compliance of mandatory

[27] P.V, P.III "Evaluierung NEH-Standard Münster – Endbericht," GERTEC / IGBEU, 2003
[28] Interview Heiner Bruns, Department of Green Spaces and Environmental Protection.
[29] http://www.Münster.de/stadt/umwelt/neubau_28091.html, Interview Heiner Bruns, Department of Green Spaces and Environmental Protection.

building energy codes would add to a city's administrative costs, but self-compliance appeared to be well-suited and quite effective for Münster, based on their evaluation.

- *Developing a city-wide political consensus*. A strong political consensus within the City Council and all political committees helped to develop the climate plans and to enforce efficiency measures in all areas, including the design and implementation of the NEH standard. The decade-long consultations of all political entities, churches, building societies, and members of the building trades led to an environmental consensus that elevated climate protection to the top of the city's priorities, transcending party lines and all parts of Münster's society.
- *Accountability and transparency*. The egalitarian approach to the implementation of the city's efficiency measures also helped the program meet its goals, regardless of the builders' political connections or the amount of employment created. For example, the large commercial buildings of the insurance company LVM or the paint company Brillux were built according to the city's NEH standard, even though following federal standards might have been less costly and bureaucratic.[30]

  To balance the political goals of CO_2 reductions and the financial impact of the NEH standard on Münster's citizens, the City Council lowered the Advisory Council's recommendation for stricter heat energy guidelines. This ensured that the City Council's environmental measures were not seen as arbitrary and allowed builders' investments in efficiency to result in economic benefits from the efficiency measures.
- *Social norms*. The Advisory Council also recommended that the NEH buildings in Münster be smaller than the conventional ones. However, the city was not successful in implementing this recommendation which, given demographical change in both Münster and Germany and societal pressures of building larger houses, was not within the realm of the city to control.

6. Financial Sustainability, Transferability, and Scalability

Economically speaking, the project was a success for the city and for builders alike. While a complete quantification of the city's benefits is difficult, the project investments for the Advisory Council is generating ongoing healthy returns of CO_2 and heat energy savings and increased national and international awareness, while adding to the education of an energy efficient-savvy citizenry. Also, the city did not have to commit vast resources, in implementation costs or subsidies, to implement the program. This helps to ensure that the program is sustainable.

Homeowners have benefitted from the city's energy efficient building standards. A weighted average incremental investment of €2,640 generates an IRR of 7 percent. If builders chose to add the subsidized quality assurance to their house, the IRR would decline to about 5 percent. The fact that 80 percent of the new buildings, even those not built on city-owned land, complied with the standard is a testament to the acceptance of the NEH standard and its market transformation success.

Given that both Germany and the City of Münster have set ambitious long-term CO_2 emissions reduction goals, the use of mandated low-energy building standards is a highly recommendable strategy to reduce the city's energy and CO_2 footprint. Together with the city's several other energy and emission savings strategies, and Münster having reduced its

[30] See http://www.new-worxs.de/live/projekte/show.php3?rubrikID=6&id=25&zf=0, and http://www.azonline.de/lokales/muenster/wirtschaft/1083285_Brillux_baut_Bueroturm.html

CO_2 footprint by 21 percent between 1990 and 2005, the NEH standard is a successful and sensible tool to reduce energy and CO_2 as well as to build a greener city. The success of Münster has led several other cities in Germany, such as Frankfurt, Heidelberg, Hanover and Dortmund to pass similar legislation.[31]

However, some of the conditions were unique; the city owned about 50 percent of the undeveloped land, city residents were supportive of broad-scale climate measures, and homeowners had the financial means to absorb a modest incremental cost for the low-energy houses. While some of these circumstances may not be easily replicated in other countries, the concept of using sale contracts to promote or impose stricter standards may be applicable.

References

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[31] Interview with Heiner Bruns, Department of Green Spaces and Environmental Protection, City of Münster, Feb. 10 2011.

ANNEX: CITY AND PROJECT PROFILE

CITY PROFILE

1. Name of the City	**Münster, Germany**
2. Area	**302 km^2 (30,296 hectares)**
3. Population	**282,718 (2009)**
4. Population Growth Rate	**0.6% (2008-2009)**
5. GDP of the City	**€12.25 billion (2007)**
6. GDP Growth Rate	**1.3% (2008)**
7. GDP per Capita	**€43,318 (2007)**

PROJECT PROFILE

1. Project Title	**Low-energy Building Standards through Sale of City-owned Land**
2. Sector	**Buildings**
3. Project Type	**Buildings standards**
4. Total Project Capital Cost	**€457,750**
5. Energy/Cost Savings	**7.5 GWh/year**
6. Simple Payback	**n.a.**
7. Project Start Date	**January 1997**
8. Project End Date	**Ongoing**
9. % of Project Completed	**Ongoing**

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