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## 斯堪的纳维亚半岛

可持续发展的城市与建筑

SUSTAINABLE URBANISM AND  
ARCHITECTURE IN SCANDINAVIA



# 可持续发展的城市与建筑

## SUSTAINABLE MUNICIPALITY AND BUILDING

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### 一、可持续发展的城市

如果一个城市不与周围乡村结合,它永远不可能是可持续发展的。为可持续发展的未来进行规划,必须同时考虑城市和乡村的脉络。对于这个目标来说,自治市可能是合适的规划区域。对于可持续发展规划,自治市的边界并不总是合适的区域。但如果你开始你的自治市规划,就必须与周边的自治市合作。

#### 1. 土地利用

##### 耕地

耕地应该保护并主要用于食物的生产。食物生产必须是生态的。这主要是指避免使用化学杀虫剂和化肥。应该采用轮作、草料、牧场和休耕地来提高土壤肥沃、土壤结构和腐殖质的量。另一个重要方面是保持牲畜与饲料的平衡,以避免营养渗透到水体。部分耕地也可以用来种植能源作物、果园、商业花园、花园城市 and 可以采食的公园把城市与乡村连接起来。

##### 森林

森林是能提供木材、纸和生物能量的重要资源。林业生产应采用混合种群和间伐等符合生态原则的方式。生物多样性与自然中优美的部分必须被保护。森林也能提供给我们蘑菇、浆果和捕获野生动物的可能性。一定不能忽视森林区域和其他自然休闲区的重要性。沿着河床和山体陡坡上的树林对避免土壤侵蚀很重要。

##### 水体和湿地

生存离不开水。水体必须保护才能用来生产饮用水。湿地作为自然营养的载体,能改进污水处理的功能。水体规划必须运用比通常更加多样化的方式。这意味着必须为保护地下水、地表水和雨水做规划。必须仔细地研究。如何生产饮用水和何处适合水厂选址。生产食物的水产业和能源作物可能是这个系统的一部分。使用水力发电和潮汐能量的可能性必须被考虑。在矿地,如有强风的海滨和浅水区,风能可以被利用。

##### 城市

城市将被很好地整合在区域中,这是一个与自然和谐相处的城市。那里有价值的自然和生产用地被保护。发展将集中在合适的地方,集中与分散的平衡将是目标。城市结构将与交通基础设施整合,目的是把交通量最小化。规划一个混合使用的城市(大部分功能分布在较短的距离内)能达到这个目的。这个城市也将以生态气候方法规划来改进当地的小气候。作为生态气候设计的一部分,城市中的水体和绿地对于空气质量和休憩很重要。生态气候走廊、林荫大道和生态气候公园渗透进城市结构中。

### 2. 基本需要

#### 交通

交通系统必须多样化,包括步行、自行车、公共交通、火车,也包括小汽车和卡车的交通。重点关注步行、自行车和公共交通交通。这样,小汽车不会在城市中占有支配地位。交通系统必须为环保交通工具(使用混合技术的节能车辆)和CO<sub>2</sub>中等排放水准的燃料进行规划。

#### 人居环境

住房必须适当地气候。必须采用严格的能源规范。我们能建造不需任何采暖系统和采暖需要非常少的房屋(被动式房屋),以可再生资源来满足采暖和热水利用。一个好的室内气候是追求的目标。这意味着使用有利于健康的材料和功能完备的空调系统。

#### 食物

发展以生态种植方式的本地食物生产,食物品质和口味是主要目标。西方世界的一大问题是人们正变得更胖。许多企业的食物产品含有化学杀虫剂。产品中维生素和营养成分也比生态食物产品要少。结果之一是,我们必须降低肉类消费,因为肉类产品的生产需要投入很大的资源。

#### 城市生活

规划的目的应该是使城市能激励城市生活。那里,人文尺度和城市文明很好地结合。城市应该是一个感觉舒适、安全的、健康的和幽美的地方。那里,人们能生活、工作、得到服务和娱乐休息。它应该是每个人的城市。有许多功能和多样性来激励城市生活,一个民主的城市应该是这样一个地方。那里,文化的和社会的特性被保护和发展的。一个民主的城市有一个居民可以影响和参与规划系统。可持续发展的生活方式意味着更多非物质的消费代替膨胀的物质消费。

#### 3. 技术

##### 运输部分

运输用的燃料应该不再用化石燃料,使用新技术生产燃料。如果自有机废物生产的沼气,来自能源农作物的酒精,以林木为原料制造的甲醇,或来自有机材料的生物柴油。电动车辆能被用于公共交通和短途运输。燃料电池和氢是其他可能应用的技术。

##### 住房部分

城市应该用集中采暖或冷却系统。电源和热源或冷却应该由联供电厂生产。联供电厂应该以林业、农业、工业和家庭中的可燃物作燃料。生产建筑材料的锯木厂和利用木材废料制造燃料芯的工厂是当地重要的工业。能源系统中一部分可以利用热泵技术。光能和太阳能集热器应该覆盖住房朝南的立面和屋顶。利用这些技

术,城市将自产电能。

##### 食物部分

为制造本地生态食品成为可能,必须创造特殊的基础设施。这意味着我们需要关注当地生态产品的匮乏、屠宰场、牛奶厂、磨粉场、面包师和酿酒厂。必须建立可选择销售途径。这样,本地小生产者能够销售他们的产品。方法可能是农贸市场、保健食品店,或者当地农民等农产品的上门直销。应该加强政策策略来激励本地产品销售到学校、医院和其他公共机构。餐馆和本地农民的合作是普及优质和健康食品的一个途径。

##### 废弃物处理

废弃物是一种资源。它能分为两大类:有机废料和无机废料。无机废料应该在设计产品时减至最少,进行分类和循环利用。有毒废弃物必须小心处理。有机废料在营养循环利用和保护土壤肥力方面担当着重要角色。它应该保持干净,避免污染。通过沼气站或堆肥处理再回到耕地中。保持耕地含有大量的腐殖质对于生态农业是非常重要的。可燃废料焚烧可生产能源。纸张能被回收,纤维素作为绝缘材料利用等。

##### 污水

污水应分类,如分为黑水(厕所污水)、灰水(洗浴、洗衣、洗碗污水)和交通污水(停车场和街道污水)。每一类污水应以合适的方式净化。富含营养素的黑色污水可在沼气站处理(图1,2)。

### 二、可持续发展的建筑

如果你研究一栋建筑的全寿命耗资,从长期来看,建造一个更贵的节能房屋从而使运行费用尽量减少总是更经济。从一种气候区到另一种,这怎么能做到?这里将介绍在瑞典这样的寒冷气候区我们是怎么做生态建筑的。

#### 节能

在寒冷气候区,很明显需要全面的隔热。为减少能量损失,我们在屋顶使用50-55cm厚的隔热层,墙体使用30-35cm,地板使用25-30cm。建筑构造应该是密封的并且没有冷桥。使用非常好的隔热窗,它有3层玻璃,一些玻璃表面是低辐射的,玻璃之间充入惰性气体代替空气,窗框有低的传热率。这样,U值可低于10W/m<sup>2</sup>K。余热回收的热交换空调系统普遍使用。体型紧凑的建筑减少屋顶和外墙表面积从而减少热损失。压力测试和热成像摄影技术用来保证技术品质。

#### 电能使用

住房装备节能的家用电器设备(冰箱、冷冻箱、洗衣机、干衣机、洗碗机、电炉和烤箱)和节能照明系统。当不需要时,调控系统关闭照明、电器设备和通风系统。好的自然照明,地冷储存库和自然晾干可减少电能需求。

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### Sustainable Municipality

A city can never be sustainable if it doesn't interact with the surrounding countryside. The way to plan for a sustainable future has to deal with the urban and the rural context at the same time. The municipality might be the right planning area for this purpose. The boundary of a municipality is not always the right area for sustainable planning, but if you start your planning of your municipality you also have to cooperate with the surrounding municipalities.

#### Land Use

##### Arable land

The arable land should be protected and used mainly for food production. And the food production has to be ecological, which mainly means to avoid chemical pesticides and the use of artificial fertilisers. Rotation of crops, fodder, grazing land and fallow should be used to enhance soil fertility, soil structure and humus amount. Another important aspect is to maintain a balance between production of cattle and fodder to avoid leakage of nutrients into the water recipients. Parts of the arable land can also be used for growing energy crops. Orchards, commercial gardens, garden cities and edible parks connect the city to the countryside.

##### Forests

The forests are important resources that can give us timber, paper and bio-energy. The forestry should be made in an ecological manner with mixed species and felling by thinning. Bio-diversity and beautiful parts in nature should be protected. The forests can also supply us with mushrooms, berries and a possibility to hunt wild animals. The importance of forest areas and other nature areas for recreation mustn't be neglected. Trees in steep mountain areas and along riverbeds are important to avoid soil erosion.

##### Water and wetlands

Water is essential for surviving and must be protected so that it can be used for producing drinking water. Wetlands act as natural nutrient traps and could improve the function of sewage work. Water planning has to be done in a much more diversified way than usually, which means that plans have to be made for the protection of ground water, surface

water and rain water. Careful studies must be done how to produce drinking water and where to situate the water works. Aquacultures for producing food and energy crops could be part of the system. Possibilities to use hydropower and wave power should be considered. In open land, on seashores and on shallow waters where strong winds are blowing, wind power can be utilized.

#### The city

A city shall be well integrated in the region. It's a city in harmony with nature, where valuable nature and productive land is protected. Development shall be concentrated to suitable places and a balance between concentration and decentralisation shall be aimed at. The urban structure shall be integrated with the traffic infrastructure where the goal is to minimise transports. Planning a mixed-use city with short distances to most functions can do this. The city shall also be planned in a bio-climatic way to improve the local microclimate. Green areas and water in the city are important for air quality and recreation, and as part of the bio-climatic design. Bioclimatic corridors, boulevards and bioclimatic parks penetrate the city structure.

#### Basic Needs

##### Transports

The transport system should be diversified into pedestrian and bicycles, public transport and trains as well as cars and lorries. The emphasis has to be on pedestrians, bicycles and public transport systems so that cars don't dominate the city. The transport system should be planned for environmental vehicles (energy efficient vehicles using hybrid technologies) and CO<sub>2</sub>-neutral fuels.

##### Habitat

Houses should be adapted to local climate. Strong energy regulations should be applied. We can build houses that don't need any heating systems (so called passive houses) or houses where the heating needs are very small. The heating and hot water needs must be supplied with renewable energy resources. Electricity and water saving devices shall be used as well as garbage sorting and recycling. A good indoor climate is aimed for, which means the use of healthy materials and well functioning ventilation systems.

#### Food

Local food produced with ecological farming methods are developed. Food quality and taste should be the main target. One of the big problems in the western world is that people are getting fatter and that lots of industrially produced food contains chemical pesticides and the content of nutrients and vitamins are lower than in ecologically produced food. One consequence of this is that we have to reduce meat consumption, as meat production demands a big input of resources.

#### City life

The goal for planning should be cities that stimulate city life where human scale and urbanity is combined. The city should be a nice, safe, healthy and beautiful place where people can live, work, get service and recreation. It should be a city for everyone, a city with many functions and diversity that stimulate city life. The city should be a place where cultural and social identity are preserved and developed. A democratic city has a planning system where its inhabitants influence planning and management. A sustainable lifestyle means more immaterial consumption instead of exaggerated material consumption.

#### Technology

##### Transport sector

Fuel for the transport sector should no longer come from fossil fuels. Biogas produced from organic waste, ethanol from energy crops, methanol made of raw material from the forest or bio diesel from organic materials is technologies to be used. Future cars and lorries should be made energy efficient and use plug in hybrid technologies. Electric vehicles can be used for public transports, and for short distance transports. Fuel cell technologies and hydrogen are other possibilities.

##### Housing sector

Cities should be heated or cooled by central systems. Electricity and heat or cooling should be produced in co-generation plants. The co-generation plants should be fuelled with burnable waste from forestry, agriculture, industry and households. Sawmills that produce building material and factories making pellets from wood waste are important local industries. Heat pump technologies



- 1 可持续发展的城市 / Concept sustainable municipality area:
- 一个建立在台湾台南 2.5 万居民的新生态城市规划。在老城冲有联系台湾南部和北部的火车快线。这个新城是围绕火车站建设的几个新城之一。规划区包括了城区和周边乡村。这个规划是由 Joachim Bile (德国), Rolf Messerschmidt (德国), Chris Buzens (挪威) 和 Vania Bakalides (瑞典) 在 2005 年实现的。/ Plan of a new eco-city near Tainan, Taiwan, for 25 000 inhabitants. The new city is one of several built around railway stations on a rapid train line, placed outside the old cities, that connects north and south Taiwan. The plan contains both the city and the surrounding countryside. The plan is made 2005 by Joachim Bile (Germany), Rolf Messerschmidt (Germany), Chris Buzens (Norway) and Vania Bakalides (Sweden).
- 运输系统 / Transport system
- 包括到台北的快速列车, 到台南老城的轻轨 (有轨电车), 到其他城市的穿梭巴士, 本地公交车巴士, 人行和自行车系统。/ Contains rapid train to Taipei, light rail (tram train) to the old city of Tainan, fast buses to other cities, local buses, pedestrians and cyclists.
- 城市区域 / City area
- 包括密集的城区 (5-7 层), 花园城区, 生态村 (乡村), 混合功能城区, 绿色产业和绿色大学。/ Contains concentrated townships (5-7 stories), garden cities, eco-villages (in the countryside), mixed use areas, green industry and a green university.
- 绿色区域 / Green area
- 包括森林, 生态农田, 果园, 能量农作物, 生态公园, 行道树, 湿地和绿色河流。/ Contains forests, ecological farmland, orchards, energy crops, bioclimatic parks, trees in the streets, wetland area and green river beds.
- 湿地 / Wetland area
- 包括一个湖, 淡水处理, 交通废水处理, 河道净化区, 雨水蓄积区和城市中的水池和喷泉。/ Contains a lake, wastewater treatment, water treatment, river purifying area, rain water retention area and ponds and fountains in the city.
- 能源系统 / Energy systems
- 包括生态农业作物的区域, 酒精厂, 沼气站, 多种能源合作生产的工厂, 服务城内的中央冷却系统, 屋顶光伏和太阳能集热器和风力发电机。/ Contains areas for growing energy crops, ethanol plant, biogas plant, co-generation plant, overall cooling system for the city, photovoltaic and solar collectors on roofs and wind generators.
- 公共设施 / Public facilities
- 包括火车站, 购物中心, 学校, 体育设施, 健康中心, 图书馆和会议中心, 休闲设施。/ Contains railway station, shopping area, sports areas, schools, sports facilities, health centre, temple, hotel and conversion areas, and leisure facilities.
- 2 生态城市和乡村流程图 / Flow scheme ecological city & country
- 可持续发展的城市 / The sustainable municipality
- 在一个可持续发展的自治市, 城市和乡村相互有紧密的联系。它由许多不同的提供社会基本需要的生态岛组成, 目的不是自给, 目的是更有效地利用本地资源, 避免营养浪费, 减少气候变化。去创造一个刺激本土文化, 本土产品和本土经济发展的自治区。/ In a sustainable municipality the city and the countryside are closely related to each other. They are connected by many different eco-cycles to provide the basic needs of the society. The aim is not to be self-sufficient. The aim is to use local resources more efficiently, to avoid leakage of nutrients, to minimize climatic change, and to create a municipality where local culture, local production and local economy is stimulated.

水

住房节省水型的洗衣机, 洗碗机, 淋浴和水龙头是节水型的并有一个控制手柄。马桶使用很少的水 (每次冲洗用 2-4 升水), 并有两个按钮控制不同的冲水需要。在缺水地区使用真空抽吸马桶 (每次冲洗用 1 升水) 或尿分开的干厕。

垃圾

厨房有足够的空间供垃圾分类, 有机垃圾在当地堆肥。市场上有功能完好的堆肥箱和堆肥机器可利用。纸, 瓦楞纸板, 玻璃, 金属和硬塑料可收集起来循环利用。建筑配有可锁定的空间供有毒废物的安全存放。其他废物由市政部门收集处理。

可再生的热能

住房还需要热水和一些采暖, 用可再生能源来获得这些能量。通常你在居室安装一个燃料电池的炉子, 炉子有水包裹, 在屋顶安装太阳能集热器, 以及一个绝缘的水箱来蓄热。另一种选择是使用现代热泵系统, 但那意味着增加使用电能。如果住房在城区, 它可以由区域采暖系统供热。

可再生的电能

简单的方法是从电网购买绿色电 (水电, 风力发电),

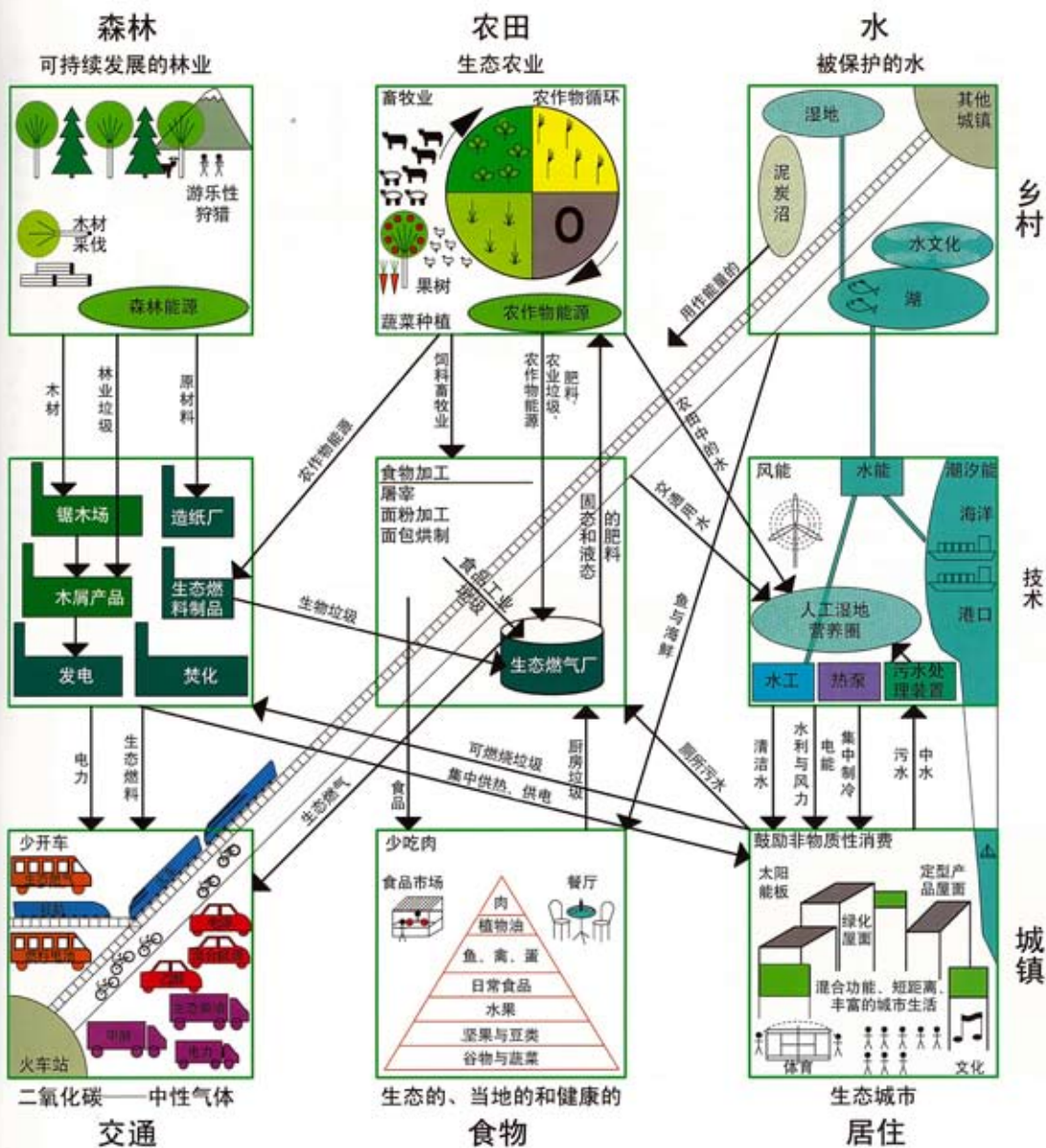
沼气发电), 新技术, 如光伏板和风力发电机配以蓄电池正在变得便宜。你用这样的系统能自己发电或至少有一个独立的后备系统。另一种正在发展中的新技术是用燃料芯作燃料的联供电厂 (涡轮发动机)。

污水

如果住房所在的区域没有污水处理系统, 你可以自己解决。如今市场上有好几种功能很好的本地污水处理系统。你可以选择一个紧凑的过滤器, 或一个小型的污水处理设备。通过把污水分类, 如尿, 黑水 (马桶和厨房切菜器污水), 灰水 (洗浴, 洗衣, 洗碗污水), 你可以简化本地的污水处理, 人工湿地可以被用来做最后的净化。

材料

所有建筑材料要从健康角度进行监控, 不使用有毒物质。诱导有机体突变或再生麻烦的化学物质, 或引起过敏反应的物质, 有很小生态印迹的材料被优先考虑。你研究功能相似的材料并且比较资源和能量的使用, 也包括每个单位材料产生的空气污染, 水污染和土壤污染, 如重金属和有机化学品等有毒物质是持久稳固的, 在生物体积累的或有毒的物质主要存在于涂料, 胶水和粘剂剂中。当你设计一栋建筑时, 可以去选择健康材料, 以纤维制品做隔热的水屋是一个不错的解决方案, 其基本



的隔热材料采用玻璃纤维。

#### 服务

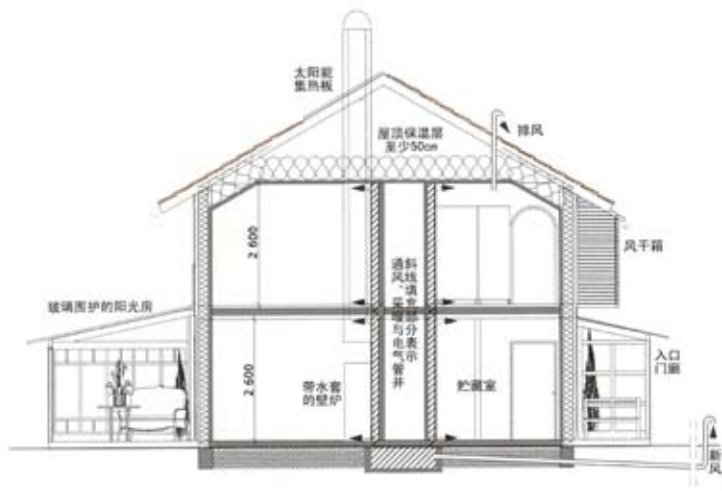
使用可根据需要进行调节的节能空调系统,自然通风系统和机械通风系统可结合成巧妙的混合系统。所有空调管道要容易清洁,给排水系统的安装要经过渗漏测试,电力系统的安装要以电磁场影响最小的方式安装,采暖要通过散热器、地板或墙体进行低温加热。

#### 建筑物

房屋建造要避免湿气问题,基础建造要能阻止蒸气从地下进入建筑,建筑物和服务设施经过设计使人能得到健康和安静的室内气候,设计的房屋便于使用,清洁和维护。

#### 执行

不同建筑构件都在干燥、清洁和在工厂控制条件下建造。建筑在基础上组装很快,当墙和屋顶就位,余下的工作能在室内进行,以这种方式建造,受恶劣天气影响的可能性很小,每个参与房屋建造的人经过环境问题的教育,这样,大家都知道我们正在追求什么目标,最后产品的控制是惯例,独立住房的买主可得到10年的产品质量保证(图3-5)。□



• 瓦里斯·帕卡戴斯 (Varis Bokalders) 是瑞典可持续建筑和规划设计方面的专家,他早年毕业于瑞典皇家理工学院建筑系,并在该系从事多年的可持续设计教学和研究工作,他还曾任瑞典皇家科学院Berijer协会研究员专门进行再生能源及其在发展中国家应用方面的研究。此后,他在斯德哥尔摩环境研究院工作,目前,他开设了一家私人建筑事务所,同时著书立说,并在世界各地大学开设可持续建筑和规划的讲座,最近他正从事台湾一个2.5万人的可持续社区规划项目。

玛丽亚·布洛克 (Maria Block), 瑞典皇家建筑师协会会员, 斯德哥尔摩布洛克建筑事务所 (Block Arkitektkontor) 负责人, 1991年获得瑞典Chalmers理工学院建筑学硕士, 她和瓦里斯·帕卡戴斯合作完成5本有关生态和可持续设计方面的著作, 最新一本为2004年出版的“生态设计策略”, 她擅长生态建筑设计, 能够承担各类规模项目的概念设计直至施工图纸, 还参与众多投标项目的评审工作。

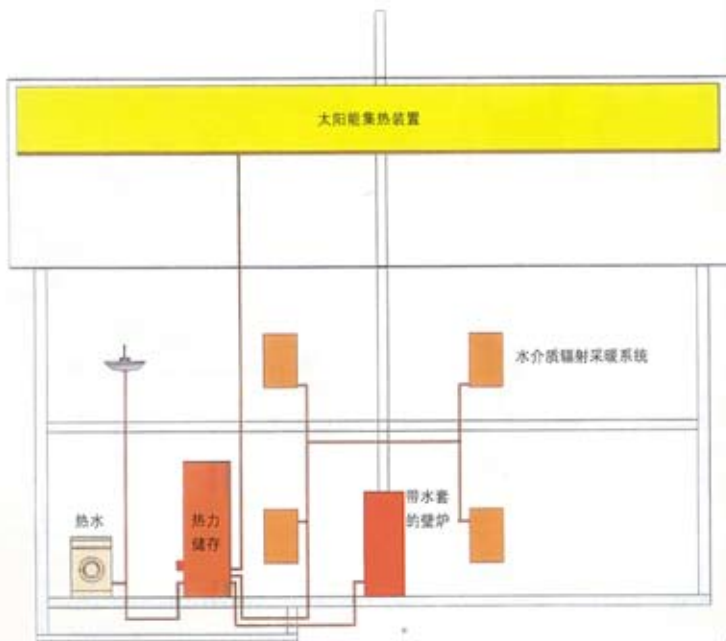


2. 独户住宅/Respective single family house

适用于瑞典传统红色木舍的概念性生态独户住宅(建筑师/Architects, Maria Block, Varis Bokalders)/Ecological concept single family house adopted, in this case, as sustainable Swedish traditional red cottages

4. 独户住宅技术原理/Principle action single family house(建筑师/Architects, Maria Block, Varis Bokalders)

5. 独户住宅采暖系统/Heating system single family house(建筑师/Architects, Maria Block, Varis Bokalders)



could be utilised as parts of the energy system. Photovoltaic and solar collectors should cover south facing roofs and facades. With this kind of technologies cities will produce their own electricity.

#### Food sector

To make ecological local production food possible specific infrastructure must be created. It means that we need slaughterers, butcheries, dairies, mills, bakeries, and breweries in the area that are concerned with ecological production. An alternative distribution must also be built up so that small local producers can distribute their products. Methods for this can be farmer markets, health food shops, or direct distribution from local farmers to your door. Political strategies should be enhanced to stimulate purchase of local products to schools, hospitals and other public institutions. Co-operation between restaurants and local farmers is one way to popularise good and healthy food.

#### Waste management

Waste is a resource; it can be divided in two main parts, organic waste and non-organic waste. The non-organic waste should be minimised in design, sorted in different fractions, reused and recycled. Toxic waste must be handled with care. The organic waste has an important role in recycling nutrients and in maintaining soil fertility. It should be kept clean from pollutants, treated in biogas plants or composts and distributed back to arable land. Maintaining high humus content in arable land is important for ecological farming. Burnable waste can be used in incineration plants for co-generation. Paper can be recycled i.e. as insulating material (cellulose fibre).

#### Sewage

Sewage should be sorted in different fractions like black water (toilet water), grey water (from showers, washing and dishwashing), and traffic water (from parking lots and streets). Each fraction should be cleaned in an appropriate way, and the black water (rich in nutrients) can be treated in biogas plants.

#### Sustainable Building

If you study the lifecycle cost of a building it's always more economic in the long run to build an energy efficient house that's more expensive to build so that running costs can be minimised. How this can be done changes from one climate zone to another. Here we will tell how we work with ecological buildings in Sweden, in a cold climate.

#### Energy efficiency

In a cold climate extensive insulation is evident. To reduce energy losses we use 50-55 cm in the roof, 30-35 cm in the walls and 25-30 cm in the floor. The construction should be airtight and without cool bridges. Super insulated windows are used, with three glasses, low emission surfaces on some of the glasses, gas instead of air between glasses and frames with low

conductivity. In this way you can reach U-values below 1,0 W/m<sup>2</sup>K. Heat recovery from ventilation with heat exchangers is common. A compact form of the buildings minimise the surface of roof and external walls, and reduces heat losses. Pressure tests and thermography are used to guaranty quality in craftsmanship.

#### Electricity use

The houses are supplied with energy efficient household equipment (refrigerators, freezers, washing machines and dryers, dishwashing machines, stoves and ovens) and energy efficient lighting systems. Regulating systems turns off lighting, electric equipment and ventilation systems when they are not needed. Good day lighting, earth-cooled larders and possibilities for natural drying minimises electricity needs.

#### Water

The houses are equipped with water efficient washing machines and dishwashers. Showers and taps are water saving and have one handle control. Toilets installed use very little water (4 and 2 litres per flush) and have two buttons for different flush-water needs. In areas with shortage of water vacuum toilets (1 litre per flush) can be used or urine separating dry toilets.

#### Garbage

In the kitchens there is adequate space for sorting the garbage in different fractions. Organic garbage is composted on site. Well functioning compost bins and composting machines are available on the market. Paper, corrugated cardboard, glass, metal and hard plastic are collected for recycling. The buildings are equipped with a lockable space where toxic waste can be safely stored. The rest of the garbage is collected and taken care of by the local municipality.

#### Renewable heat

The houses still need hot water and some heating. To get this energy with renewable energy, you usually install a pellets burning stove with a water jacket in the living room and a solar collector on the roof, and an insulated water tank for heat storage. Another option is to use a modern heat pump system, but that means an increased use of electricity. If the house is in a city it can be heated with district heating.

#### Renewable electricity

The simplest way is to buy "green" electricity (hydro, wind or co-generated by biomass) from the grid. New technology, like photovoltaic panels and small wind generators complemented with a battery bank is getting cheaper. With a system like this you can produce your own electricity or at least have an independent back-up system. Small co-generation plants (Stirling engines) fuelled with pellets are another new technology that is developing.

#### Sewage

If the house is in an area where the infrastructure

does not include a sewage system you can solve the problem with your own system. Today there are several well functioning local sewage systems on the market. You can choose a compact filter or a small sewage plant. By sorting the sewage in different fractions like urine, black-water (from toilets and kitchen shredders) and grey-water (from showers, washing and dishwashing) you can simplify the local sewage system. Artificial wetlands can be used for final cleaning.

#### Materials

All materials in the building are monitored from a health aspect. No chemical substances that are carcinogen, mutagen or reproduction disturbing are used, or substances that causes allergic reactions. Materials with small ecological footprints are prioritized. You study materials with similar functions and compare use of resources and energy as well as pollution of air, water and soil per unit produced. Poisonous substances like heavy metals and organic chemicals that are persistent, bio accumulative and/or toxic are mainly found in paints, glues and joints. There are possibilities to choose only healthy materials when you design a building. A wooden house insulated with cellulose fibre with a foundation insulated with foam-glass is one example of a good solution.

#### Services

Energy efficient ventilation systems that can be regulated according to need are used. Natural ventilation and mechanical ventilation are combined into smart hybrid systems. All ventilation ducts are made easy to clean. Water and sewage systems are installed in a leakage proof way. Electricity systems are installed in such a way that electric and magnetic fields are minimised. Heating is done by radiation at low temperatures from radiators, floor heating or wall heating.

#### Constructions

The houses are constructed so that moisture problems are avoided. The foundations are made in such a way that radon gases from the ground can't get into the building. The constructions and services are designed so that you get a healthy and silent indoor climate, and the houses are designed so that they are easy to use, clean and maintain.

#### Implementation

The different components are built in dry, clean and controlled conditions in a factory. The montage of the building onto the foundation is fast, and when the walls and roof are in place, the rest of the work can be done indoors. In this way bad weather has small possibilities to influence the result. Everybody involved in the building of the house is educated in environmental issues so that all know what we are aiming for. Control of the final product is routine and the buyer of a single-family house gets 10 years warranty. □