Niobium

Grams saving tonnes

Rio de Janeiro, September 22, 2010

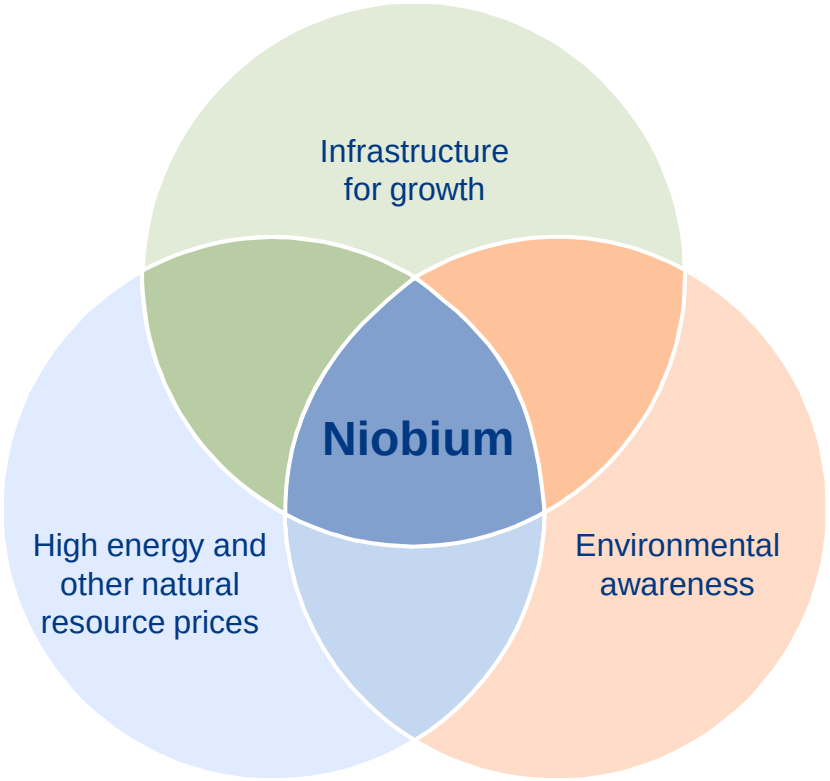
CBMM

Innovate, Respect, Compete.

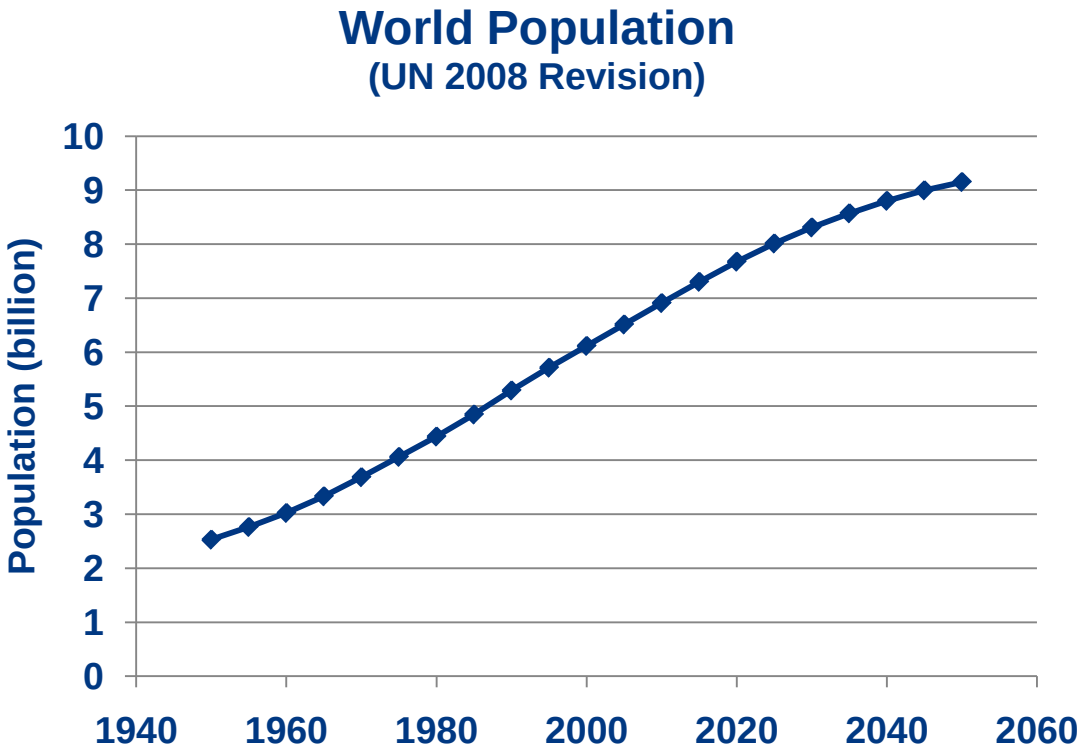
Efficient use of natural resources

- **The need for, and increasing use of, more complex infrastructure**
- **Increasing prices for natural resources**
- **Increasing environmental awareness**

The best replacement for steel is better steel



Infrastructure



United Nations

- **Additional 2 billion people in one generation.**
- **60% living in cities by 2030.**

Infrastructure needs (New and Replacement)

Food, fuel, housing, transportation, power and water.

Energy - Oil and gas transportation

Decline of 'easy oil and gas' → development of more challenging hydrocarbon sources → more advanced infrastructure required

Conventional oil

New finds increasingly in harsh environments such as ultra deepwater and the Arctic

Unconventional oil

Oil sands

New methods

New conditions

Earthquakes and permafrost

New mediums

pH-value – sour service

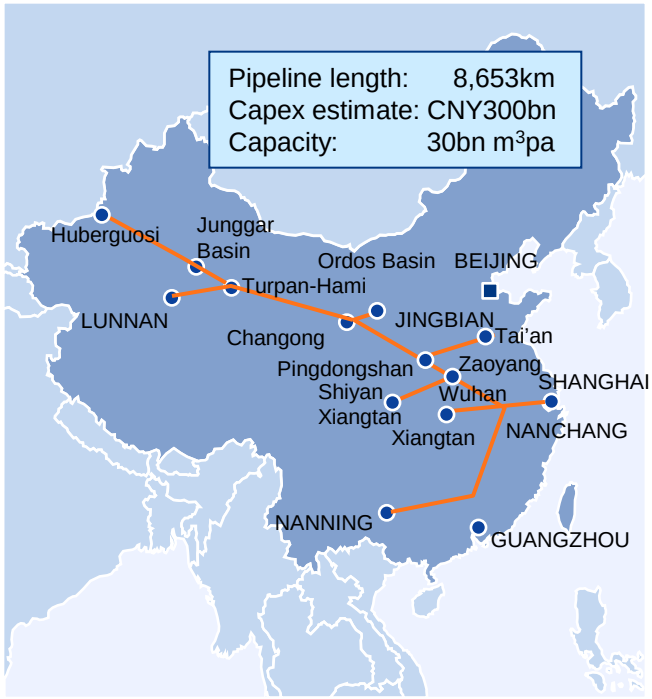
Stronger and tougher pipelines required due to

I. **Increased distance of**
   - **Field to infrastructure**
   - **Field to market**

II. **Harsher environments**
   - **Low temperatures**
   - **Ice / icebergs**

Energy - Oil and gas transportation

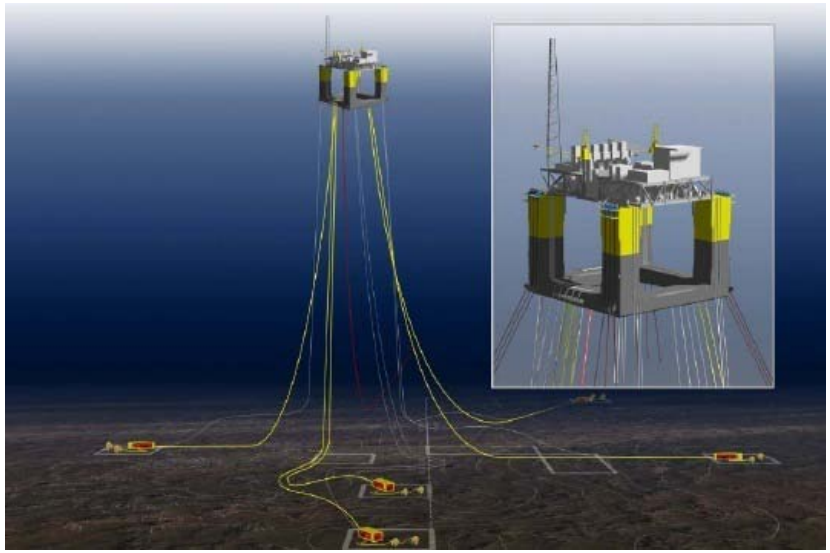
China West-East II pipeline



Source: Wood Mackenzie

Gulf of Mexico – Deepest offshore platform

8,000 ft deep / HPT steel-0.1%Nb



Source: Heijermans, B.H. "Global Oil & Gas, Deepwater Challenges and the Use of Alternative Methods and Materials for Deepwater Oil and Gas Production" International Symposium on Microalloyed Steels for the Oil and Gas Industry, TMS (The Minerals, Metals and Materials Society), 2007, p.3-14

Efficient use of resources - Energy Generation

Turbines

Applications

- Nickel-based super-alloys incorporating niobium
  - form the backbone of jet engines, both commercial and military
  - also used in land turbines to generate electricity

Rationale for niobium use

- Provides creep strength in applications where strength at high temperature is an important engineering consideration

➡ 5% niobium allows higher operating temperatures → higher efficiency

➡ + 10ºC operating temperature = +1% efficiency

Aircraft engine

Courtesy of Rolls Royce

Land based turbine

Courtesy of GE Power Systems

Environmental Awareness - Automotive

(China Daily - Sep 09, 2010)

Ministry of Industry and Information estimated 200 million vehicles on the road in 2020.

The biggest single source of air pollution in the cities is emissions from motor vehicles.

China could produce more than 31 million units every year by 2015.

Outdoor air pollution has become a major concern for public health.

China became the world´s largest auto market in 2009 (13.6 million vehicles sold).

It´s important to increase the use of renewable energy, energy efficient and clean-fuel vehicles. This is a necessary investment for China´s future.

Automobile emissions

MINISTRY OF INDUSTRY AND INFORMATION officials estimated at the weekend that more than 200 million motor vehicles will be on the road in China in 2020. Environment officials, however, said about 10 percent of Chinese cities suffer from serious air pollution and motor vehicles are the main pollutant source in most of the cities.

The amount of exhaust fumes from 200 million automobiles should be grave enough to send a chill up our spine. Before our city dwellers are choked by their emissions, decision-makers should come up with a clear strategy of the road for China's auto industry to travel in the future.

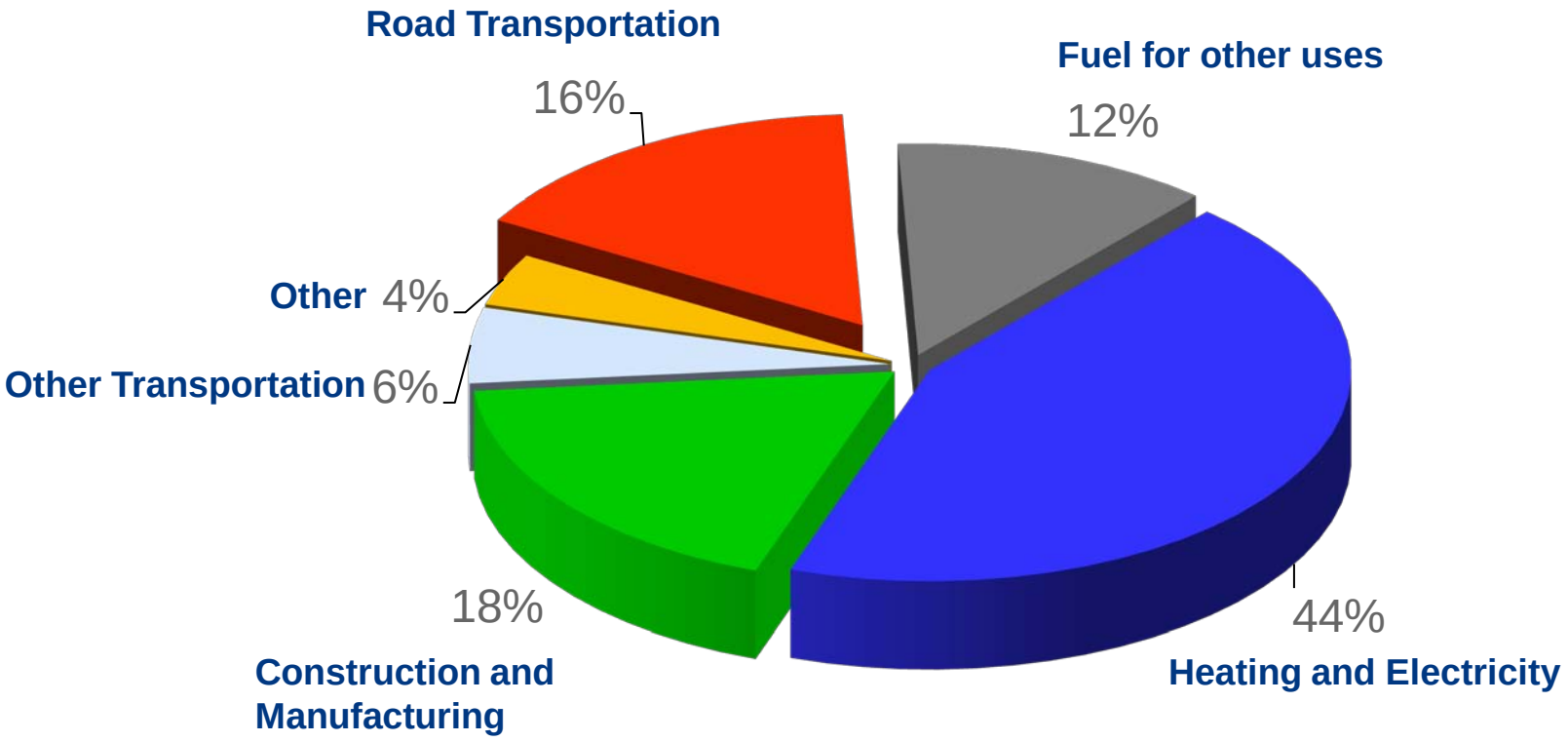
Problems arise from several sources of air pollution. But the biggest single source, given their volatile, atmospheric organic compounds and other harmful pollutants, is emissions from motor vehicles. Air pollution raises the risk of respiratory illnesses and the World Health Organization ranks urban outdoor air pollution as the 13th greatest contributor to disease and death worldwide.

Economic incentives have driven many regions to build auto factories. They count on this sector to be the driver for their economic growth. Blind investment in the industry has caused over-capacity. China could produce more than 31 million units every year by 2015, a large number for any nation.

Although its air quality has improved substantially, China is still facing serious air pollution. Outdoor air pollution has become a major concern for public health.

China became the world's largest auto market last year, when over 13.6 million vehicles were sold. It's important to increase the use of renewable energy, energy efficient and clean-fuel vehicles. This is a necessary investment for China's future.

Environmental Awareness
CO_2 Emmissions by source (2008)



World Resources Institute, Climate Analysis Indicators Tool- 2008

Efficient use of natural resources

Oil and gas transmission pipelines

- **Superior performance to withstand increased pressure and transport volumes over greater distances**

Large structures

- **Larger and leaner structures can be built at lower costs with more advanced specifications**

Niobium

Automobiles

- **Improves fuel efficiency, emissions control and safety**

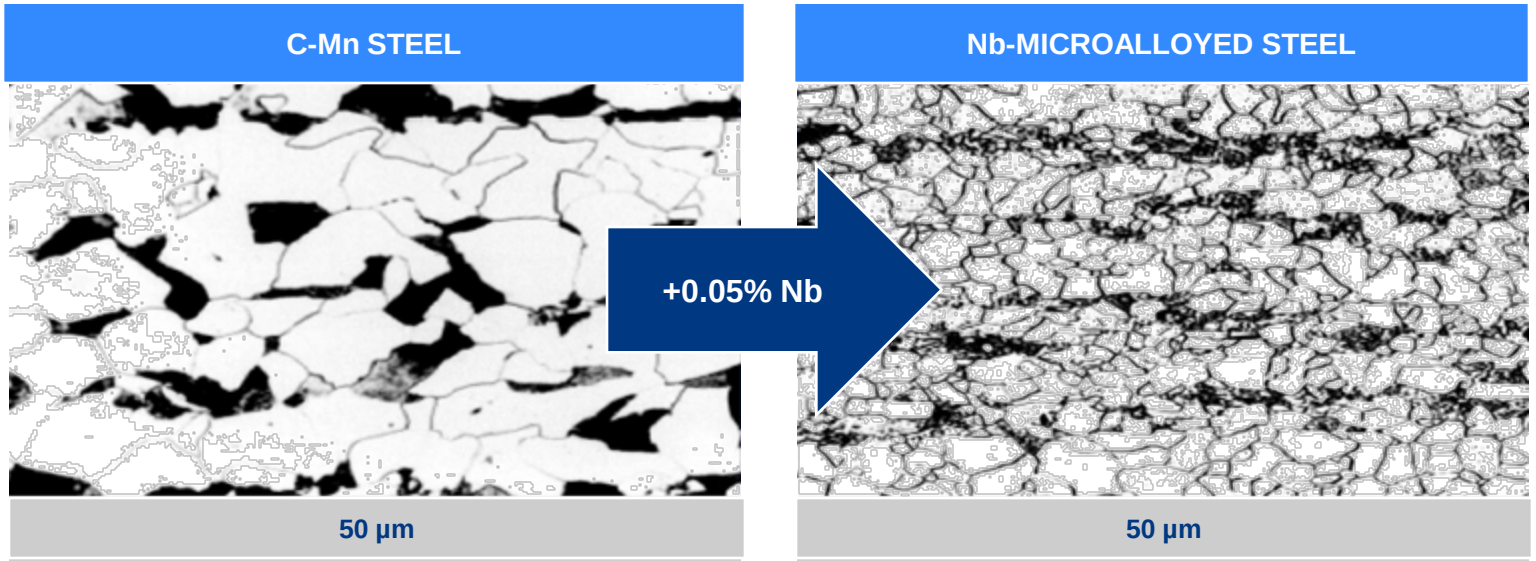
Turbines and other applications

- **More efficient due to higher operating temperatures**

Source: CBMM

Niobium enhances special steels

NIOBIUM → **is an alloying element for** → **STEEL & SUPERALLOYS**



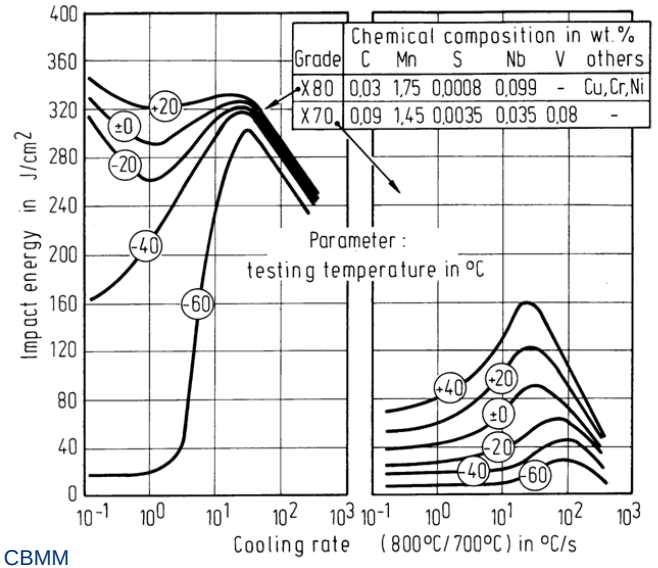
Source: Subgrain and precipitation – strengthening effects in hot-rolled, columbium-bearing steels. Pages 59-70 (Mangonon Jr, P.L. & Heitmann, W.E.) MicroAlloying '75.

The importance of Niobium in steels

- **Niobium is unchallenged for its main applications**

WITHOUT NIOBIUM – LOW RESISTANCE TO CRACK ADVANCE (TOUGHNESS)

X80 – 0.099 Nb **X70 – 0.035 Nb**

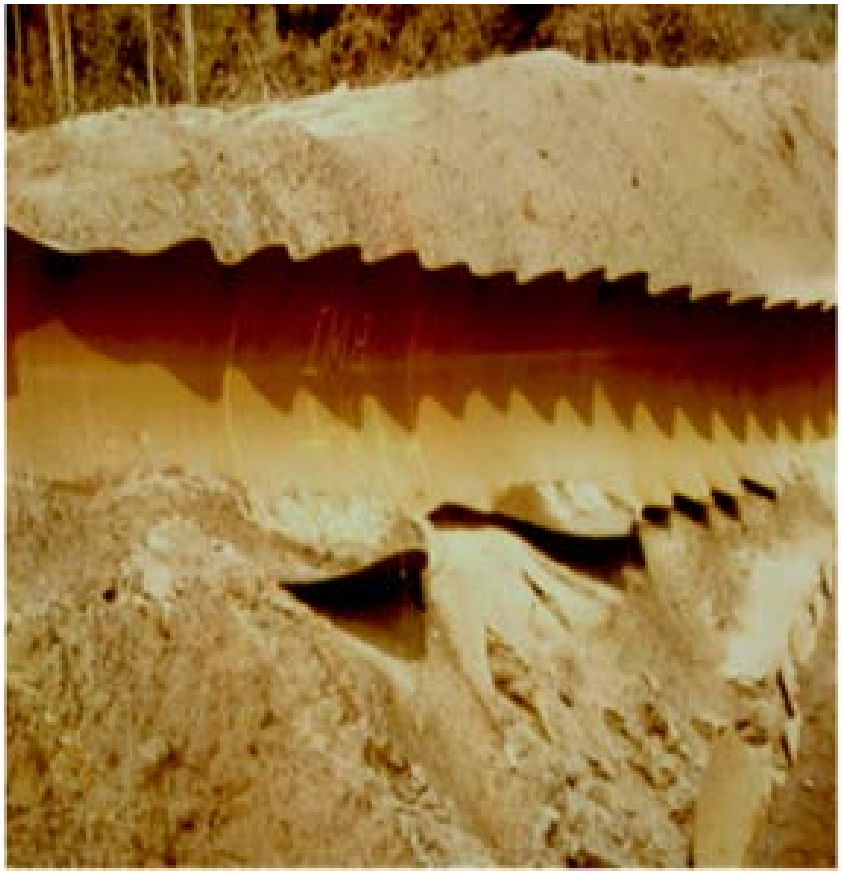


Source: CBMM

NIOBIUM TECHNOLOGY ARRESTS CRACKS

Tougher rather than brittle

No niobium used	With niobium



Niobium – indispensable and the most advantageous

Hot Rolling as a High-Temperature Thermo-Mechanical Process

By **Isao Kozasu,** Manager
Chiaki Ouchi, Assistant Manager
Tetsuya A. Sampei and **Tomoyoshi Okita,** Research Engineers, Steel Products Section
Technical Research Centre; Nippon Kokan K.K.; Kawasaki, Japan

"Microalloying is an important contribution to the development of controlled rolling. For example, niobium (columbium) was first introduced as a strengthening element in the late 1950's and was later found to be an indispensable element for controlled-rolled steels."

"The beneficial effect of controlled rolling largely depends on the alloying elements employed. Niobium (columbium) has been found to be the most advantageous because of its ability to retard austenitic recrystallization. Therefore, refinement resulting from deformation below the recrystallization temperature is achieved easily even at relatively high temperatures."

Efficient use of natural resources

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Niobium

Automobiles

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Turbines and other applications

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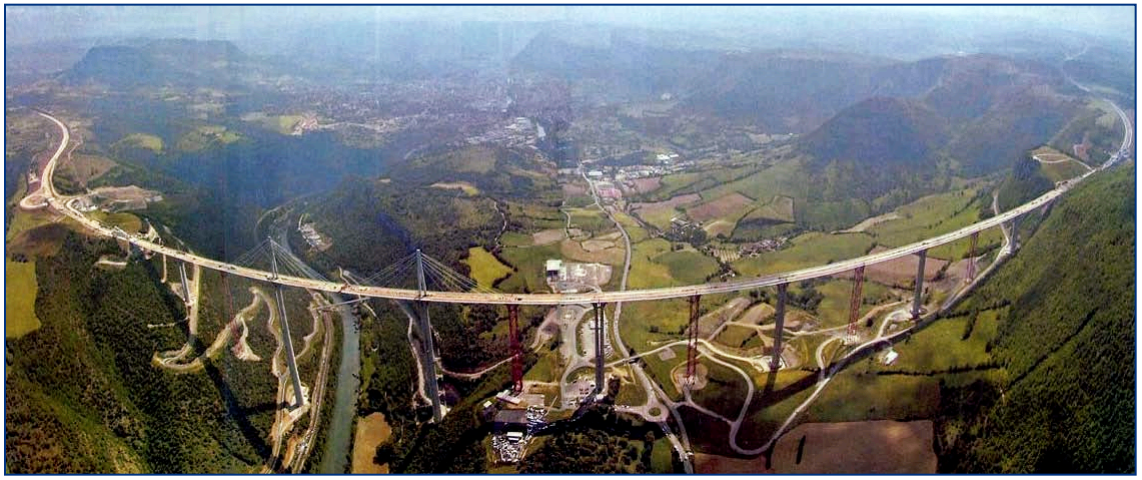
Source: CBMM

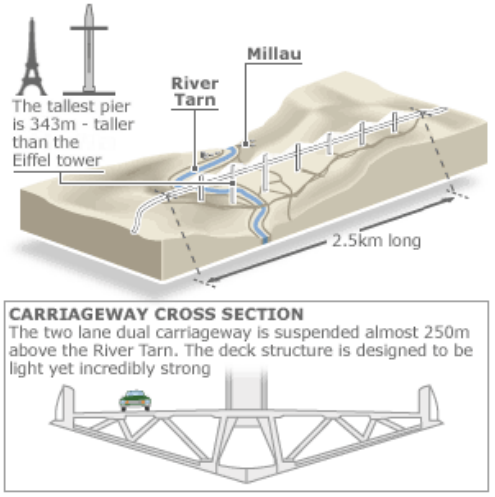
Infrastructure and efficiency – Millau Valley Bridge



Millau Valley Bridge, France – Sir Norman Forster, architect

Millau Valley Bridge

- Construction cost of €390m
- 60% weight reduction (steel & concrete)
- 40Kt of steel plate used (S460M) – 0.025% Nb

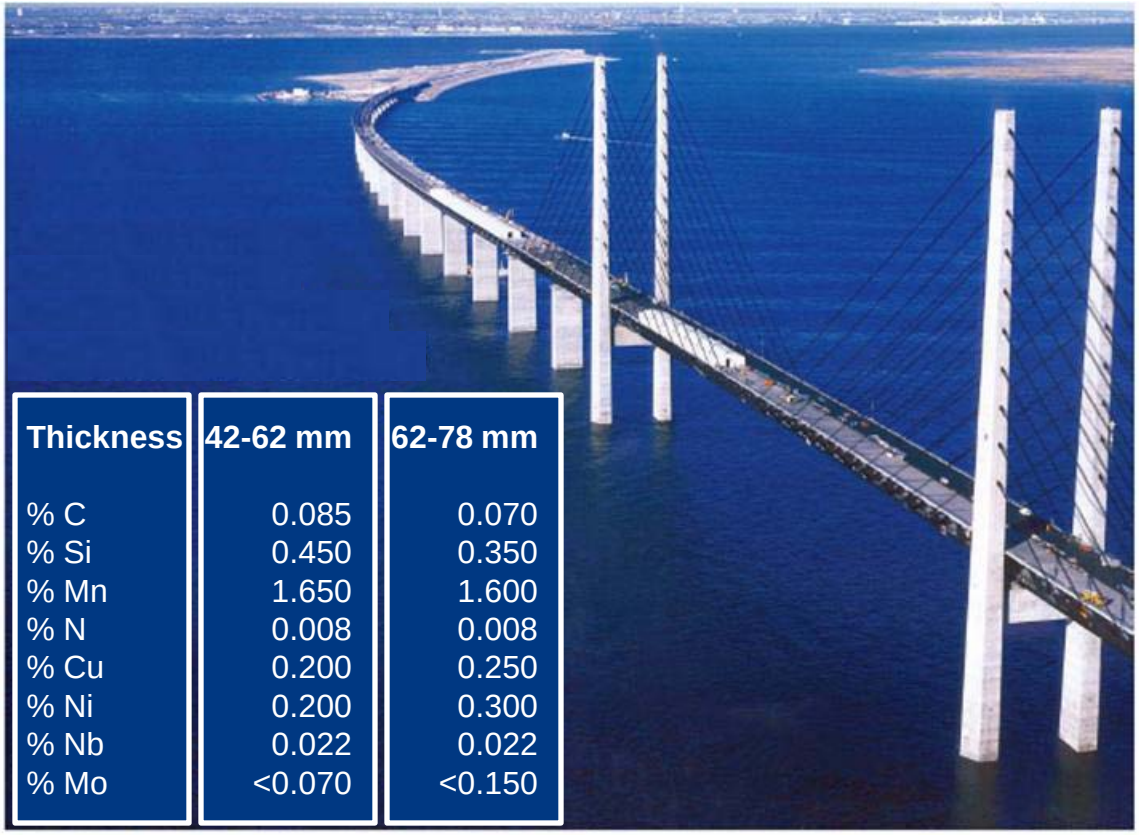


Crossing the valley

The bridge spans the valley of the River Tarn, a 2.5 km wide gorge dividing two plateaux in France's rugged Massif Central region

The largest pylon is 343 metres high-taller than the Eiffel Tower

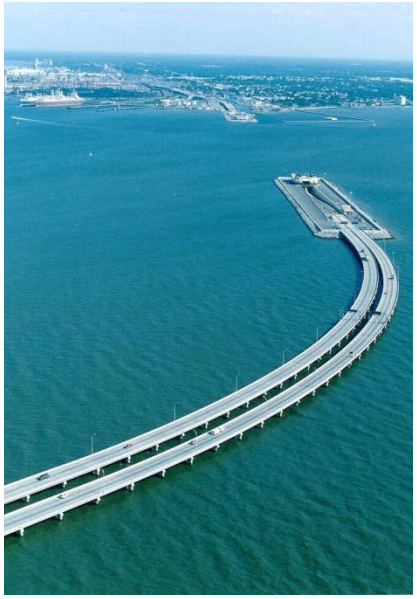
Infrastructure and efficiency - Øresund bridge



Thickness	42-62 mm	62-78 mm
% C	0.085	0.070
% Si	0.450	0.350
% Mn	1.650	1.600
% N	0.008	0.008
% Cu	0.200	0.250
% Ni	0.200	0.300
% Nb	0.022	0.022
% Mo	<0.070	<0.150

Øresund bridge

- 82 Kt of micro-alloyed steel (S460 steel grade)
- 15 Kt weight reduction
- US$25 million cost reduction



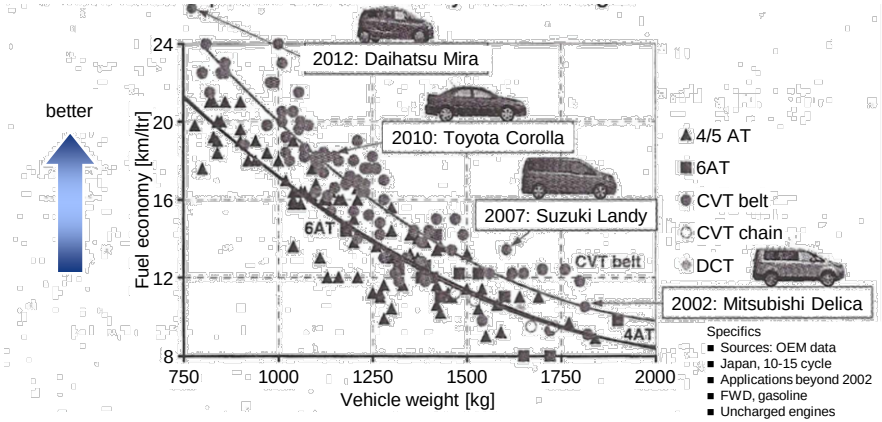
Infrastructure and efficiency – Commerzbank Tower

Commerzbank Tower
(Frankfurt / Main)

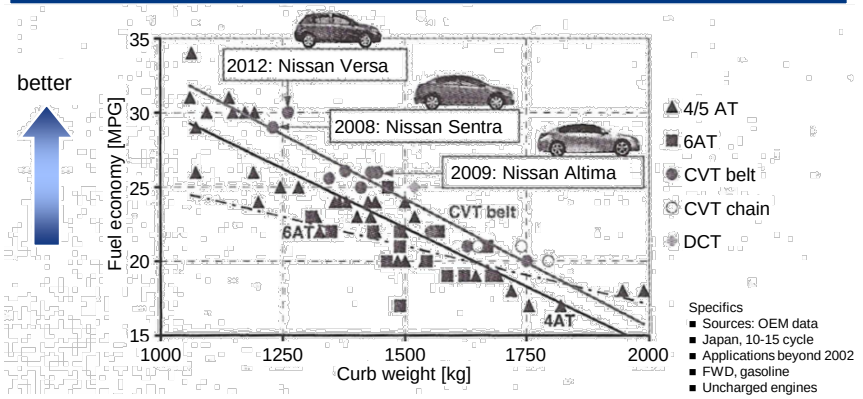
- 300m high
- Space for 2,400 employees on 63 floors
- 60 Kt weight reduction compared to reinforced concrete
- 19.5 Kt of steel used in total
  - 10 Kt of steels containing 0.03% – 0.05%Nb (S355M and S460M)

Energy and efficiency - Saving fuel

Japan



USA



Source: Wijk, E. Current Status and Future Development of Continuously Variable Transmission Worldwide (2007), SAE-China Congress Proceedings, pages 59-66

Automobile manufacturers continually striving to

1. **Reduce weight**
2. **Increase fuel efficiency**
3. **Reduce emissions**

Environmental Awareness - Reduced emissions

Stricter emissions standards will promote increased niobium usage as niobium improves fuel economy and reduces emissions

- **2012 EU target of 130g CO_2 /km (18km/L of gas)**
- **currently, cars can perform up to ~180/190g CO_2 /km**

US$9 of niobium per car

100kg weight reduction of mid size car with little or no system cost change[(a)]

1 litre of fuel savings per 200km

Corresponds to a lifetime saving of 2.2 tonnes of CO_2 equivalents per vehicle, based on LCA[(a)]

Savings in emissions is more than the total amount of CO_2 emitted during the production of all the steel in the vehicle

(a) World Steel Association
(b) Life cycle assessment

Environmental Awareness - Automotive Industry

Stricter emissions regulations

(NO_x max from 3.0 to <0.5 g/km)

Higher catalytic chamber temperatures (↑ 100ºC)

+

10-year warranty for exhaust parts

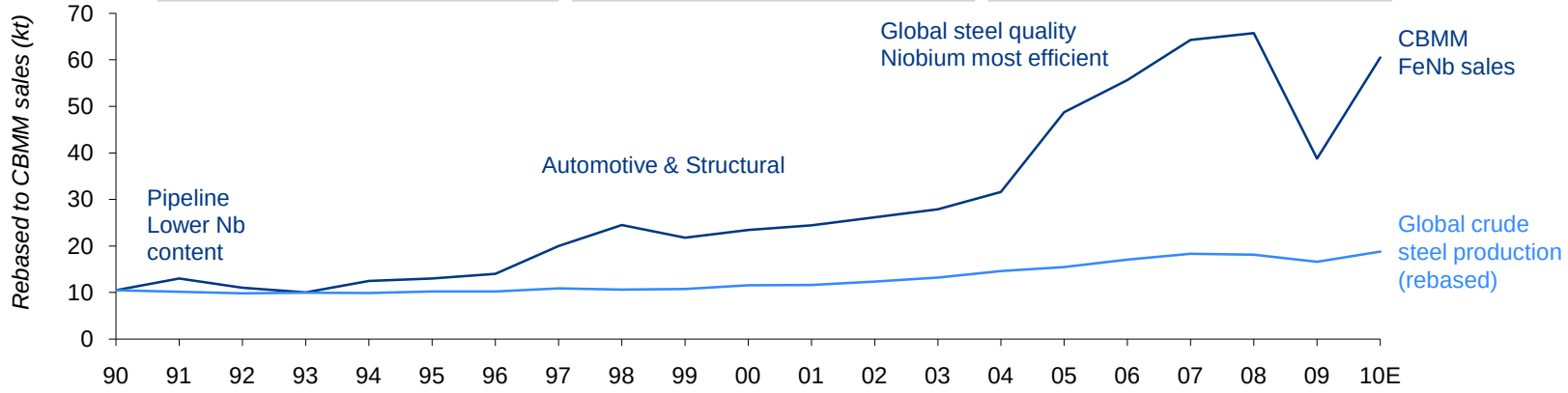
Niobium bearing ferritic stainless steel

Source: Hiramatsu, N. Niobium in Ferritic and Martensitic Stainless Steel – Niobium Science and Technology (2001), pages 961-974

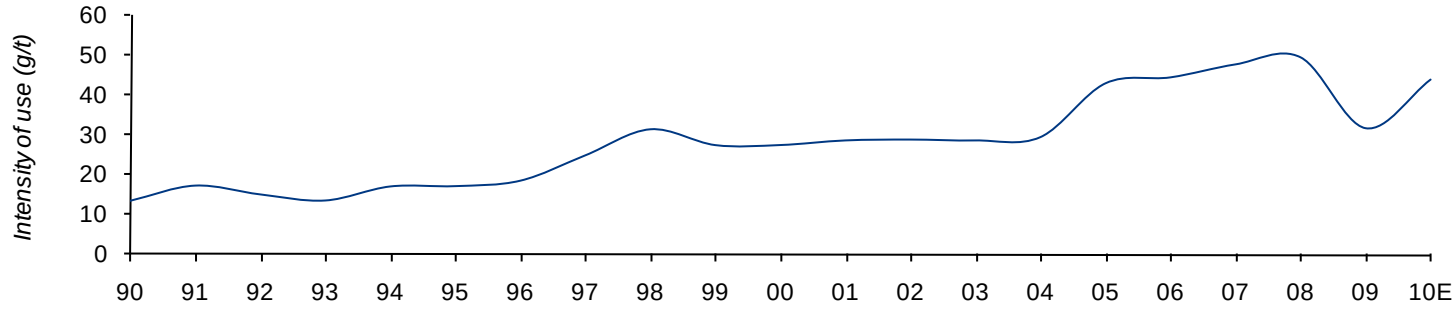
Market Recognition
Ability to deliver more results with less resources

CBMM FeNb sales vs. crude steel production for 20 years

1990 – 1996 CAGR		1996 – 2003 CAGR		2003 – 2010E CAGR	
Niobium:	5%	Niobium:	10%	Niobium:	12%
Steel:	(0.4)%	Steel:	4%	Steel:	5%



Increased Niobium intensity of use



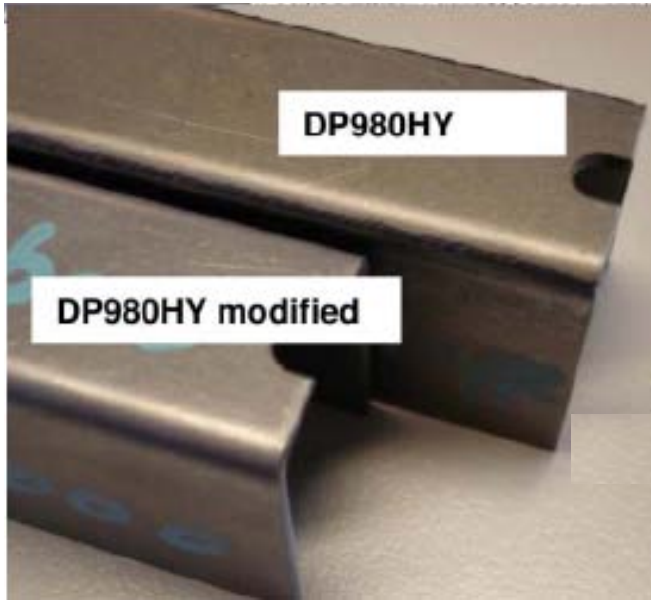
Source: CRU, CBMM

Sustainable Program

Adding value to the entire chain

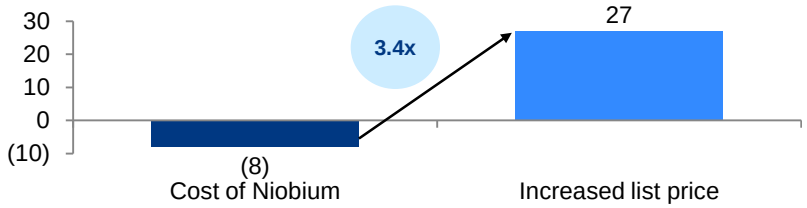
Modified DP steels for profiling operations

- ✓ Bending radius can be tighter
- ✓ Profile cross section is smaller
- ✓ Reduction of weight
- ✓ Improvement of packaging
- ✓ Works for DP590, 780, 980 by 0.02% Nb alloying

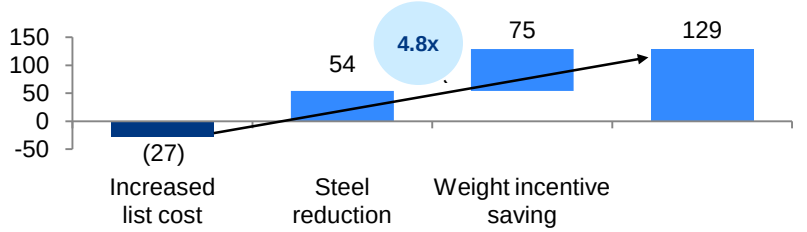


Indicative cost-benefit analysis (US$/t)

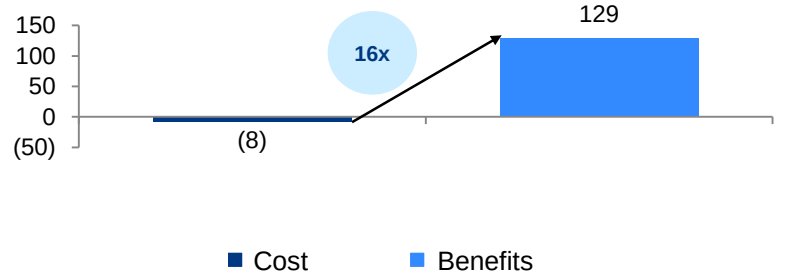
Steel producer



Automotive producer



Across the value chain



Increasingly efficient solutions

China West – East pipeline comparison

	1st line – X70	2nd line – X80	X80 vs. X70
Steel used (Mt)	1.58	4.34	
Total length (km)	3,874	8,653	
Steel used (kt/km)	0.41	0.50	1.23x ↑
Capacity			2.14x ↑

✓ Achieved 2.14x capacity increase while only using 1.23x tonnage of steel

✓ CNY6.5bn capex savings

✓ CNY0.7bn opex savings

Source: Wood Mackenzie, TGRC, China

Sustainable Program

CBMM headquarters – Araxá, Minas Gerais