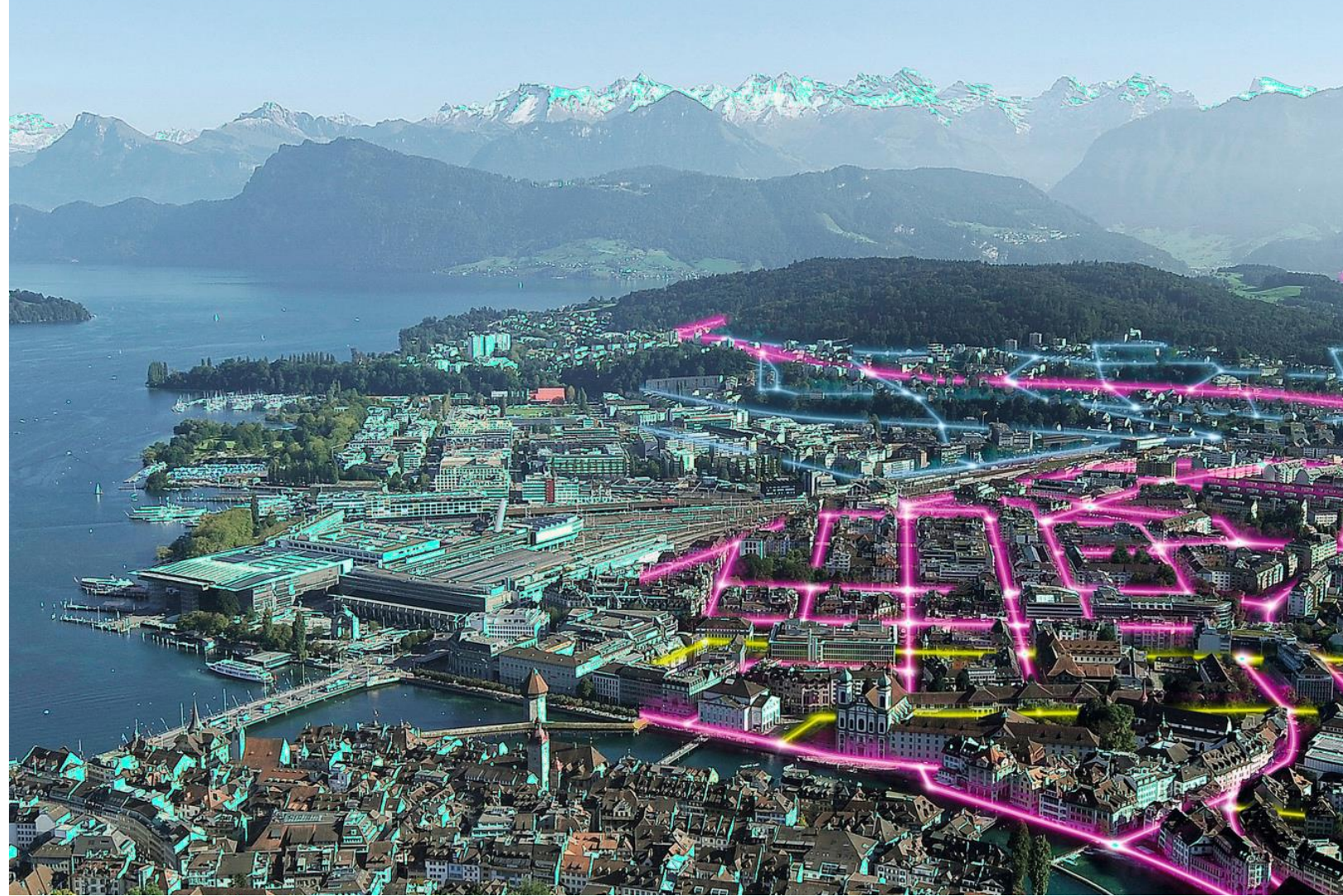


## HSLU Institute for Building Technology and Energy

卢塞恩应用科学和艺术大学  
建筑技术和能源研究所



**HSLU:** 卢塞恩应用科学和艺术大学

**HSLU: LUCERNE UNIVERSITY OF APPLIED SCIENCES AND ARTS**



## MARVIN KING

Dipl. Ing. Architect SIA, Building economist AEC  
 Senior Researcher 建筑师和建筑经济学家  
 Lucerne University of Applied Sciences and Arts  
 Institut for Building Technology and Energy  
 卢塞恩应用科学和艺术大学，建筑技术和能源研究所  
 Research Group: Sustainable Building and Renewal  
 研究小组：可持续建筑和可再生能源

## RESEARCH TOPICS 研究课题

- Holistic consideration of the life cycle of buildings and components / Circular Economy  
对建筑及其组件全生命周期的考虑 / 循环经济
- Refurbishment strategies in the utilisation cycle  
使用循环中的修复策略
- Life cycle cost assessment 生命周期成本估算
- Life cycle assessment of real estate 房地产生命周期估算
- Urban management 城市管理
- Author and editor of various publications  
各类出版物的作者和编辑



## ABOUT THE SPEAKER



## SINA BÜTTNER

Architect, M.Eng. Energy-efficient construction 建筑师和节能建筑硕士

Researcher 研究员

Lucerne University of Applied Sciences and Arts 卢塞恩应用科学与艺术大学

Institut for Building Technology and Energy 建筑技术与能源研究所

Research Group: Sustainable Building and Renewal 研究小组：可持续建筑和可再生能源

### RESEARCH TOPICS 研究课题

- Circular building 循环建造
- Building in climate change - mitigation and adaptation of the building stock 建筑与气候变化 – 建筑存量的缓减与适应
- Greenings at buildings and in cities 建筑和城市的绿化
- Daylight in buildings 建筑中的日光
- Well-being and health 舒适与健康

## ABOUT THE SPEAKER



## 目录 TABLE OF CONTENT

- 建筑的隐含碳 • Introduction Embodied Carbon Emissions in Buildings
- 节材设计的重要性 • The Importance of Material-Efficient Design
- 什么是循环建造 • What Means Circular Construction
- 低隐含碳建筑和循环建造的  
案例 • Case Studies of Buildings with low Embodied CO<sub>2</sub> and  
Circular Construction
- 总结 • Conclusion

# 低碳建材的ZEB设计

# ZEB Design with Low Carbon Building Material

PRESENTATION OF HSLU  
SWITZERLAND  
16<sup>th</sup> SEPTEMBER 2022  
MARVIN KING

瑞士  
卢塞恩应用科学和艺术大学  
嘉宾演讲  
2022年9月16日  
MARVIN KING

EXPERIENCES FROM SWITZERLAND

瑞士经验

## The all-changing perspective 都在发生变化的视角

«Earthrise» shows our planet in its full beauty, the consciousness of a closed system first had to emerge at that time.

“升起的地球”展示了我们星球的美丽，但也首次让我们意识到我们的封闭系统。

«The Overview-Effect»  
«总览效应»



# INTRODUCTION

Excessive consumerism and  
a society that has gone off  
the tracks

过度的消费让一个社会偏  
离了它的运作轨道

The mindset in the  
construction sector also  
needs to change

建筑领域的思路  
也应有所改变



How much does your Building weigh? Counting CO<sub>2</sub> instead of calories  
你的建筑有多重? 这里, 我们不数卡路里, 而是要数二氧化碳排放量

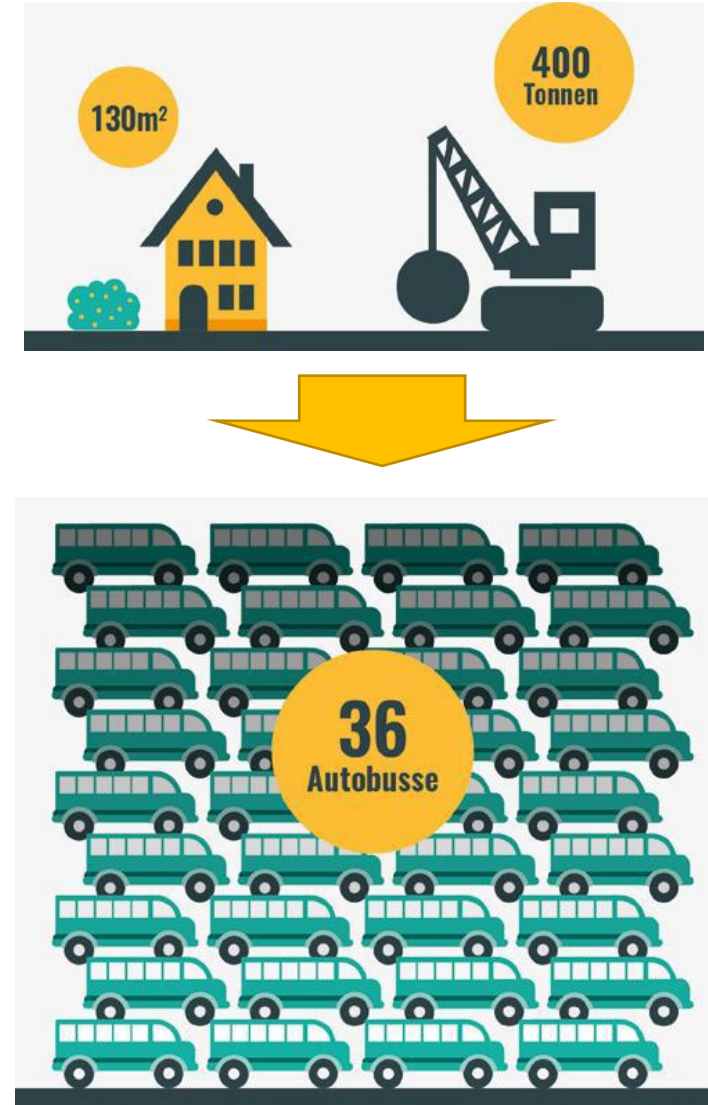
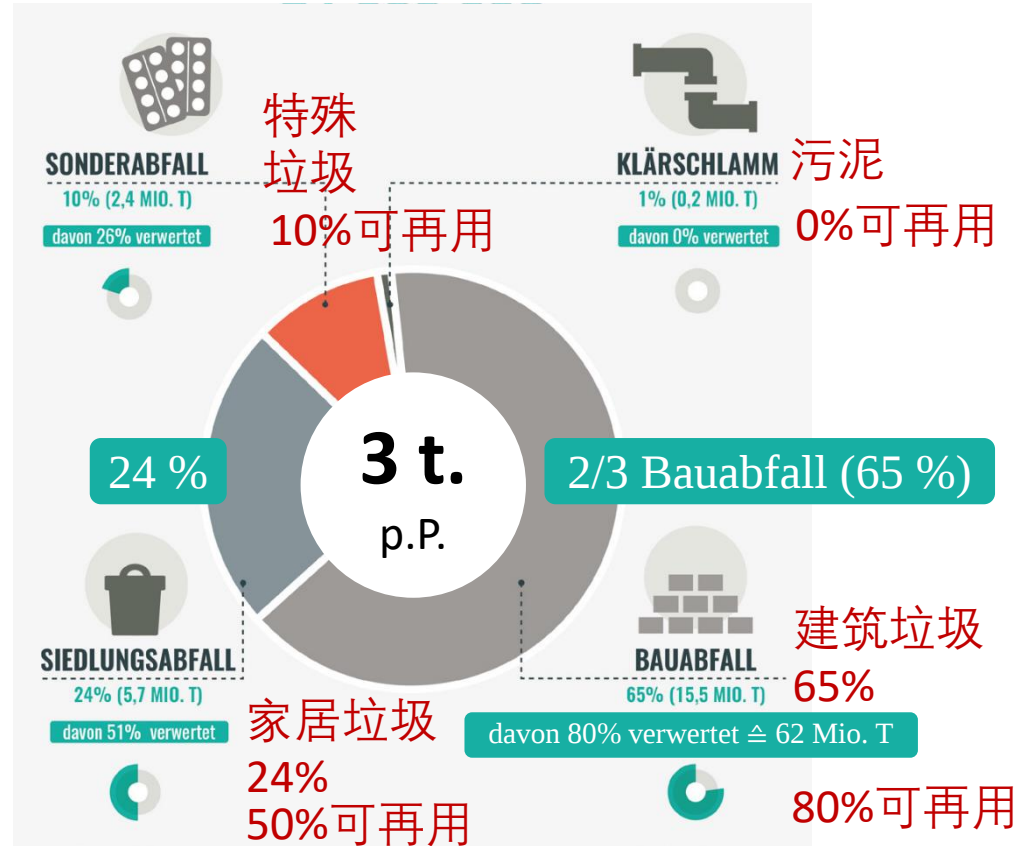
# INTRODUCTION

介绍

## How much waste does Switzerland produce each year? 瑞士每年生产多少垃圾？

Switzerland produces approx. **24 million tonnes** of waste per year =  
 Is equivalent to **2860 kg** per head and year, of which is 700 kg municipal waste (household waste) and **1900 kg construction waste**.

瑞士每年大约会产生**24**百万吨的垃圾 = 相当于每人每年**2860**公斤，其中**700**公斤是家居垃圾，**1900**公斤是建筑垃圾。



瑞士垃圾产出

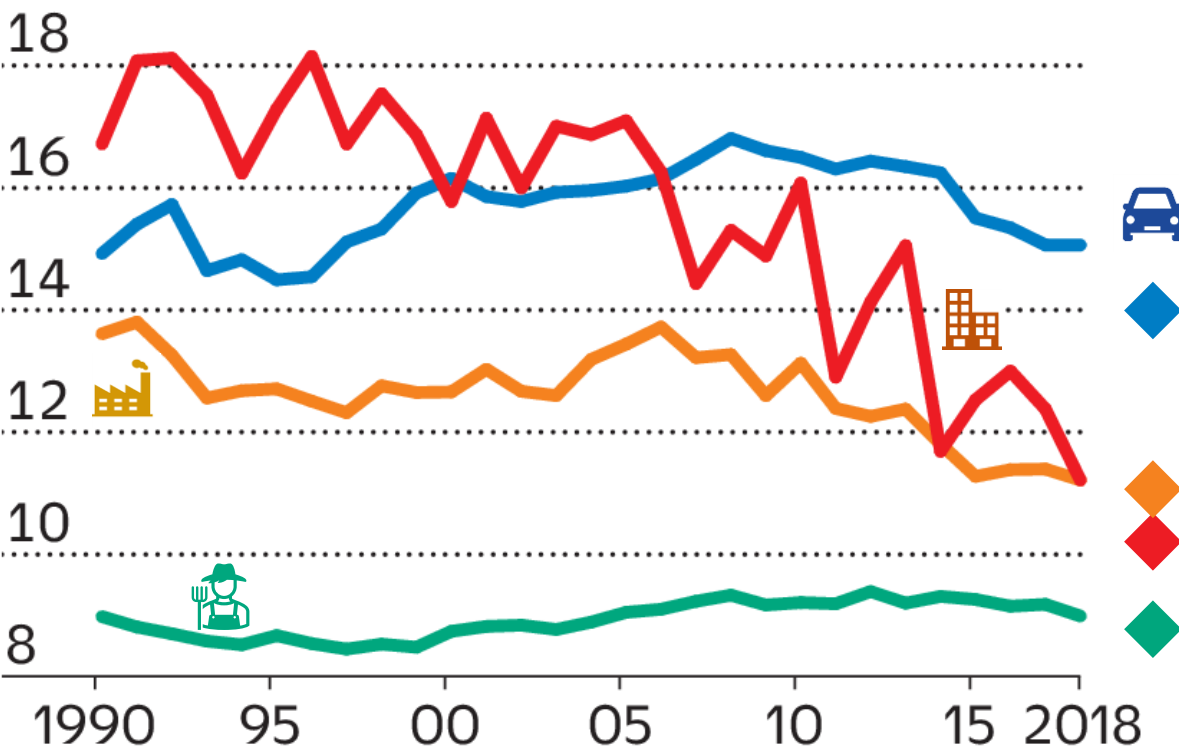
INITIAL POSITION

# Greenhouse Gas Emissions by 2020: Total 43.4 Mio. t CO<sub>2</sub>-Equivalent

到2020年为止的温室气体排放：  
总共43.4百万吨二氧化碳当量

- 
**Transport 32% (1%, 2020-Target -10%)**  
 交通32% (+1%, 2020-目标-10%)
- 
**Building 24% (-34%, 2020-Target-40%)**  
 建筑 24% (-34%, 2020-目标-40%)
- 
**Industry 25% (-14%, 2020-Target -15%)**  
 工业 25% (-14%, 2020-目标 -15%)
- 
**Other 19% (0%, 2020-Target -10%)**  
 其他 19% (0%, 2020-目标 -10%)

20 Mio. t CO<sub>2</sub>-Equivalent (百万二氧化碳当量)



## EMBODIED CARBON EMISSIONS IN SWISS BUILDINGS

瑞士建筑  
隐含碳排放

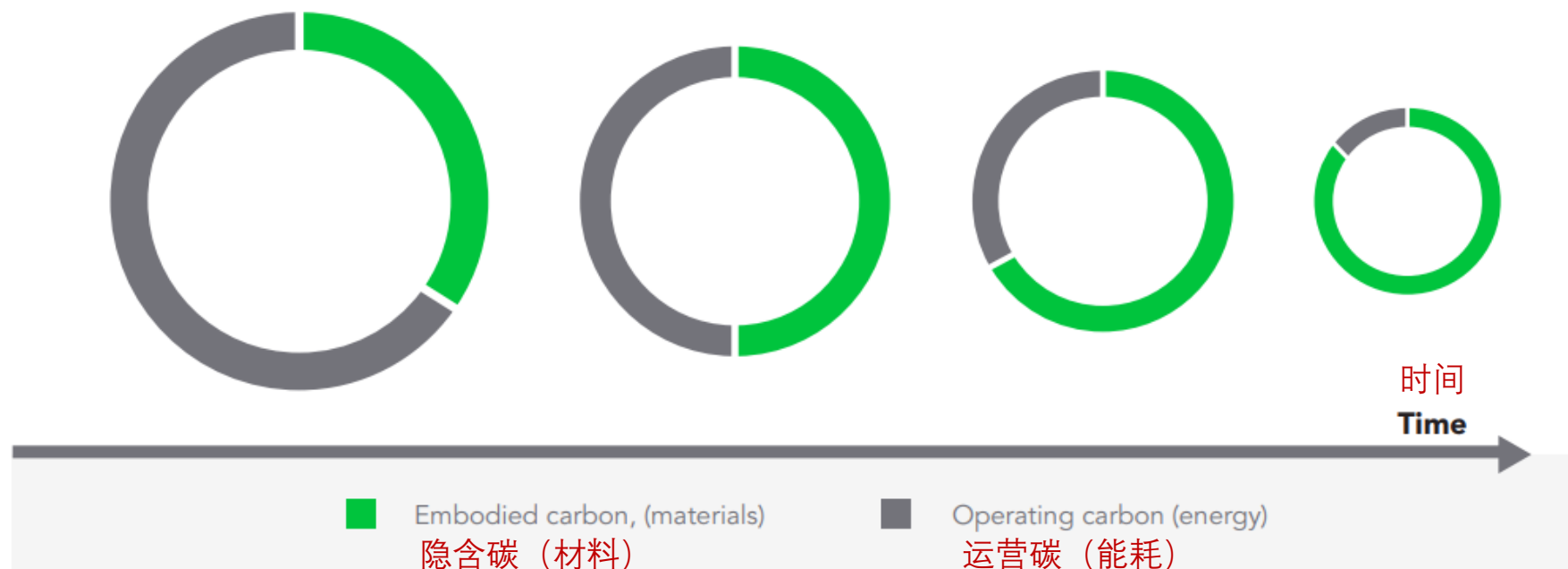
## Greenhouse Gas

### Emissions:

Embodied carbon  
importance grows  
constantly

温室气体排放:

隐含碳的重要性不断增长



# EMBODIED CARBON EMISSIONS IN SWISS BUILDINGS

瑞士建筑  
隐含碳排放

## Scale levels 规模水准

### How do we plan sustainable cities?

#### 我们如何规划可持续城市？

- Reduce land consumption 减少土地使用
- Reuse structures 重复使用建筑结构
- Plan cool urban spaces 规划凉爽的城市空间

### How do we construct sustainable buildings?

#### 我们如何建造可持续建筑？

- Create biodiverse living spaces 创造生态多样化生活空间
- Promote sufficiency 鼓励自改自足
- Avoid demolition 避免垃圾

### How do we construct sustainable details?

#### 我们如何建造可持续细部？

- Repair instead of replace 修理再用代替更换
- Use little material 使用尽可能少的材料
- Use resource-saving building materials 使用节资建材



Countdown 2030  
倒计时2030

THE BIGGEST LEVERS FOR SUSTAINABLE CONSTRUCTION

可持续建筑  
最大水准

## Bundesrat soll Mieter entlasten

Sanierungen Wälzen Hauseigentümer Sanierungskosten zu stark auf die Mieter ab? Eine neue Bundesstudie befeuert einen alten Streit.

Klimaschutz kann wehtun. Ein Hausbesitzer modernisiert sein Gebäude für 3,5 Millionen Franken. Ein Viertel davon entfällt auf Massnahmen, die den Energieverbrauch senken, etwa Dämmung der Fassade. Nach der Sanierung müssen die Mieter 1630 Franken für ihre Wohnung bezahlen, gut 400 Franken mehr als zuvor. Frankens davon sind eine Folge der energetischen Sanierungen. Auf der anderen Seite sparen die Mieter zwar...

Klimaschutz die Schraube anziehen, und just beim Wohnen besteht ein grosser Hebel: Der Gebäudepark ist für ein Drittel des CO<sub>2</sub>-Ausstosses der Schweiz und 40 Prozent des Energieverbrauchs verantwortlich. Die schlechten Nachrichten für die Mieter könnten sich also häufen.

gel zu 50 bis 70 Prozent als vermehrende Investitionen steht es in der entsprechenden Verordnung – seit 1977.

Studie nicht repräsentativ Im Auftrag der beiden Kantone hat nun die Hochschule Luzern 20 Fallbeispiele un-

## Wer trägt die Kosten der Sanierung?

Eine Dacheindeckung, welche im alleinigen Sondernutzungsrecht des dazugehörigen Stockwerkeigentümers steht, soll saniert werden. Es stellt sich die Frage nach...



Mieterverband nicht: «In der momentanen Situation mit den hohen Energiepreisen und Anlagenkosten...»

zerlegen, hält er in einer Mitteilung fest. Er kritisiert auch die in der Studie gewählte Methodik als «reine Augenwischererei», komme es zu einer Schätzung ohne Schät-

## NZZ am Sonntag



## Sanierung lohnt sich in jedem Fall

Mehr als die Hälfte aller Wohnimmobilien ist über vierzig Jahre alt. Viele gelten als energetisch sanierungsbedürftig.

## Ein Fonds, um die energetische Modernisierung anzukurbeln

In der Schweiz werden zu wenig Gebäude energetisch saniert. Das ist schlecht fürs Klima und für den Werterhalt der Immobilien. Nötig ist deshalb ein neuer Ansatz zur Finanzierung der Gebäudemodernisierung.

SWISS CLEANTECH  
Wirtschaft klimatauglich.

Stadt Luzern  
Stadtrat

Bericht und Antrag  
an den Grossen Stadtrat von Luzern  
vom 30. Juni 2021 (StB 524)

B+A 22/2021

Klima- und Energiestrategie  
Stadt Luzern

- Reglement für eine nachhaltige städtische Energie-, Luftreinhalte- und Klimapolitik (Energierglement); Teilrevision
- Reglement für eine nachhaltige städtische Mobilität; Teilrevision
- Reglement über die Nutzung des öffentlichen Grundes; Teilrevision
- Sonderkredite für die Umsetzung der

OVERARCHING HOLISTIC APPROACHES

## Calculating and Comparing Embodied CO2 Emissions

计算和比较隐含二氧化碳排放量

Comparison between 4 modern Hybrid Timber  
Buildings and conventional construction  
systems 4种现代木建筑和传统结构体系对比

S22



S04



S06



S43/45

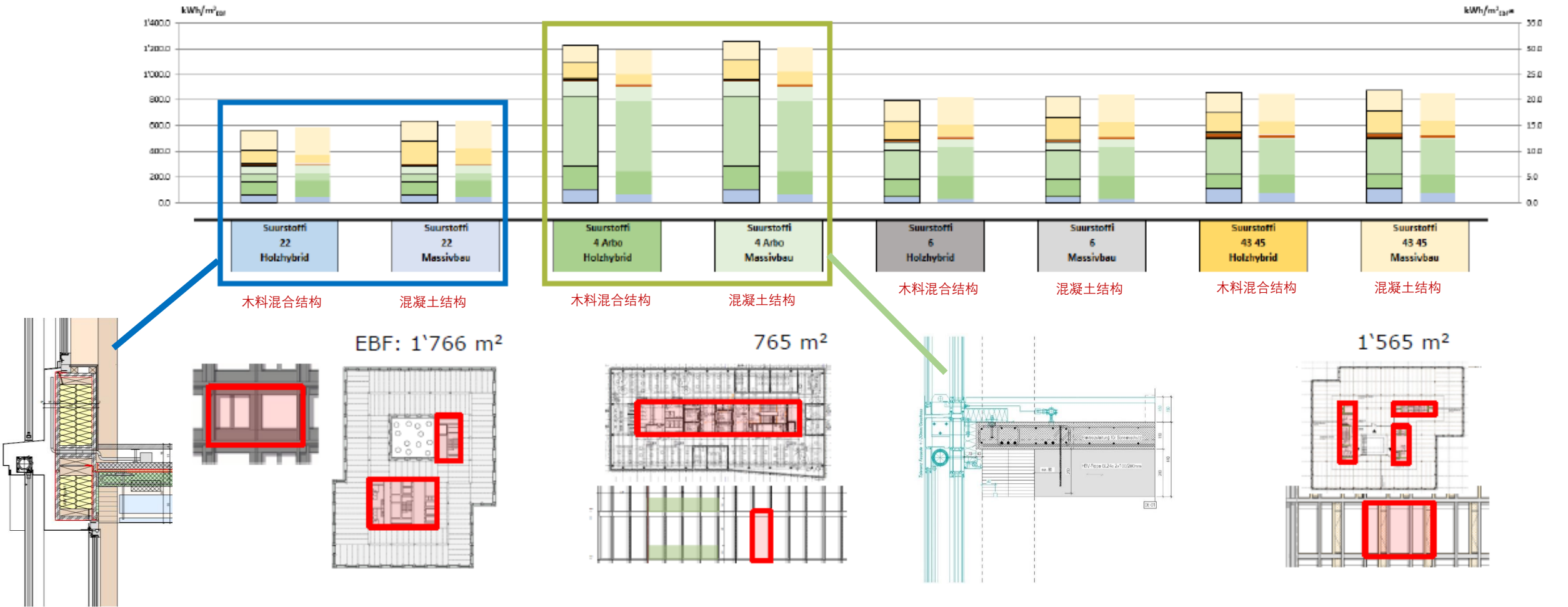


Building  
建筑

**A SUSTAINABLE BUILDING IS NOT  
POSSIBLE WITHOUT A LIFE CYCLE ASSESSMENT**

可持续建筑  
必须考虑全生命周期评估

# Embodied Energy 隐含能耗



A SUSTAINABLE BUILDING IS  
NOT POSSIBLE WITHOUT A LIFE CYCLE ASSESSMENT

可持续建筑  
必须考虑全生命周期评估

## Lifecycle stages 生命阶段

Embodies Energy – SIA 2032

隐含碳 – SIA 2032

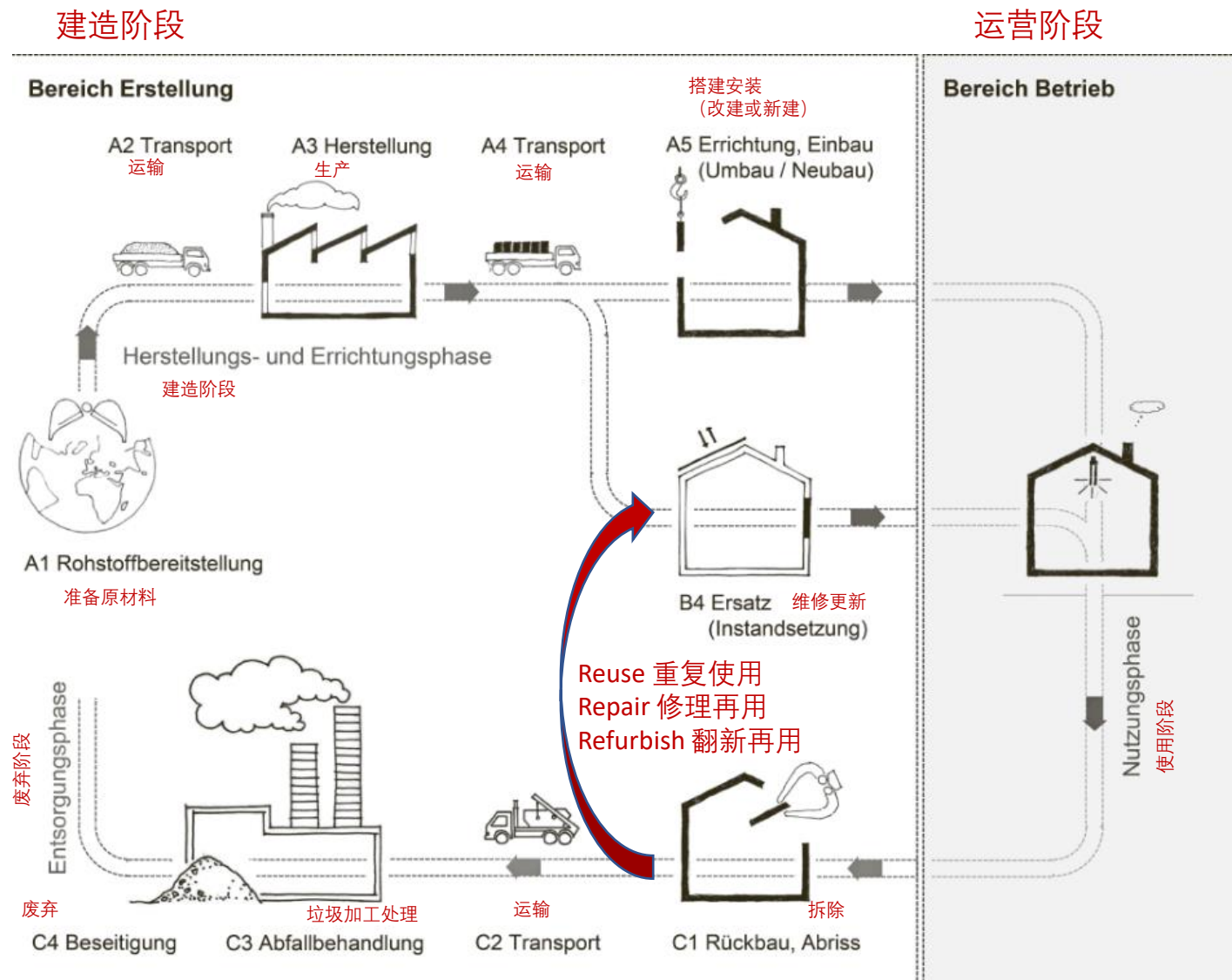
Production stage (A1-A3) 生产阶段(A1-A3)

Construction stage (A4-A5) 建造阶段(A4-A5)

Use stage (B1-B7) 使用阶段(B1-B7)

End of life stage (C1-C4) 生命阶段结束(C1-C4)

Potential for reuse, recovery or recycling (D)  
 重复使用的潜力, 重复使用或加工再用(D)



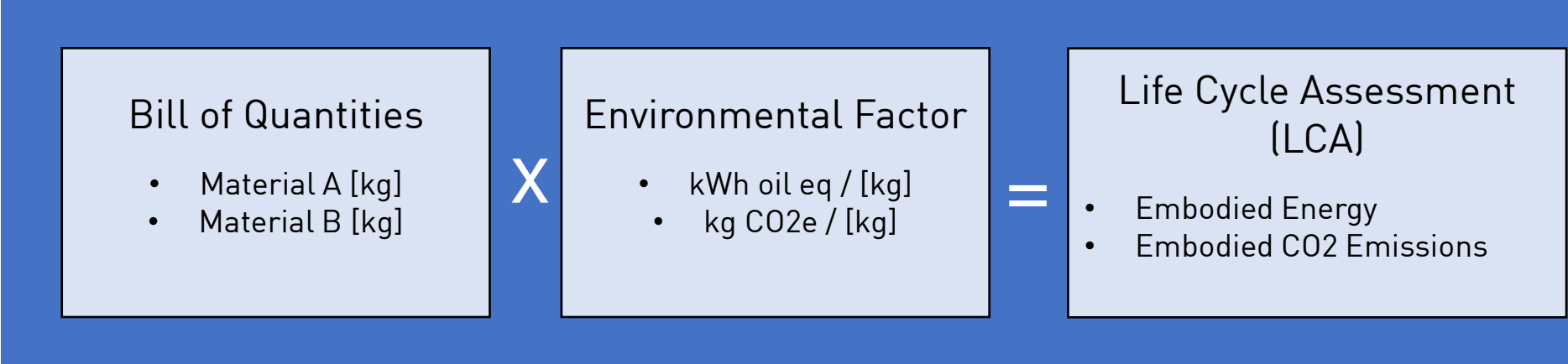
# THE SWISS CALCULATION TOOL FOR EMBODIED CO2

瑞士建筑隐含碳  
计算工具

Calculating the  
Life Cycle Assessment

计算生命周期评估

Principle of calculation  
计算原则



Completely  
mineral  
Façade system  
完全的  
矿物质  
外墙面系统



Components, Material &  
Resources

IMPLEMENTATION IN PRACTICE

实际例子

Building technology /  
system separation

建筑技术 / 系统分离



Components, Material &  
Resources

IMPLEMENTATION IN PRACTICE

实际例子

## Take Home Message

# Calculating the Life Cycle Assessment

## Basic formula for planners

**build light, efficient (with less material)  
and frugal (sufficiency)**

建得轻盈，有效（用材少），  
节省（充足）

**build with ecological,  
sustainable materials**

用生态而可持续的材料来建造

## Life Cycle Assessment

- Embodied Energy
- Embodied emissions

## 生命周期评估

- 环境评级
- 隐含能耗
- 隐含排放

needs to be optimized  
需要优化

# Bill of Quantities

- Material A [kg] 材料A
- Material B [kg] 材料B

Reference Area [m<sup>2</sup>]  
参考面积（平方米）  
Energy reference area / Floor  
area  
能耗面积 / 建筑面积

**build compact and  
space-efficient**

## 建得紧凑且空间有效

## Environmental Factor

- kWh oil eq / [kg]
- kg CO<sub>2</sub>e / [kg]

Lifespan [years]  
寿命 (年)

## build long lasting (durable)

建得持久耐用

# CONCLUSION

## 总结语

## Take Home Message 带回家的信条

- The location has a major influence on the real estate strategy and the building standard (=Return)  
地点对房地产政策和建筑标准有着主要的影响(=回报)
- Early planning of a holistic strategy is crucial (analysis & measures).  
今早规划全方位的策略非常重要(分析和措施)
- Shorter construction times, lower investment costs and lower life cycle costs can be realised through modularisation and system separation.  
模块化和系统分离建造方式可以实现较短的建造时间, 较少的投资成本和较低全生命周期成本
- Sustainable construction is not possible without life cycle assessment  
可持续建造离不开全生命周期评估
- The potential of the circular economy must be used consistently at all scale levels.  
循环经济的潜力必须在所有规模水准上得到充分利用

## CONCLUSION

# 循环建造概览

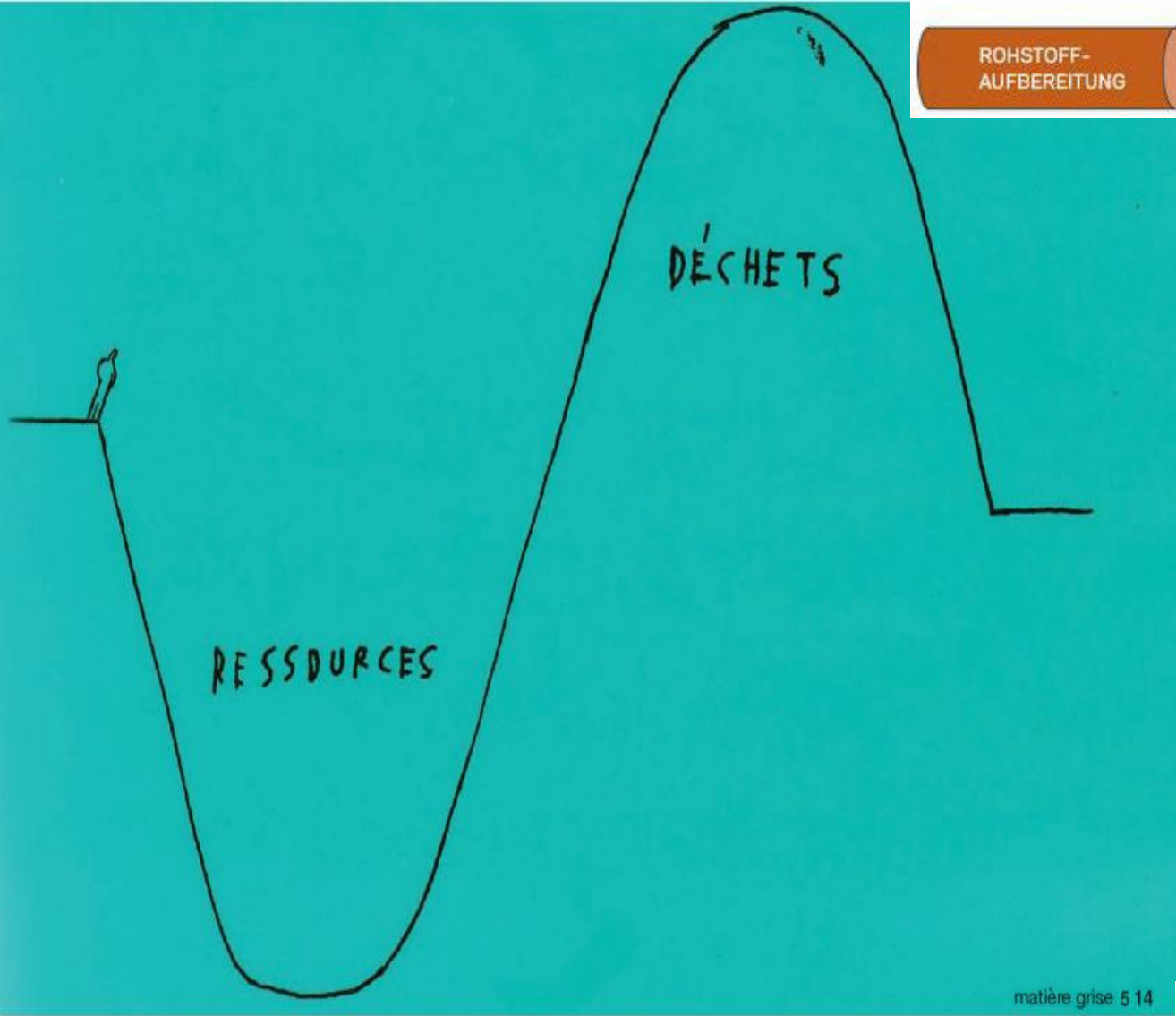
# A short introduction to Circular Construction

PRESENTATION OF HSLU  
SWITZERLAND  
16<sup>th</sup> SEPTEMBER 2022  
SINA BÜTTNER

瑞士  
卢塞恩应用科学和艺术大学  
嘉宾演讲  
2022年9月16日  
SINA BÜTTNER

EXPERIENCES FROM SWITZERLAND

瑞士经验



LINEAR  
ECONOMY



RECYCLING  
ECONOMY



CIRCULAR  
ECONOMY



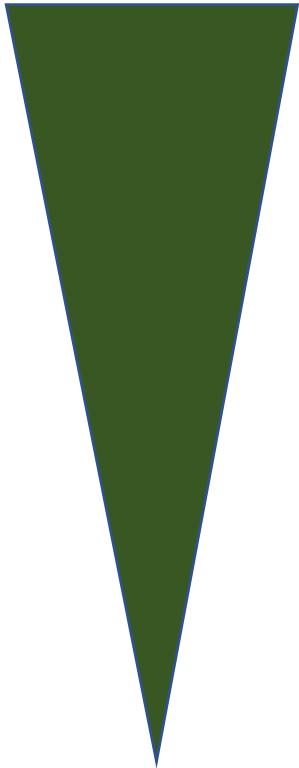
© BAFU, muntagnard, Vortrag Mark Angst (Baubüro in situ)

LINEAR, RECYCLING AND CIRCULAR ECONOMY

线性经济，回收经济，  
循环经济

High Impact

影响程度高



Less Impact

影响程度低

**REFUSE:** prevent raw materials`use **拒用:** 拒绝部分原材料使用

**REDUCE:** decrease raw materials` use **少用:** 降低原材料使用

**REDESIGN:** reshape your project in view of circularity **重新设计:** 从循环性的角度重新塑造项目

**REUSE:** use building elements again (second hand) **再用:** 重新使用建筑构件（二手）

**REPAIR:** maintain and repair building elements **修复:** 维护和修葺建筑构件

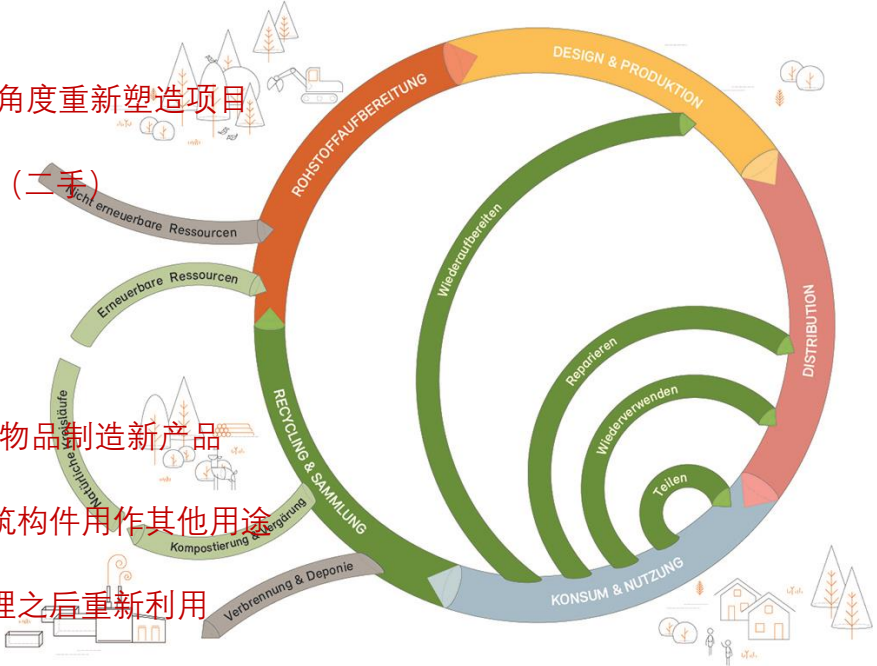
**REFURBISH:** revive building elements **翻新:** 建筑构件的翻新

**REMANUFACTURE:** make new products from second hand **再制造:** 利用二手物品制造新产品

**REPURPOSE:** re-use building elements but with other function **再利用:** 将建筑构件用作其他用途

**RECYCLE:** salvage material streams with highest possible value **循环利用:** 处理之后重新利用

**RECOVER:** incinerate waste with energy recovery **能源利用:** 垃圾作为能源使用



© BAFU

Burohaus 2226, Lustenau, Austria,  
baumschlager eberle, 2013

→ REFUSE, REDUCE

→ 拒用和少用, 奥地利, 2013

Compact office building without heating, cooling and active ventilation  
systems 紧凑的办公建筑, 没有供暖制冷和主动的通风系统

Every second ventilation sash is running automated  
每两个通风风扇是自动运行的

In summer the building is naturally cooled at night  
建筑夏季夜间采用自然冷却

During winter the internal gains through employees and appliances is  
enough to heat the building  
冬季室内雇员和设备散热足以给建筑供暖

Dispensing building technology\* - reducing operational energy, but  
adding thermal mass 减少建筑设备 - 进而减少运营能耗, 但增加热质量

\*: usually 20-30% of the embodied CO<sub>2</sub> of buildings  
通常占据20-30%的建筑隐含碳排放



CASE STUDIES OF BUILDINGS – REFUSE, REDUCE

案例分析  
拒用和少用

Burohaus 2226, Lustenau, Austria,  
baumschlager eberle, 2013

→ REFUSE, REDUCE

→ 拒用和少用的案例, 奥地利, 2013



CASE STUDIES OF BUILDINGS – REFUSE, REDUCE

案例分析  
拒用和少用

Lysbüchelareal, Basel, Switzerland

Baubüro in situ, 2020

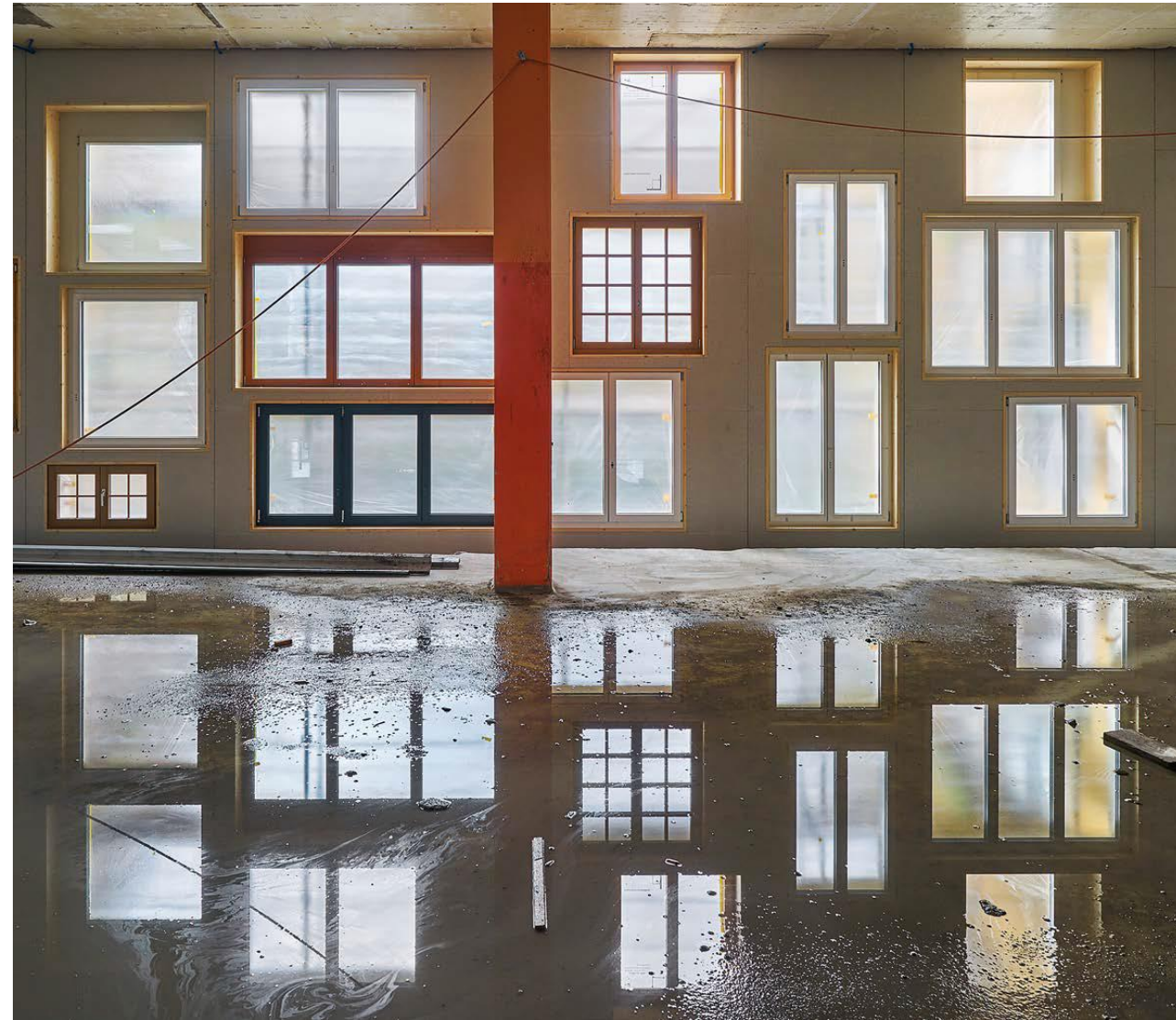
→ REUSE

→ 瑞士再利用的例子，瑞士巴塞尔  
的办公建筑，2020

The façade of the inner courtyard was constructed by using windows from surplus or reserve stocks from around ten Swiss window manufacturers. 内院立面是使用大约十家瑞士窗户制造商的剩余或储备库存的窗户建造的

If they had not been used here, they would have been disposed. 如果它们不被用在这里，它们就会被丢弃

The thermal insulation mats and the wood for the facade elements are also partly from existing stock. 保温层和立面组件上的木材也部分来自现有的库存材料



© Baubüro in situ

CASE STUDIES OF BUILDINGS - REUSE

案例分析  
建筑构件再利用



© Baubüro in situ

## CASE STUDIES OF BUILDINGS - REUSE

案例分析  
建筑构件再利用



## Lavezzorio Center, SOS Kinderdorf, Chicago, USA Studio Gang, 2008 美国芝加哥, 2008

Concrete donations were collected for the building.

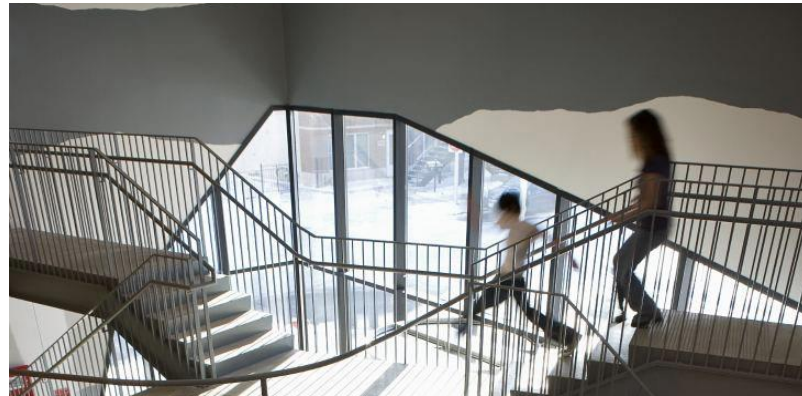
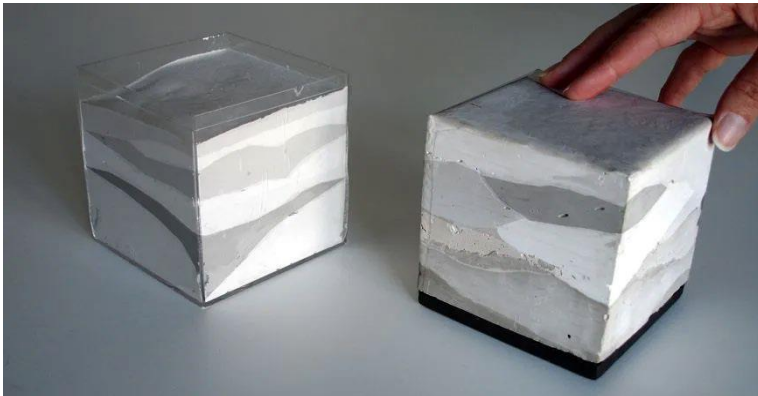
为建设该项目专门进行了废旧混凝土的收集。

The architects worked with the material they received through the donations.

建筑师们利用通过捐赠得到的建材进行工作。

The result is this façade design, which shapes the building of the SOS Children's Village.

结果呈现出了图示的立面设计, 同时也将该建筑打造为儿童之村。



© studiogang.com

## CASE STUDIES OF BUILDINGS – INTERNATIONAL PROJECTS

案例分析  
国际项目



## The Green House, Utrecht, Neatherlands Cepezed, 2018

荷兰乌特勒支

→REDUCE, REFUSE, REDESIGN, REUSE

少用，拒用，重新设计，再用

The pavilion can be completely dismantled, so all the elements used can be reused and rebuilt elsewhere.

该项目可以得到完全拆除，其所有构件可以被重新使用在任何地方。



© itinari.com, archdaily.com

## CASE STUDIES OF BUILDINGS – INTERNATIONAL PROJECTS

案例分析  
国际项目

## The Green House, Utrecht, Neatherlands Cepezed, 2018

荷兰乌特勒支，绿色之家，2018



## →REDUCE, REFUSE, REDESIGN, REUSE

少用, 拒用, 重新设计, 再用

Greenhouse  
建筑绿化

PV panels  
光伏板

Air ducts made of metal  
(screwed) or resistant  
textile  
金属(螺纹)或耐腐蚀  
织物制成的风管

Prefabricated and  
demountable  
WC units  
预制的和可拆卸的卫  
生间单元

Light «as-a-service»,  
Billing according  
to use  
照明作为一种服务,  
按照使用情况付费

Reused  
glass panels  
再利用的玻璃组件

Trees as natural sun  
protection (outside)  
树木作为天然的遮阳措  
施(外部)



© archdaily.com

District heating /  
cooling supply  
区域供暖和制冷

The entire interior design  
follows the principle  
«pay-for-use»  
整个内部设计遵循的原则  
是“按使用付费”

Greening inside to improve the  
indoor climate  
室内绿植, 帮助提高室内舒适度。

Rainwater reservoir, irrigation of  
plants and green areas  
雨水蓄水池, 灌溉植物和绿地

## CASE STUDIES OF BUILDINGS – INTERNATIONAL PROJECTS

案例分析国际项目

K 118 – Kopfbau Halle 118,  
Winterthur, Switzerland  
Baubüro in situ, 2021

→ REUSE

→ 瑞士温特图尔办公建筑K118再用  
方案, 2021

Reuse steel beams and stairs  
重复使用的钢梁和楼梯

Façade with insulated aluminum windows  
and red facade slabs from Winterthur and  
Zurich, complemented by natural building  
materials such as wood, straw and clay  
外墙采用来自温特图尔和苏黎世的隔热铝窗和红色外墙板, 辅  
以木材、稻草和粘土等天然建筑材料

→ Total: 494 tons of greenhouse gases were  
saved through reuse 通过这样的重复再用  
总共节省了494吨温室气体排放



Holcim Award  
for Sustainable  
Construction  
European & Global Gold Winner

Prix  
Acier  
2021

POTENTIAL OF REUSE – HOW MUCH CO<sub>2</sub> CAN BE REDUCED?

材料再用的节能减排  
潜力



© Baubüro in situ

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K 118 – Kopfbau Halle 118,  
Winterthur, Switzerland  
Baubüro in situ, 2021

→ REUSE

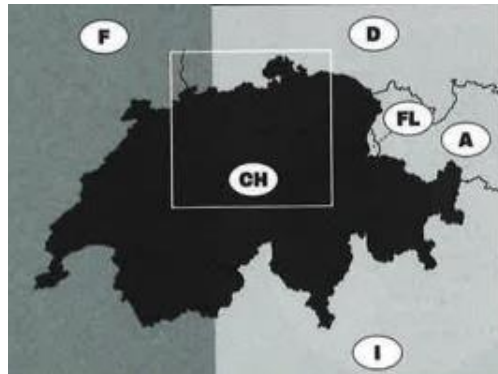
→ 瑞士温特图尔办公建筑K118再用  
方案, 2021

Where do the reused components come from? The component map gives an overview.

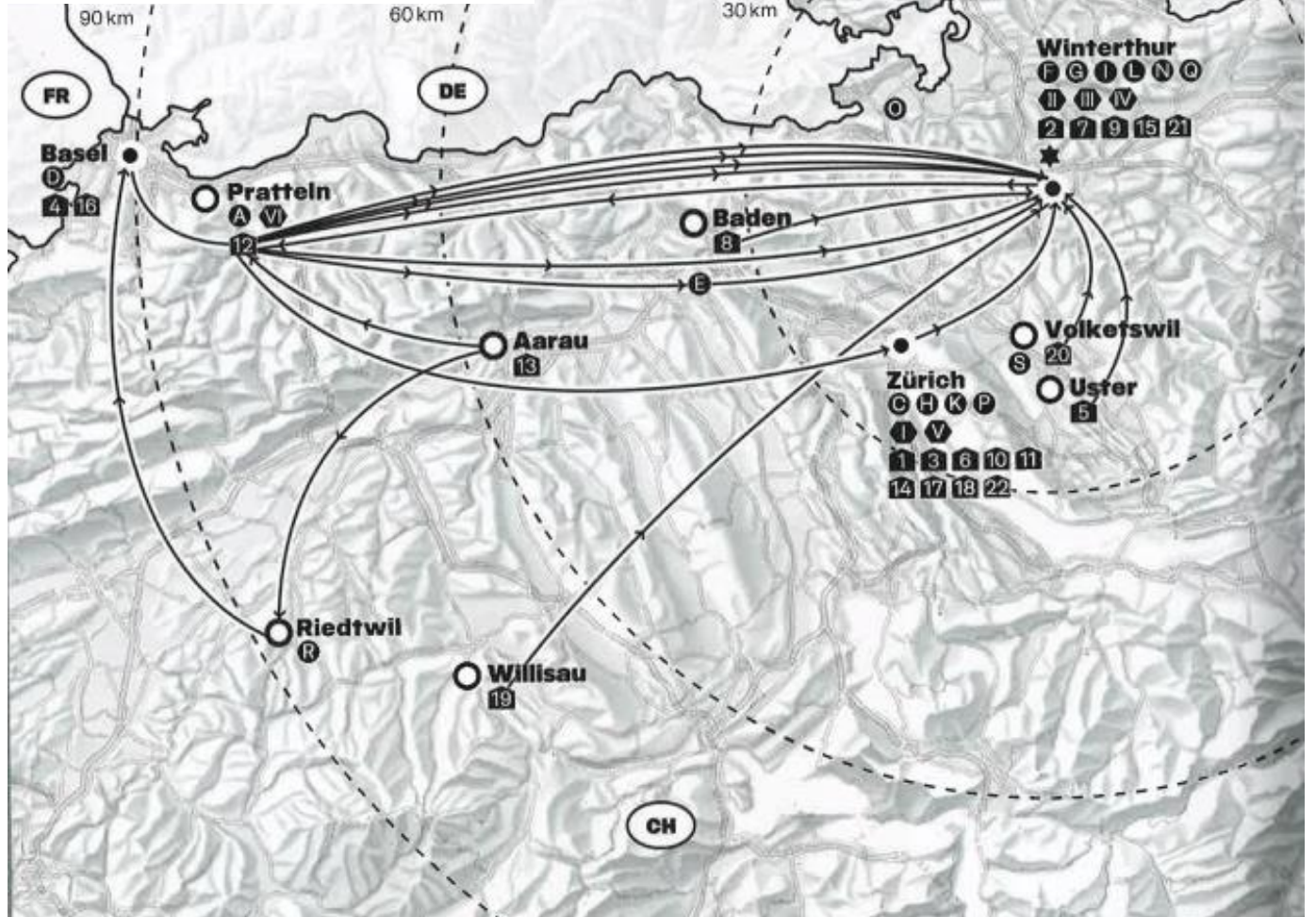
地图给出了再利用建筑构件的来源。

In order to keep the transport routes as short as possible, the search was conducted at companies, second-hand platforms and construction sites in central Switzerland.

为了尽可能地减少建筑材料的  
运输距离, 在位于瑞士中  
心的企业、二手建材平台  
和建筑现场之间做了相应的  
研究。



## Building component map

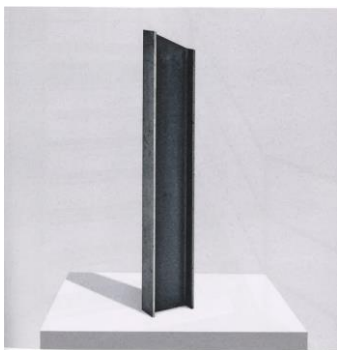


HALLE K118 – REUSED ELEMENTS

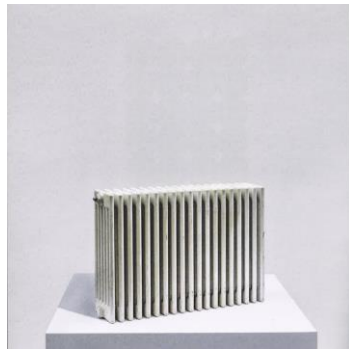
重新再用的建筑构件



Steel structure 钢结构



Steel profiles 钢梁



Heating element 供暖构件



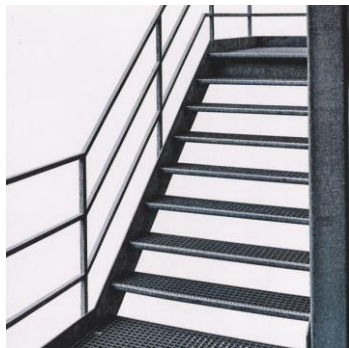
Facade sheet metal  
外墙金属板



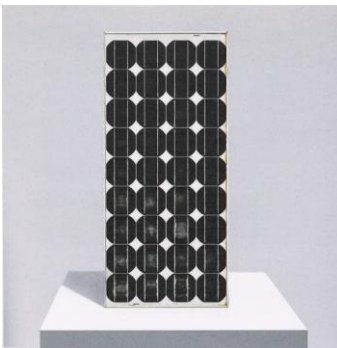
Industrial windows  
工业窗户



Insulation board 保温板



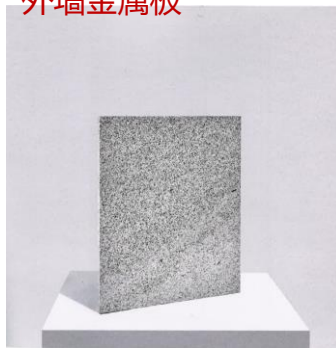
External staircase  
外置楼梯



Photovoltaic system  
光伏组件



Sink 洗手池



Facade panel 外墙板



Window 窗户



Interior door 室内门



Wood parquet (spruce)  
木质地板 (云杉木)



Wooden panel (spruce)  
木板 (云杉)

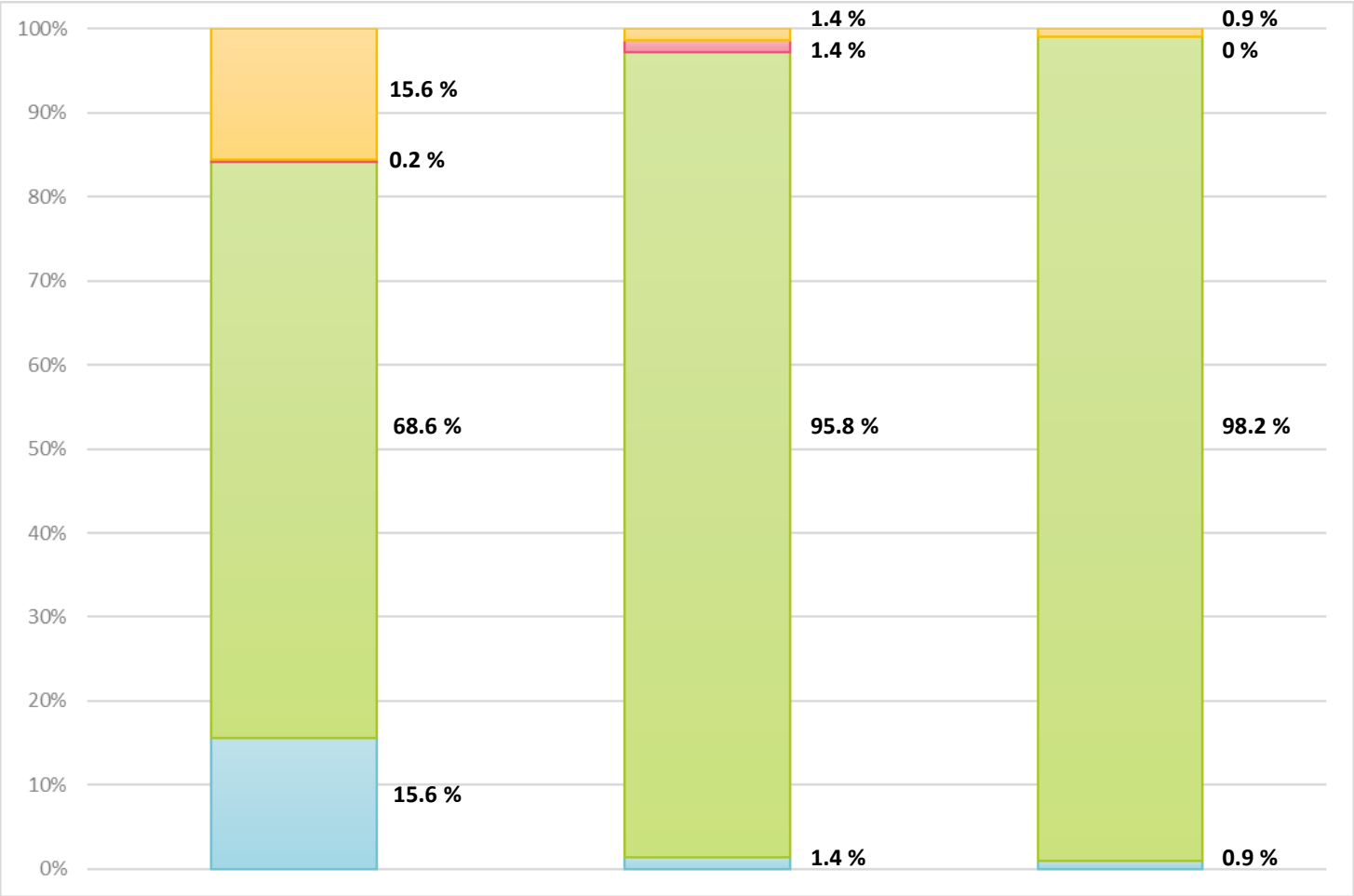


Mailboxes 信箱

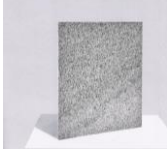
# HALLE K118 – REUSED ELEMENTS

© Buch «Bauteile wiederverwenden»

重新再用的建筑构件



Steel structure 钢结构



Facade panel 外墙板



Heating element 供暖设施

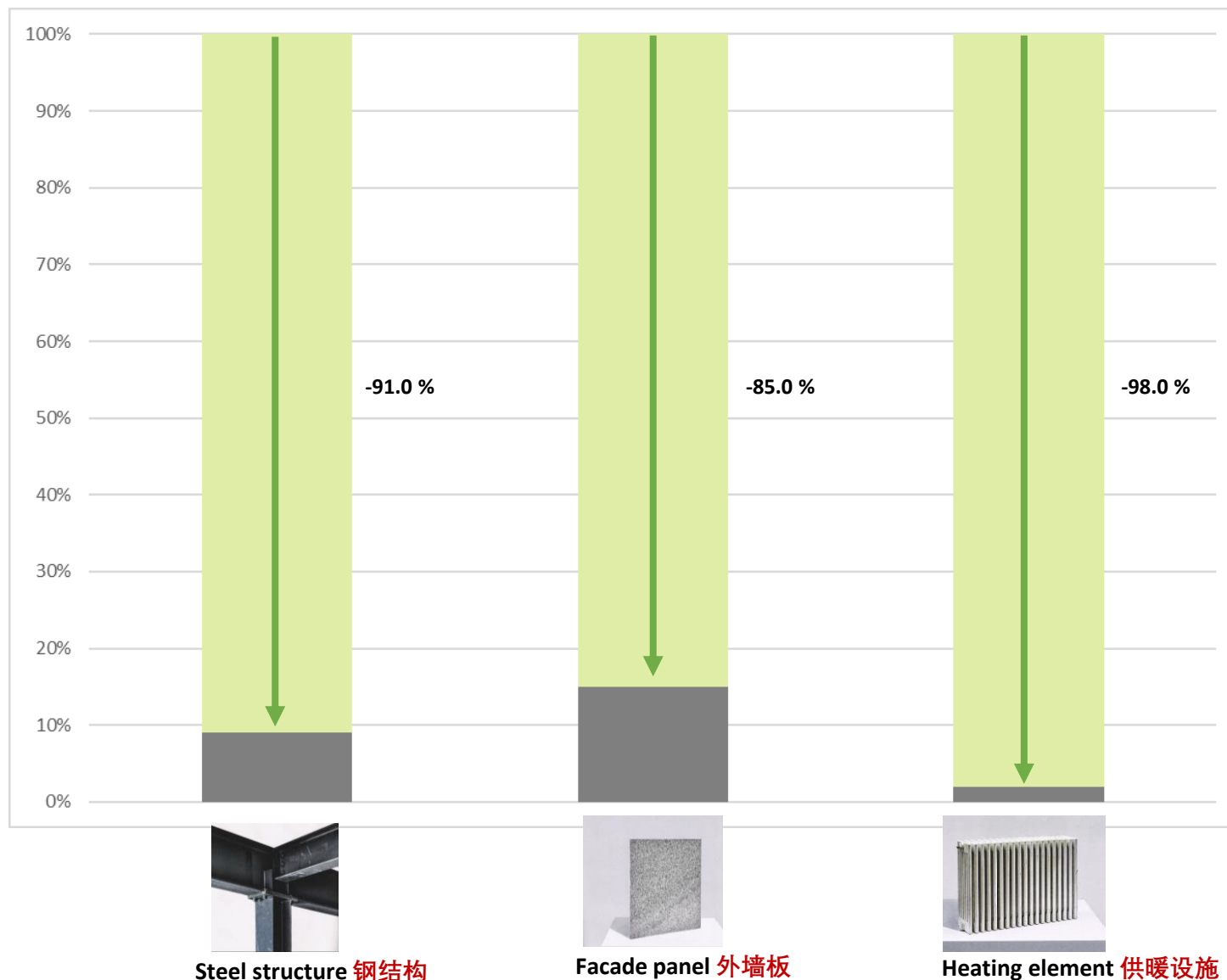
Legend

- Reinstallation 再安装
- Preparation 处理
- Transport 运输 ←
- Deconstruction 拆卸

CO<sub>2</sub>-emissions from the reuse of components,  
3 components in comparison  
三种组件再利用的  
二氧化碳排放比较

EMISSIONS PER COMPONENT (COMPOSITION)

每个建筑构件的碳排  
放来源



CO<sub>2</sub>-emissions from the reuse of  
components,  
3 components in comparison  
三种组件再利用的  
二氧化碳排放比较

### Legend



Saving 节约潜力



Emissions Reuse 再利用的二氧化碳排放  
(Reinstallation, Preparation, Transport,  
Deconstruction)  
拆卸, 处理, 运输, 再安装

# SAVINGS PER COMPONENT

每个建筑构件的节能  
减排潜力

© Baubüro in situ



15.1 % Existing building 既有建筑

21.4 % Construction Building  
建筑施工

18.5 % Building technologie  
建筑技术

30.7 % Facade 外立面

7.3 % Roof 屋顶

7.0 % Interior of the Building  
建筑室内部分

再利用的组件 Reused components 1%

新的建筑材料 New building materials

494 t  
CO<sub>2</sub>

SAVING  
59 %

843 t  
CO<sub>2</sub>

TOTAL  
100 %

再利用的  
节能减排潜力

6 t CO<sub>2</sub>

343 t  
CO<sub>2</sub>

40 %

K 118

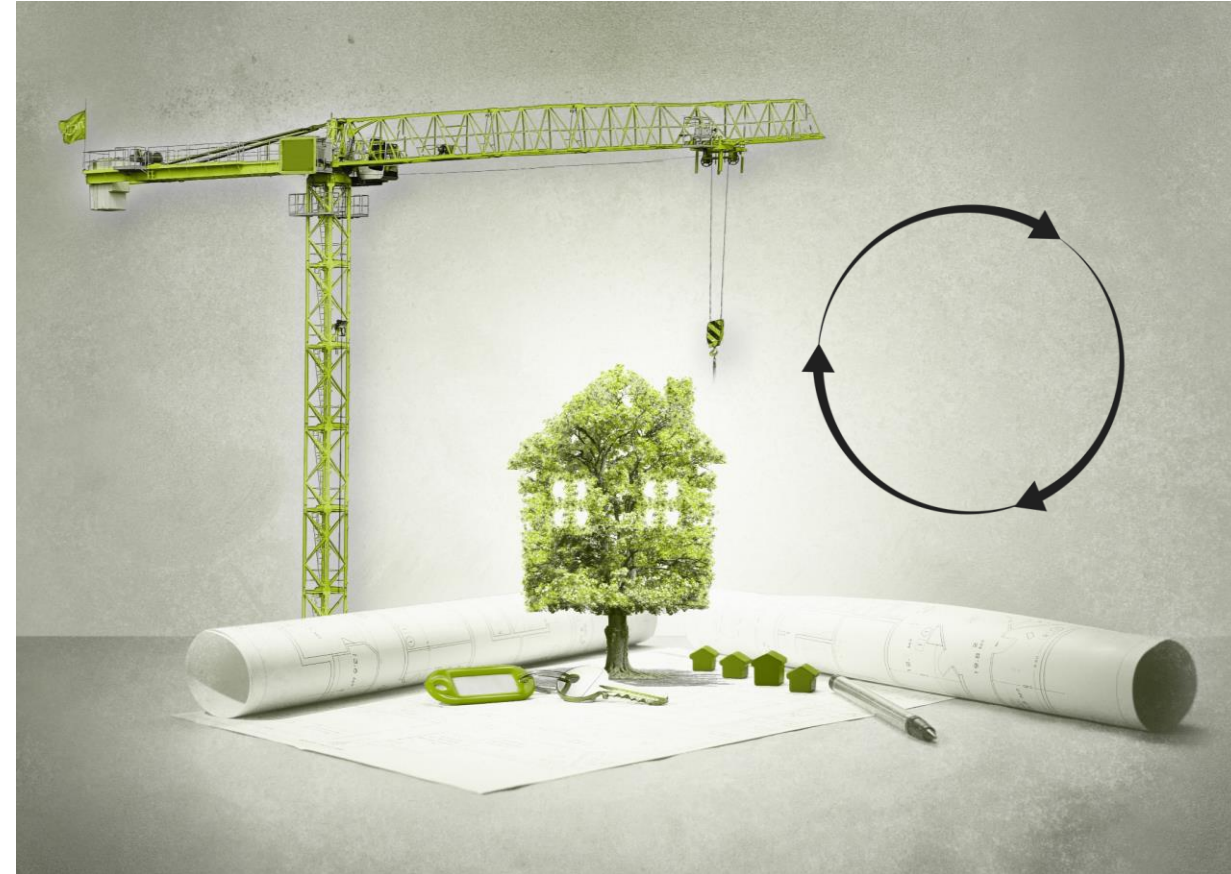
再利用  
方案

New

Building  
新建建筑

POTENTIAL OF REUSE

- Reuse pays off! 建材再用经济可行。
- Resources are conserved, CO<sub>2</sub>-emissions are reduced. 资源得到保护，二氧化碳的排放得到减少。
- Circular buildings can be very different. 循环建筑可以是与众不同的。
- It needs openness for new things and creativity. 需要对新事物的开放性和创造性。
- The biggest levers are REFUSE, REDUCE, REDESIGN. 最值得推广的是拒用、少用、重新设计。
- Circular building is not always easy, but technically feasible. 循环建筑并不总是容易的，但在技术上是可行的。
- Start and gain experience! 现在就行动起来，积累经验。



## CONCLUSION

结论

THANK YOU FOR YOUR ATTENTION  
感谢您的关注