How we all can increase the competitiveness of steel

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Introduction

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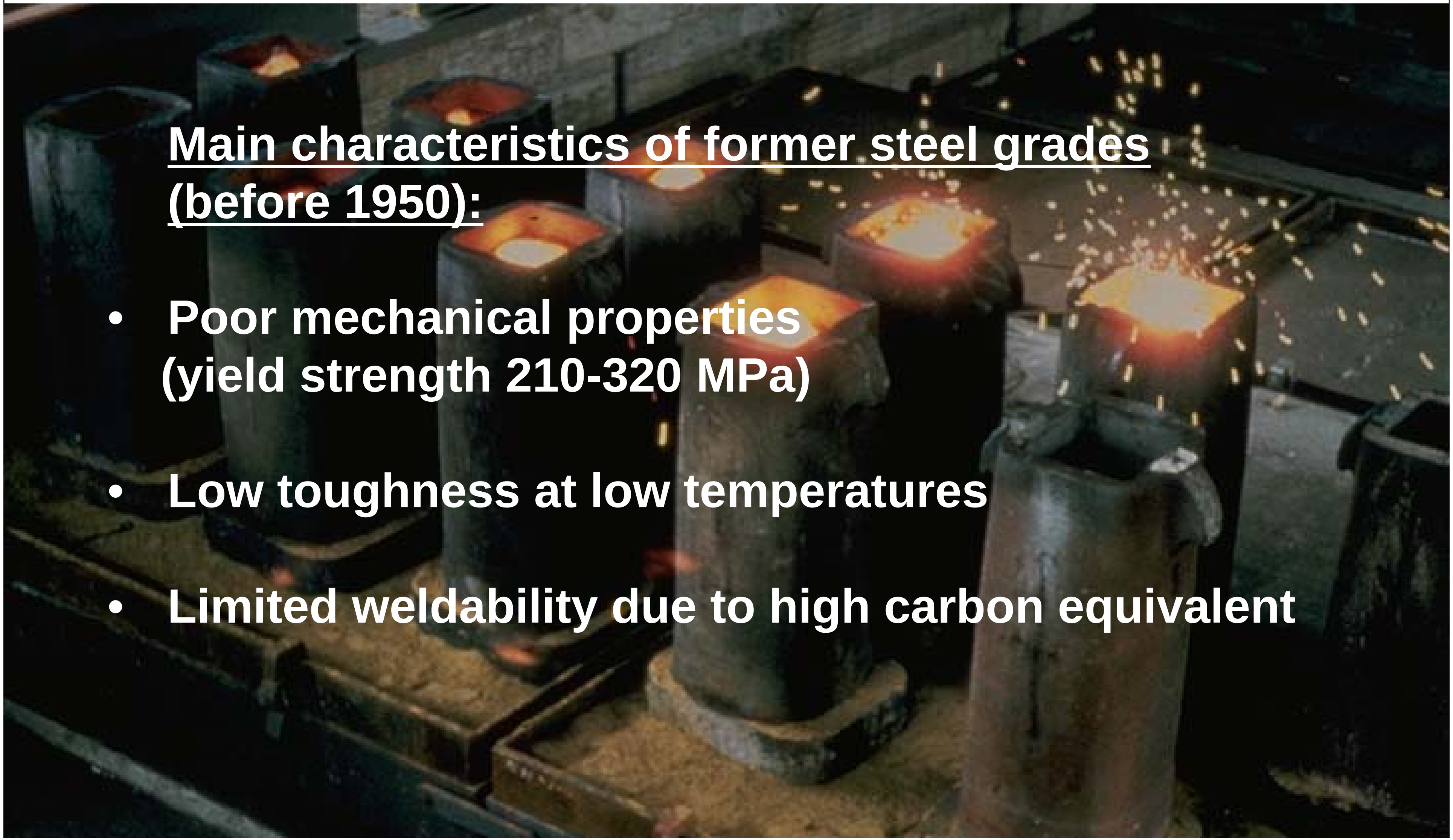
It is common knowledge that building products with higher strength enable to build with less material quantity and thus more competitively and “sustainably”.

In practice, typically design and execution is done ”as always“, which means quite often by using only low strength steel S235 or S275 (understood as cheapest per ton and immediately available).

Innovations and product improvements like S460, but sometimes also S355 are still unknown, ingnored or even declined in the worst case.

History of steel production



<u>Main characteristics of former steel grades (before 1950):</u>

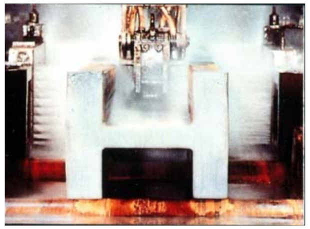
- **Poor mechanical properties (yield strength 210-320 MPa)**
- **Low toughness at low temperatures**
- **Limited weldability due to high carbon equivalent**

Industrial development

- Improvements in production of sections:
  - Melting: Precise alloying

  - Casting: Continuous casting of beam blanks

  - Rolling: Thermomechanical processing



STEEL GRADES OF SECTIONS
History and possible outlook

	« yesterday »	« today »	« tomorrow »
« low strength »	-	-	~~S235 / S275~~
« standard »	St37 / A36	S235 / ~~A36~~	S355 / Gr 50
« higher strength »	-	S355 / Gr 50	S460 / Gr65
« high-strength »	St52 / Gr50	S460 / Gr 65	S500 / Gr 70

Note: The change towards higher grades took already place in:

- *USA (about 1990-2000): From Grade 36 (250 MPa) to Grade 50 (345 MPa)*
- *UK (about 2000-2010): From S275 to S355*

Today‘s steel grades in EN

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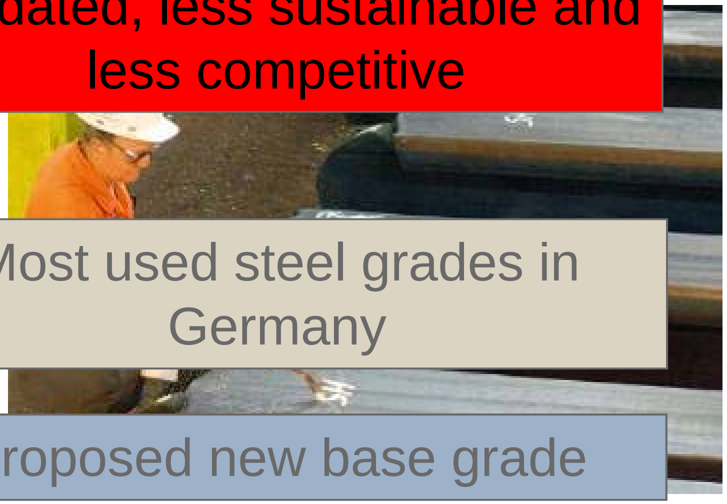
EN 10025-2:2004 **neu**	EN 10025:1990 +A1:1993 **alt**
	~~S235JR~~
	~~S235JRG1~~
S235JR	S235JRG2
S235J0	S235J0
	~~S235J2G3~~
S235J2	S235J2G4
S275JR	S275JR
S275J0	S275J0
	~~S275J2G3~~
S275J2	S275J2G4
S355JR	S355JR
S355J0	S355J0
	~~S355J2G3~~
S355J2	S355J2G4
	~~S355K2G3~~
S355K2	S355K2G4
S450J0	

EN 10025-4:2004 **neu**	EN 10113-3: 1993 **alt**
S355M	S355M
S355ML	S355ML
S460M	S460M
S460ML	S460ML



Outdated, less sustainable and less competitive

Most used steel grades in Germany

Proposed new base grade

Trend in Europe to higher grades in sections

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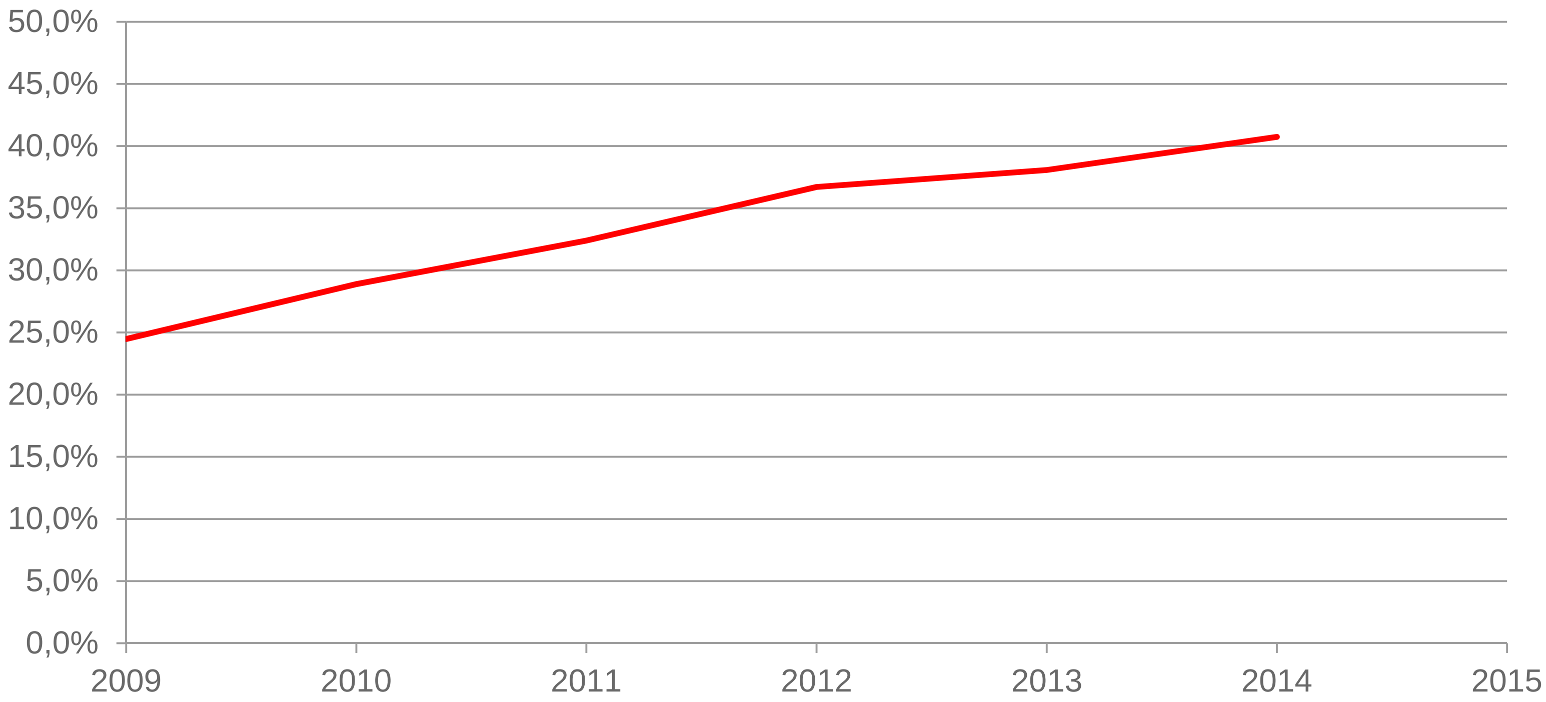
Shipments in grades S355 or higher



Estimated market share of steel in construction

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	S235, S275 / A36 (250 MPa)	S355 / Grade 50 (345 MPa)	S420, S460 / Grade 65 (450MPa)	Market share of Steel in building construction*
USA, Canada	< 1%	> 95%	> 1%	70%
UK	10%	90%	< 1%	70%
Scandinavia	10%	90%	< 1%	40%
Poland	60%	40%	< 1%	30%
Italy	50%	50%	< 1%	20%
Benelux	85%	15%	< 1%	20%
France	90%	10%	< 1%	20%
Germany	80%	20%	< 1%	10%

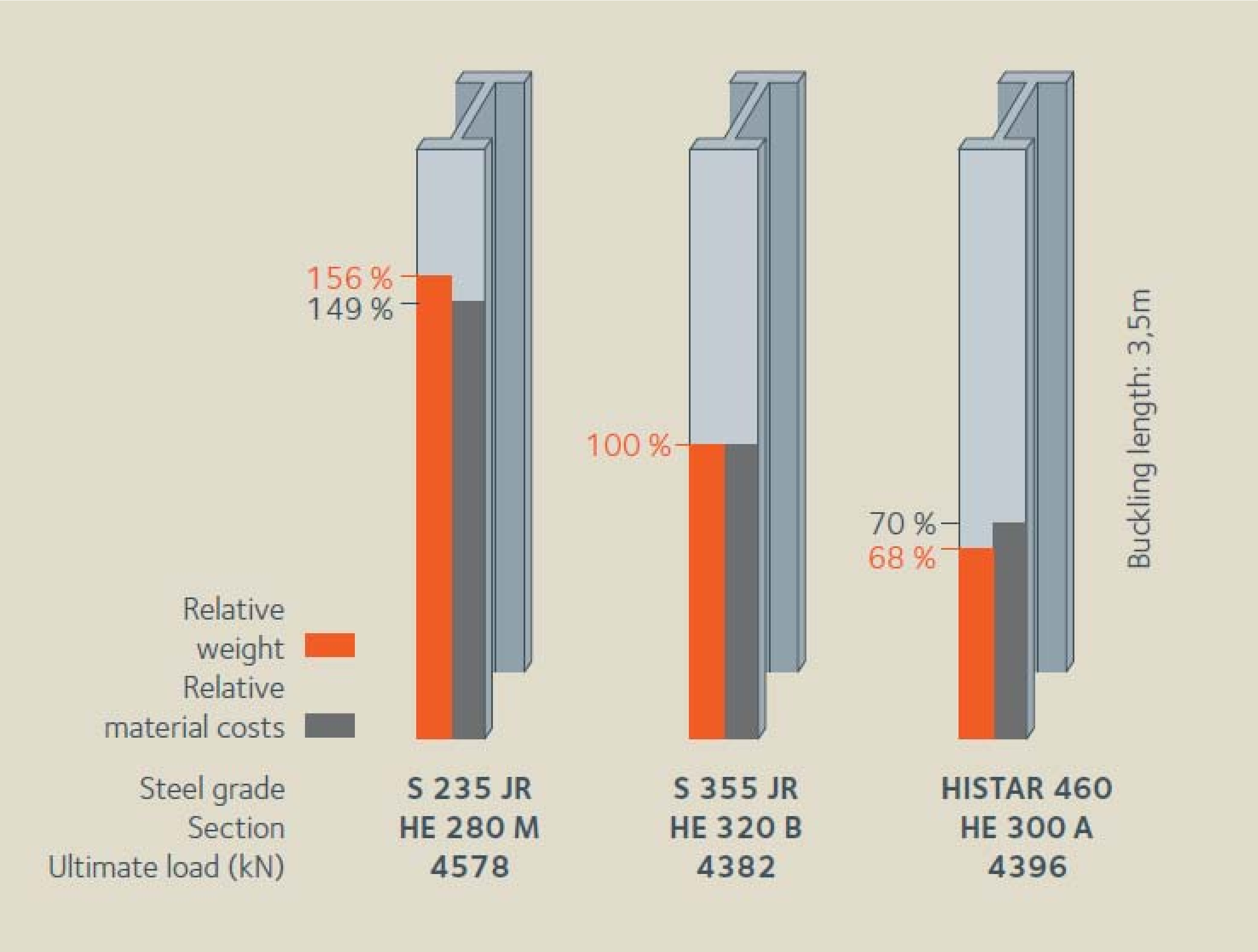
* Various sources / estimates 2012

Coincidence or correlation of market share of steel versus predominant use of higher strength steel ?

Material efficiency = Cost efficiency = Sustainability

Material and cost savings with higher strength sections:

Building columns



Material and cost savings with higher strength sections:

Composite car park girder

Car park girder	Variant 1	Variant 2	Variant 3
Steel grade	**S235JR+M** EN10025-2:2004	**S355J0+M** EN10025-2:2004	**S460M** EN10025-4:2004
Profile	IPE 600	IPE 550	IPE 500
Yield strength	225 N/mm² (t_f =19 mm)	345 N/mm² (t_f =17,2 mm)	460 N/mm² (t_f =16,0 mm)
Tensile strength	360 – 510 N/mm²	470 – 630 N/mm²	540 – 720 N/mm²
Profile height	600 mm	550 mm	500 mm
Girder weight*	2,12 t 114%	1,86 t 100%	1,61 t 87%
Cost*	**110%**	**100%**	**90%**
Total tonnage girder**	530 t	465 t	403 t
Girder per truck	10	12	14
Trucks to jobsite **	**25**	**21**	**18**

* Cost and weight estimate for ready-to-install girder of 16m length including cambering, shear studs, galvanization, connection plates, delivered to the jobsite

** Car park with 1000 parking places and 250 girders, max. truck load LKW 23 t

Material and cost savings with higher strength sections:

Crane runway beam

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Tabelle 7. Exemplarischer Vergleich DIN- mit Eurocode-Bemessung
Table 7. Exemplary comparison of DIN with Eurocode design

Radlast	DIN S235 [7]	A	DIN S355 [9]	A	EC S355 [9]	A	Flächenersparnis DIN (S235; HEB) / DIN (S355; HD)	DIN (S235; HEB) / EC (S355; HD)
in kN	Profil	in cm²	Profil	in cm²	Profil	in cm²	in %	in %
80	HEB 360	180,6	HD360×134 **	170,6	HD360×134	170,6	5,5 %	5,5 %
90	HEB 400	197,8	HD360×134 **	170,6	HD360×134	170,6	13,8 %	13,8 %
100	HEB 450	218,0	HD360×134	170,6	HD360×134	170,6	21,7 %	21,7 %
120	HEB 700	306,4	HD360×147 **	187,9	HD360×147	187,9	38,7 %	38,7 %
140	–	–	HD360×162 **	206,3	HD360×162 **	206,3	–	–
160	–	–	HD360×179 **	228,3	HD360×179 **	228,3	–	–
180	–	–	HD400×187	237,6	HD400×187	237,6	–	–
200	–	–	HD400×216	275,5	HD400×216	275,5	–	–

Possible consequences on market demand: Germany

STARTING POINT

Market share of steel (source bauforumstahl) :

- 30% in single storey buildings
- 5% in multi-storey buildings

2020

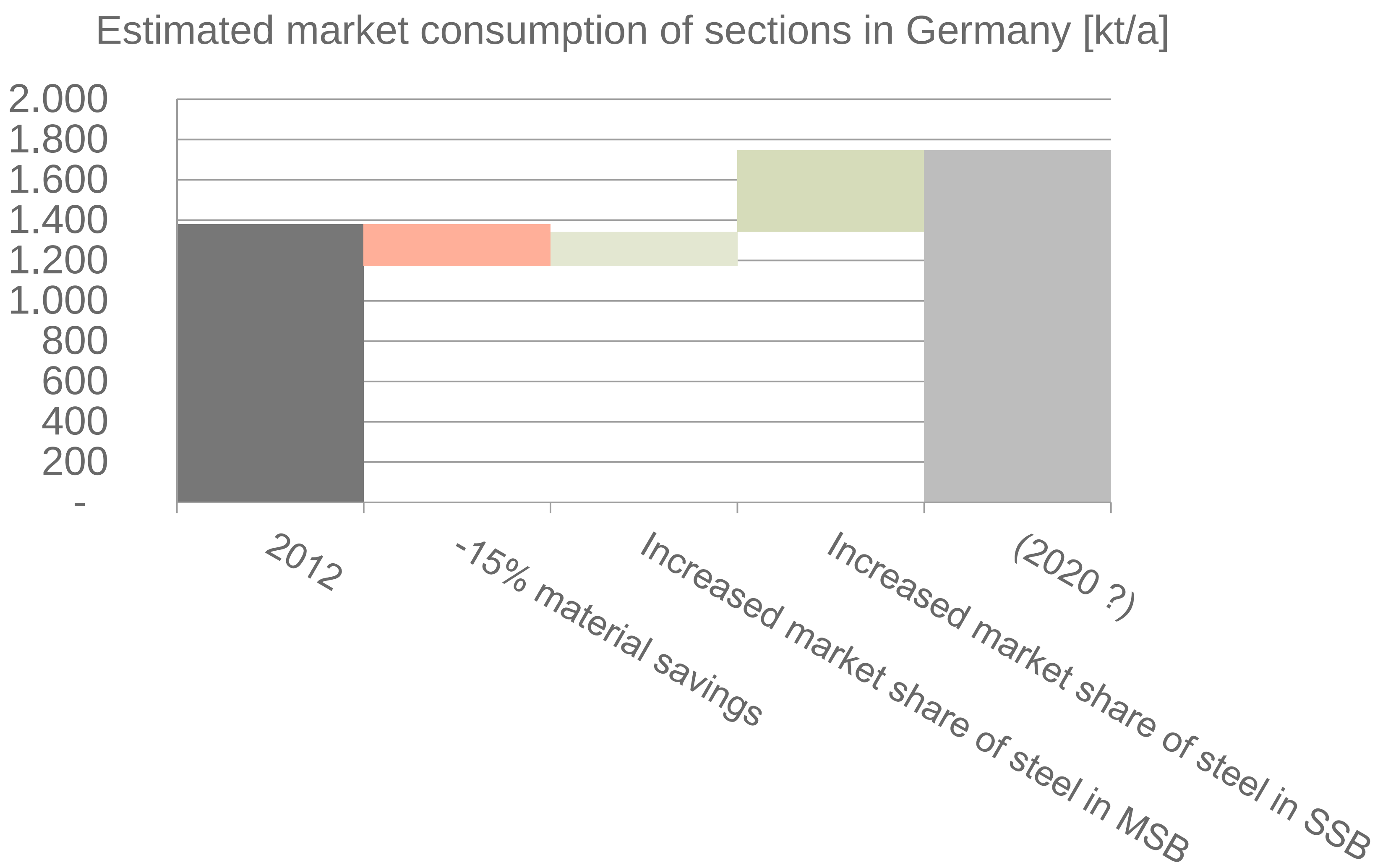
Possible outcome after transition from S235JR to S355J0:

Market share of steel:

- 40% in single storey buildings
- 10% in multi-storey buildings

S355 is structurally more efficient and allows about 15% material savings.

Possible outcome on demand of sections in Germany



General considerations

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Driven by the need for cost effective construction and sustainability, the material consumption and environmental impact can be easily reduced with higher strength steels.

A (slight) trend towards S355 as base-grade can be monitored for the majority of the European markets.

S460 is used project based by steel fabricators for value-engineering and thus material and cost optimization.

Normative situation

- Steel grades for sections from S235 to S460 well covered by
  - design standard: EN1993
  - product standard: EN10025
  - execution standard: EN1090 (product processing)

NEW: EN1993-1-1, Annex C

Engineer's responsibility:

The Execution Class (EXC) must be specified for:

- the works as a whole
- an individual component
- a detail of a component

Note:

EN1090-2, 4.1.2:

If no execution class is specified **EXC2** shall apply.

NEW: EN1993-1-1, Annex C

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Table C.1: Choice of execution class (EXC)

Reliability Class (RC) or Consequences Class (CC)	Type of loading	
	Static, quasi-static or seismic DCL[a]	Fatigue[b] or seismic DCM or DCH[a]
RC3 or CC3	EXC3[c]	EXC3[c]
RC2 or CC2	EXC2	EXC3
RC1 or CC1	EXC1	EXC2

[a] Seismic ductility classes are defined in EN 1998-1: Low = DCL; Medium = DCM; High = DCH.

[b] See EN 1993-1-9.

[c] EXC4 may be specified for structures with extreme consequences of structural failure.

(6) The National Annex may specify the choice of execution class in terms of types of components or details.
The following is **recommended**:
If EXC1 is selected for a structure, then **EXC2** applies to the following types of component:
a) welded components manufactured from **steel products of grade S355 and above**;
b) welded components essential for structural integrity that are assembled by welding on the construction site;
c) welded components of CHS lattice girders requiring end profile cuts;
d) components with hot forming during manufacturing or receiving thermic treatment during manufacturing.

Misperception about EXC1 ?
-> Only for consequence Class CC1

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EN1990 **Table B1 - Definition of consequences classes**

Consequences Class	Description	Examples of buildings and civil engineering works
CC3	**High** consequence for loss of human life, *or* economic, social or environmental consequences **very great**	Grandstands, public buildings where consequences of failure are high (e.g. a concert hall)
CC2	**Medium** consequence for loss of human life, economic, social or environmental consequences **considerable**	Residential and office buildings, public buildings where consequences of failure are medium (e.g. an office building)
CC1	**Low** consequence for loss of human life, *and* economic, social or environmental consequences **small or negligible**	Agricultural buildings where people do not normally enter (e.g. storage buildings), greenhouses

Consequence Class acc. to EN1991-1-7, Table A.1	**Example of categorisation of building type and occupancy**
CC1	Single occupancy houses not exceeding 4 storeys.
	Agricultural buildings.
	Buildings into which people rarely go, provided no part of the building is closer to another building, or area where people do go, than a distance 1½ times the building height.

NEW: EN1993-1-1, Annex C

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RC3 or CC3	EXC3[c]	EXC3[c]
RC2 or CC2	EXC2	EXC3
~~RC1 or CC1~~	~~EXC1~~	~~EXC2~~

[a] Seismic ductility classes are defined in EN 1998-1: Low = DCL; Medium = DCM; High = DCH.

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c) welded components of CHS lattice girders requiring end profile cuts;
d) components with hot forming during manufacturing or receiving thermic treatment during manufacturing.

Improved traceability

Steel grade (EN10025, ETA-10/0156)	Execution class of component (EN1993-1-1, Annex C)	Certificate (EN 10204)
~~S235 JR / J0, S275 JR / J0~~	~~EXC1-EXC2-EXC3-EXC4~~	~~→ 2.2~~
~~S235 J2, S275 J2~~	~~EXC1-EXC2-EXC3-EXC4~~	~~→ 3.1~~
S355 JR / J0	~~EXC1~~ EXC2 - EXC3 - EXC4	~~→ 2.2~~ → 3.1
S355 J2 / K2 / M / ML, HISTAR 355 / 355L	~~EXC1~~-EXC2-EXC3-EXC4	→ 3.1
S450 J0, S460 M / ML, HISTAR 460 / 460L	~~EXC1~~-EXC2-EXC3-EXC4	→ 3.1

Inspection documents
EN 10204: 2004

Required for S355 → and higher

Table A.1 — Summary of inspection documents

EN 10204 Reference	Designation of the document type			Document content	Document validated by
	English version	German version	French version		
Type 2.1	Declaration of compliance with the order	Werksbeschei-nigung	Attestation de conformité à la commande	Statement of compliance with the order	The manufacturer
Type 2.2	Test report	Werkszeugnis	Relevé de contrôle	Statement of compliance with the order, with indication of results of non-specific inspection	The manufacturer
Type 3.1	Inspection certificate 3.1	Abnahmeprüf-zeugnis 3.1	Certificat de réception 3.1	Statement of compliance with the order, with indication of results of specific inspection	The manufacturer's authorized inspection representative independent of the manufacturing department
Type 3.2	Inspection certificate 3.2	Abnahmeprüf-zeugnis 3.2	Certificat de réception 3.2	Statement of compliance with the order, with indication of results of specific inspection	The manufacturer's authorized inspection representative independent of the manufacturing department and either the purchaser's authorized inspection representative or the inspector designated by the official regulations

Just to compare…

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Steel grade	Strength	Unit cost	Material consumption	Material cost	Trace-ability	Weld-ability	Welding quality requirements	Mill availabilty
S235	100%	100%	100%	100%	Non-specific	Good	Elementary in EXC1	Good
S275	117%	100%	95%	95%	Non-specific	Good	Elementary in EXC1	Good
S355	**150%**	**105%**	**85%**	**90%**	**Specific**	**Good**	**Standard in EXC2**	**Good**
S460	196%	115%	70%	80%	Specific	Good	Standard In EXC2	Good

Examples of major Construction Projects in S355 and S460 – EXC2/EXC3

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Office for environmental affairs - Brussels

Residence Palace- Brussels

Waalse Krook- Ghent

Ghelamco Stadion - Ghent

Comparison of steel grades

Reinforcing steel			Structural steel			
			Hollow sections		**Rolled open sections**	
Grade	Strength	Availability	Grade	Availability	Grade	Availability
BSt 22/34 FeB 220	220 MPa	Out of use	S235	Out of use	S235	Still stocked
BSt 34/50 FeB 400	360 MPa	Out of use	S355	Basis	S355	Available
BSt 500 FeB 500	500 MPa	Basis	S460	Available	S460	Available

Conclusions from the European standardization

- The purpose of Consequence Class (CC) is to ensure that buildings are constructed with the appropriate level of quality control.
- The majority of structures in Europe is expected to be in CC2.
- Execution Class EXC2 will be the appropriate requirement for the majority of buildings constructed in Europe.
- Sections’ base grade S355J0+M with Inspection certificate 3.1 meets the technical and economical requirements of the European structural steel fabricators.

THANK YOU!

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Using S355J0+M as base grade for sections will increase the competitiveness of steel !

Questions?

Fragen?

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