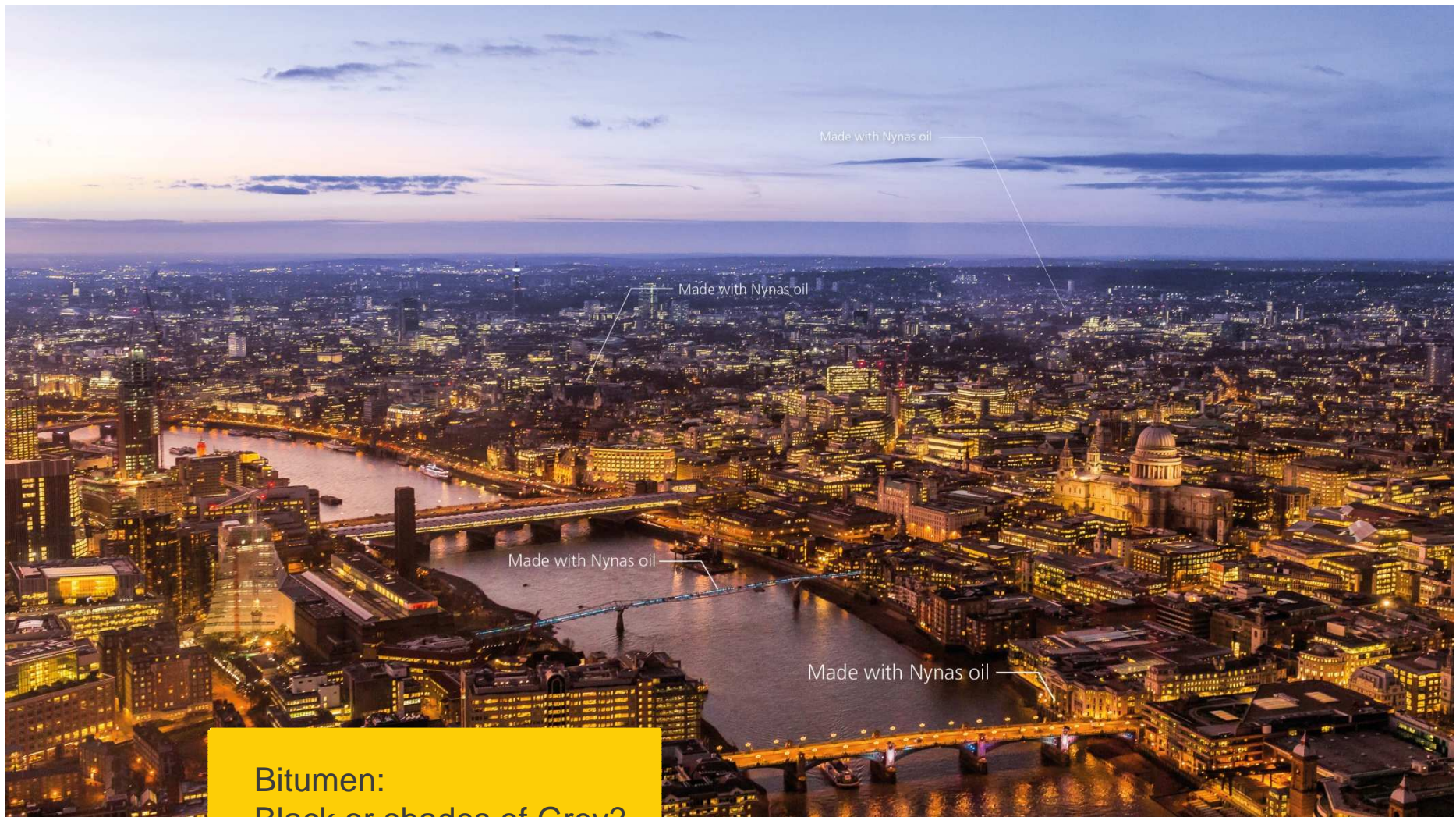


How far a drop of oil
took one company

Welcome to Nynas



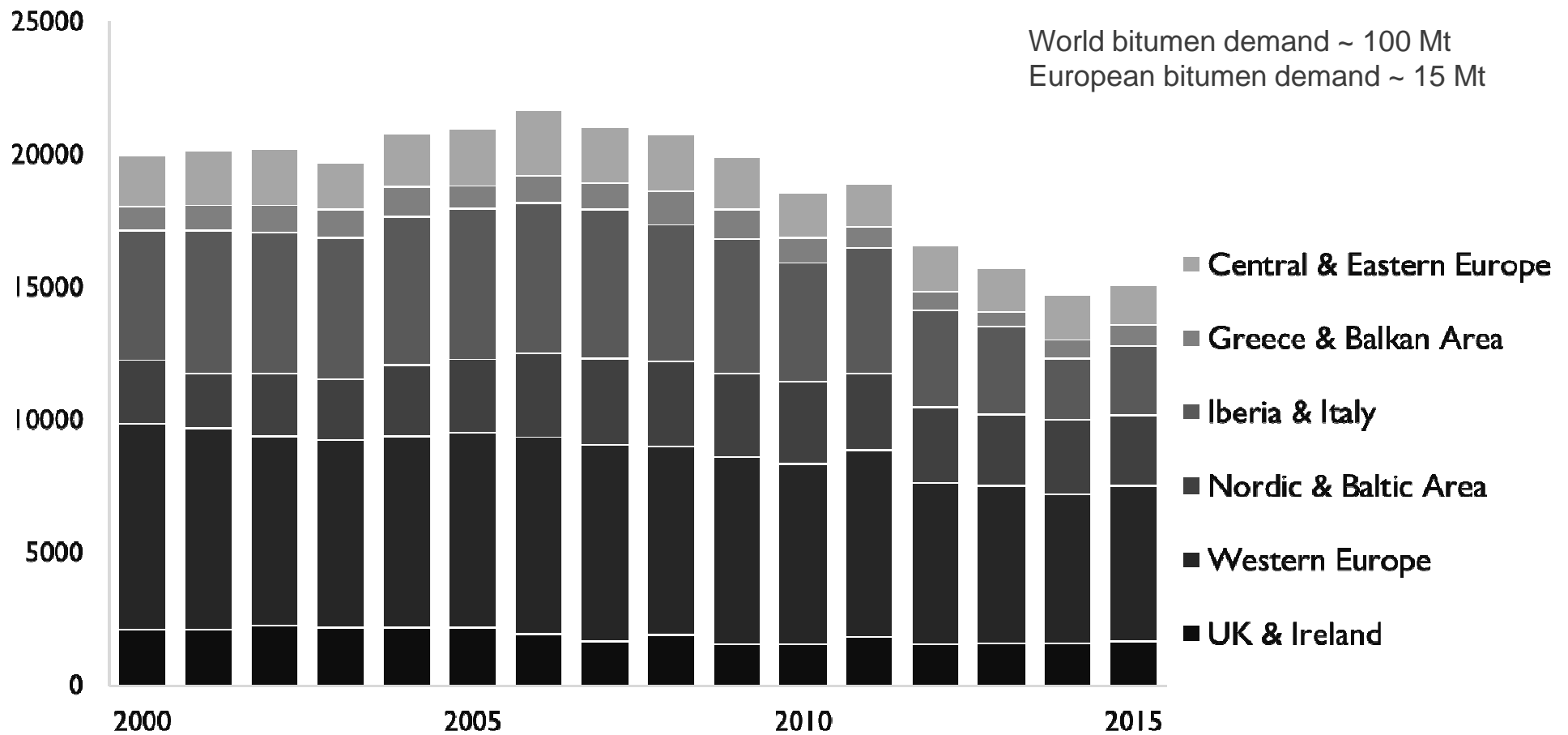


Bitumen:
Black or shades of Grey?

Carl Robertus



European bitumen demand

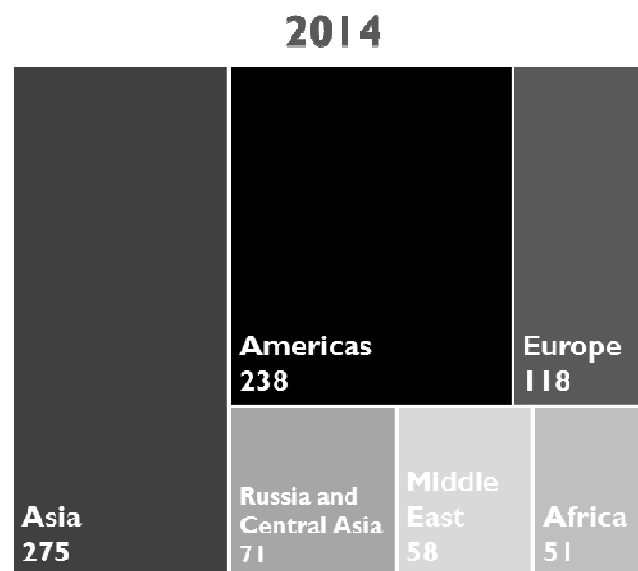
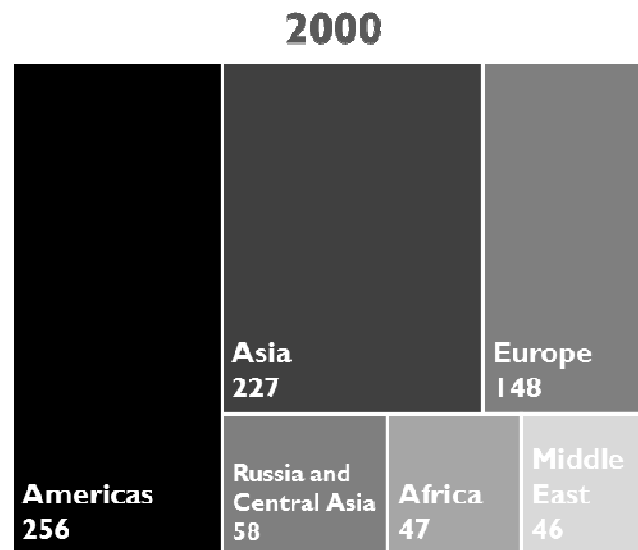
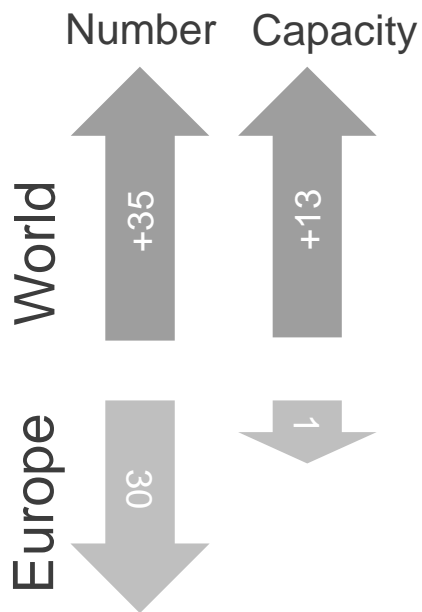


Source : Nynas estimates based on various sources.

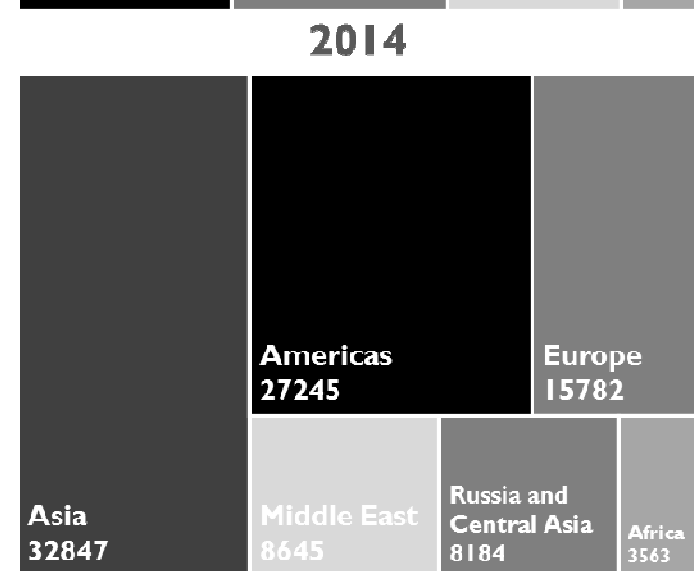
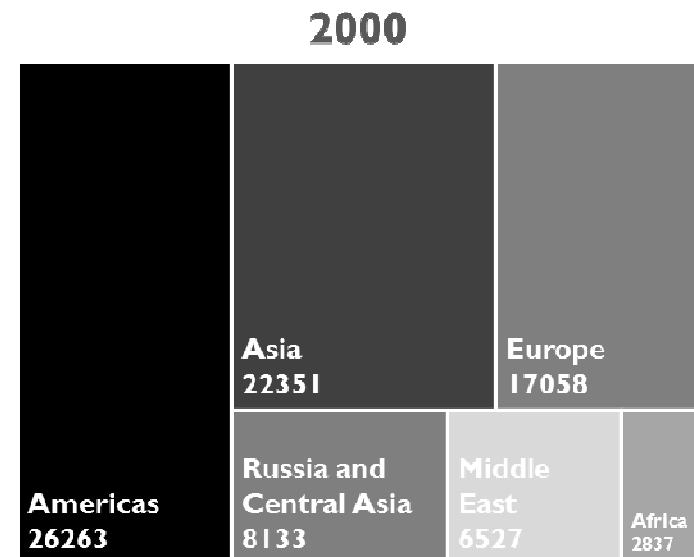




Refineries

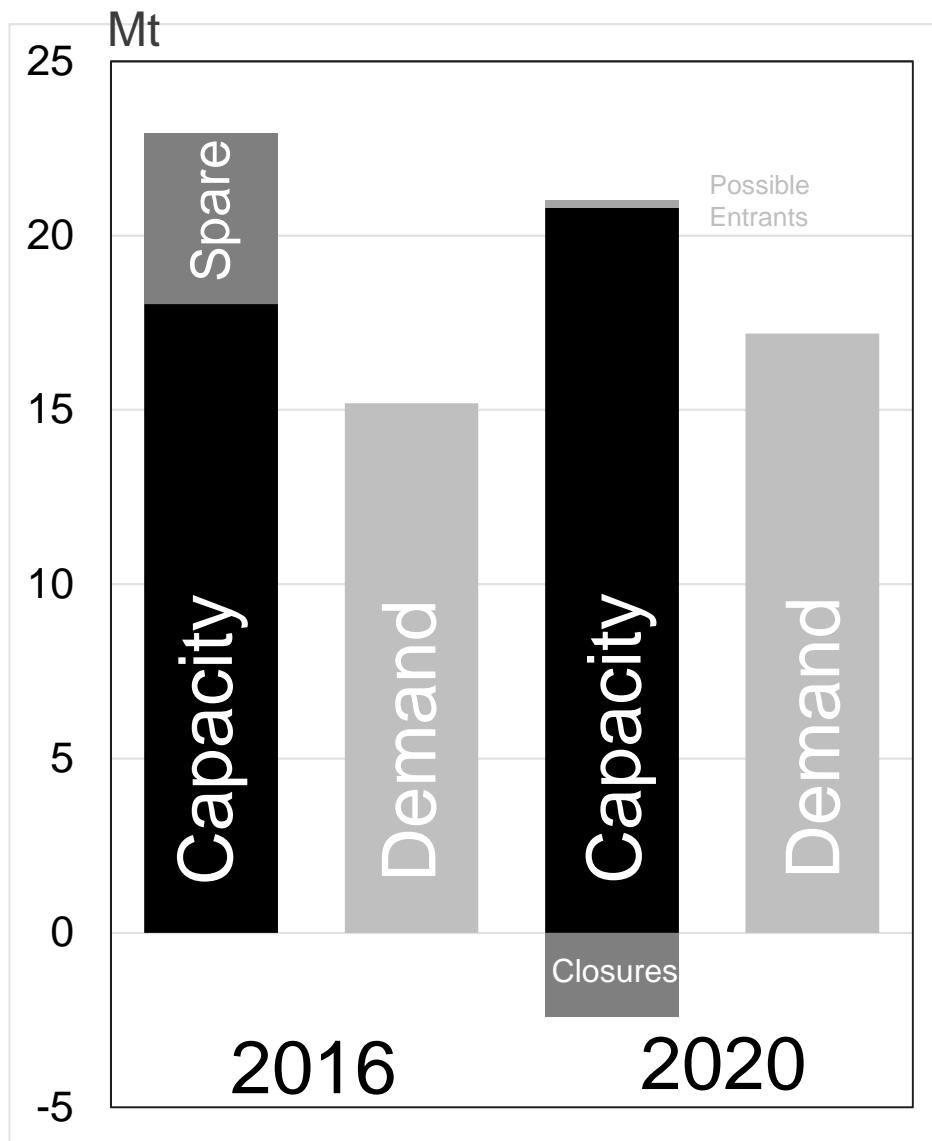


Number

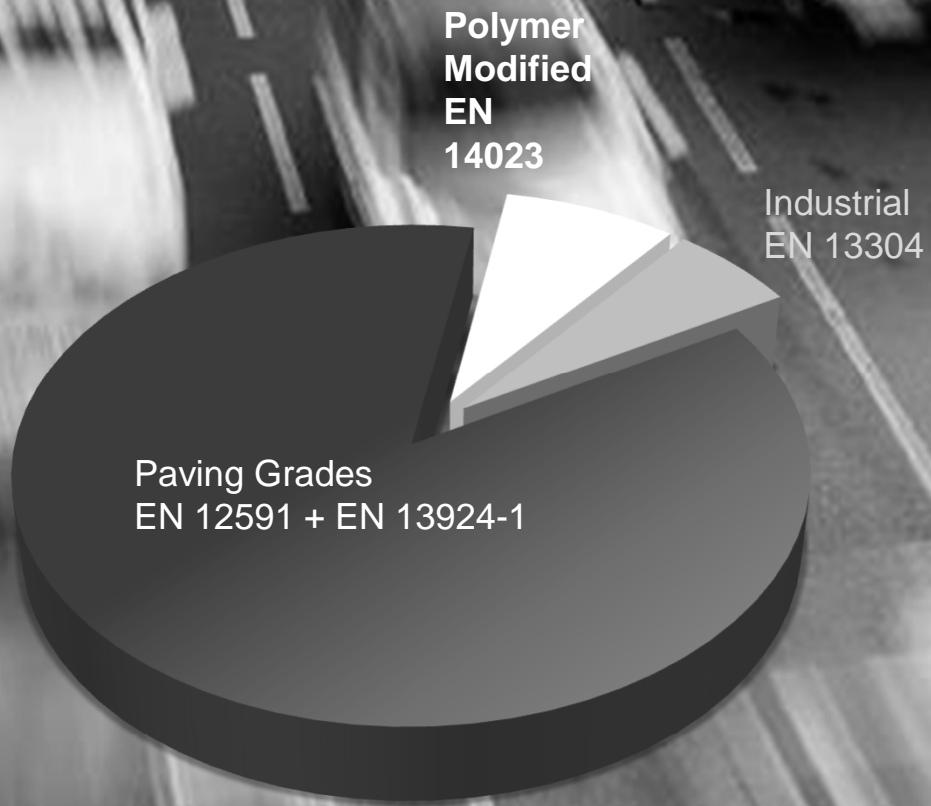


Capacity, kb/d

Where is bitumen produced in Europe?



Bitumen grades in Europe



FORMAL DEMANDS

Construction Products Regulation (EU) No 305/2011

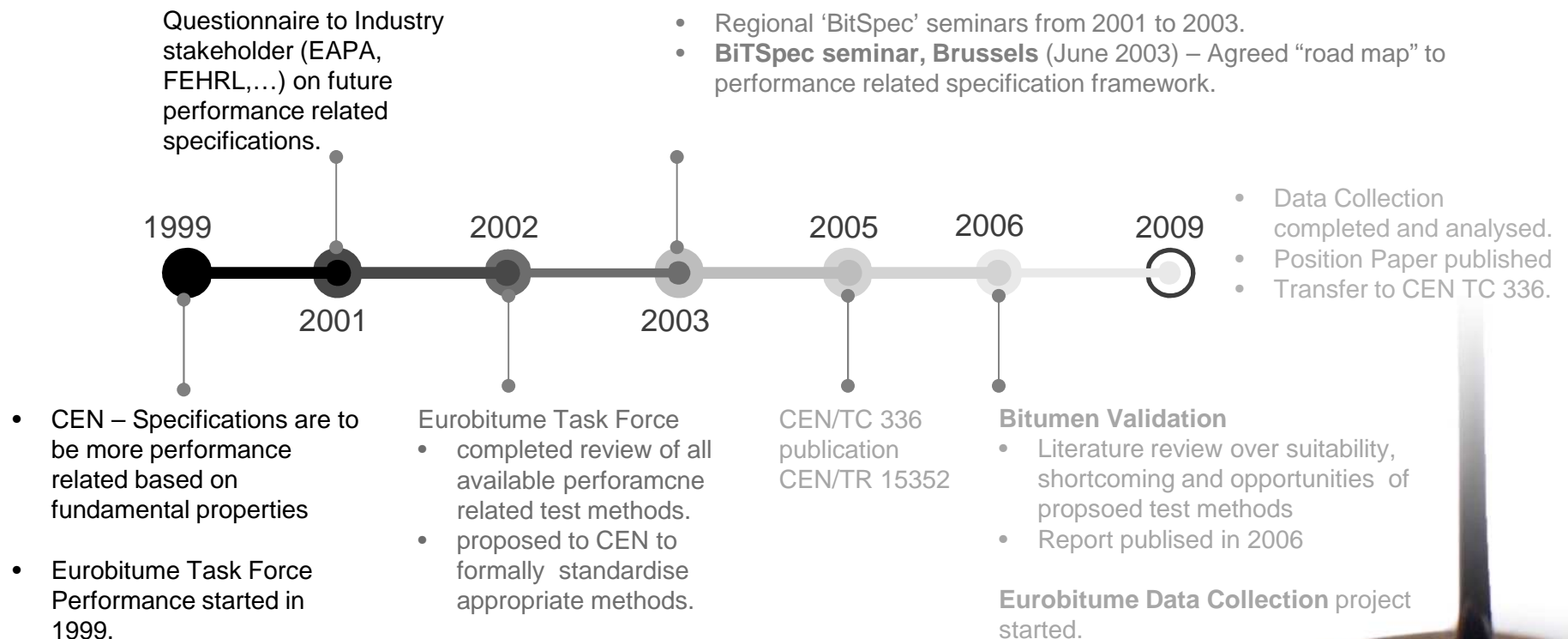
- Establishes 'Basic Requirements'
 - Mechanical resistance and stability
 - Safety in case of fire
 - Hygiene, health and the environment
 - Safety and accessibility in use
 - Protection against noise
 - Energy economy and heat retention
 - Sustainable use of natural resources
- Must be incorporated into bitumen standards

Bitumen Quality ...?

Table 1 — Paving grade bitumen specifications for grades from 20 x 0.1mm to 220 x 0.1mm penetr

Characteristics	Unit	Test method	Class 0 ^a	20/30	30/45	35/50	40/60	50/70
Penetration at 25°C	0,1 mm	EN 1426	/	20 – 30	30 – 45	35 – 50	40 – 60	50 – 70
Softening point	°C	EN 1427	/	55 – 63	52 – 60	50 – 58	48 – 56	46 – 54
Resistance to hardening at 163°C		EN 12607-1	/					
Retained penetration	%		/	≥ 55	≥ 53	≥ 53	≥ 50	≥ 50
Increase in softening point, max - <i>Severity 1</i> or Increase in softening point, max - <i>Severity 2^b</i>	°C		/	≤ 8 or ≤ 10	≤ 8 or ≤ 11	≤ 8 or ≤ 11	≤ 9 or ≤ 11	≤ 9 or ≤ 11
Flash point ^b	°C	EN ISO 2592	/	≥ 240	≥ 240	≥ 240	≥ 230	≥ 230
Solubility ^b	%	EN 12592	/	≥ 99	≥ 99	≥ 99	≥ 99	≥ 99
Change of mass after RTFOT ^b	%	EN 12607-1	/	≤ 0,5	≤ 0,5	≤ 0,5	≤ 0,5	≤ 0,5

Bitumen specification timeline from empirical to more fundamental performance



Ageing induced cracking

Observations:

- Block cracking can occur on aged pavements without reaching BBR $T_{critical}$
- Materials rank differently for block vs. transverse cracking



Two binder parameters have been introduced in 2011*

- **ΔT_c** from Bending Beam Rheometer
- **Glover – Rowe** from Dynamic Shear Rheometer (G^* , δ at $T=15^\circ\text{C}$ and $\omega=0.005\text{ s}^{-1}$)

* Anderson, King, Hanson, Blankenship, *Evaluation of the Relationship between Asphalt Binder Properties and Non-Load Related Cracking*, AAPT 2011, p615

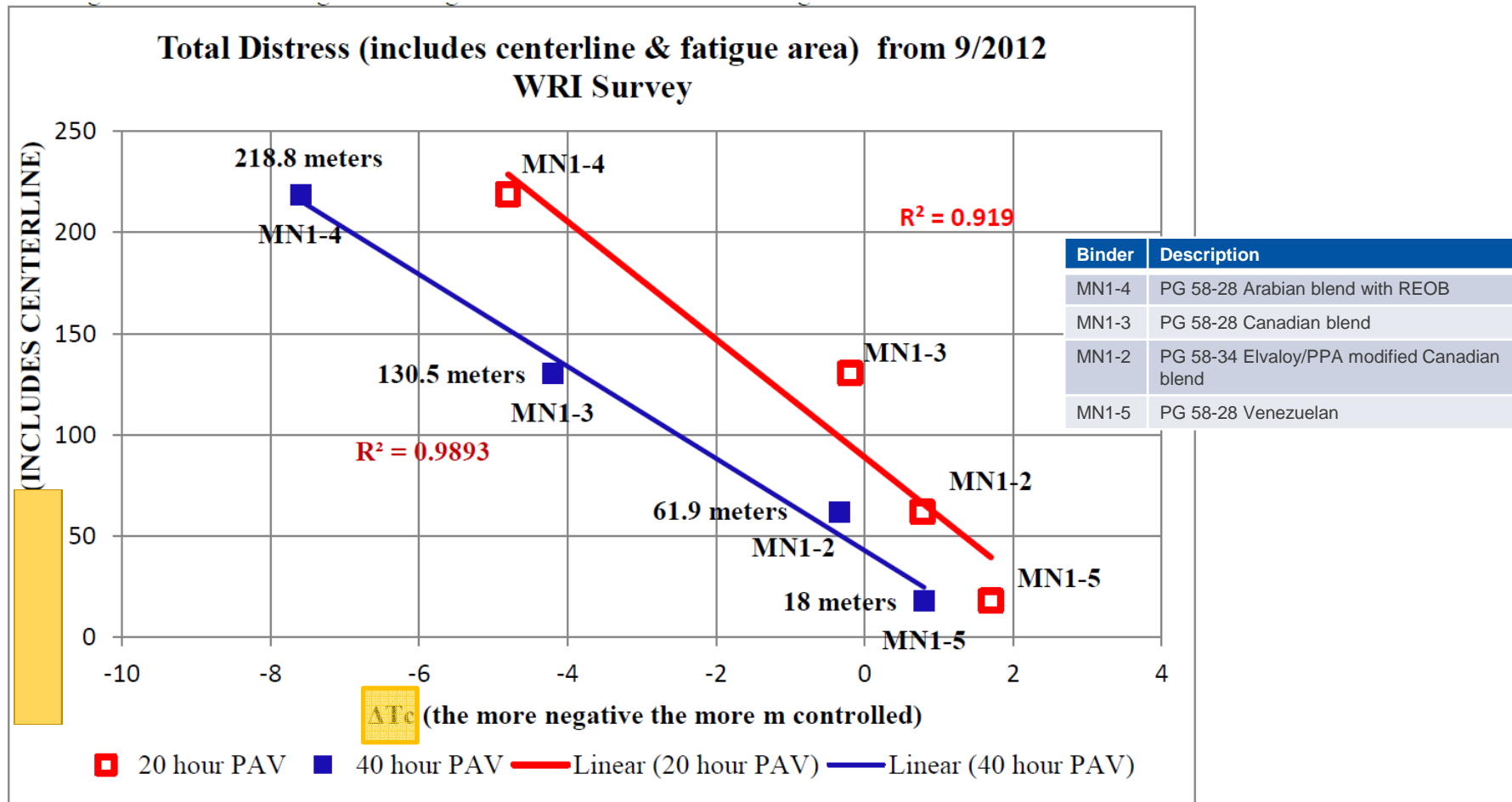


Figure 3: Total Pavement Distress as Function of ΔT_c of 20 and 40 Hour PAV Residues

$$\Delta T_c = LST - LmT$$

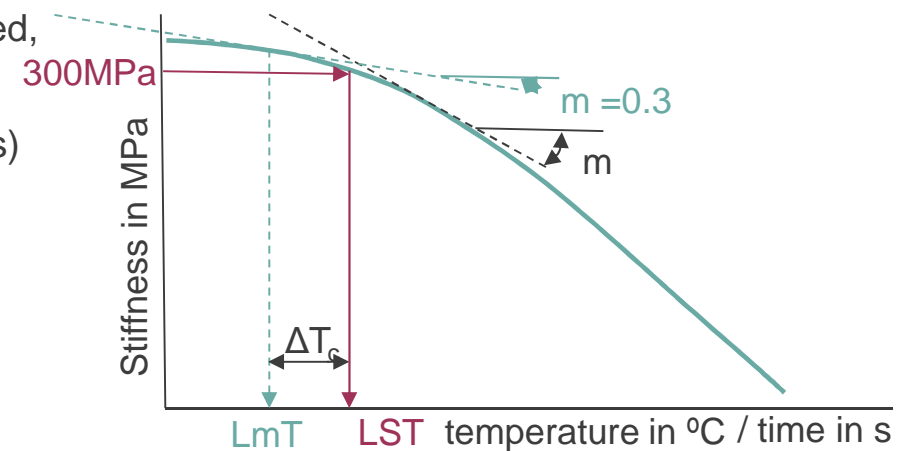
Gerald Reinke, Andrew Hanz, R. Michael Anderson, Mary Ryan, Steven Engber, Douglas Herlitzka, *Impact of re-refined engine oil bottoms on binder properties and mix performance on two pavements in Minnesota*
 E&E Congress 2016

Bending Beam Rheometer EN 14771

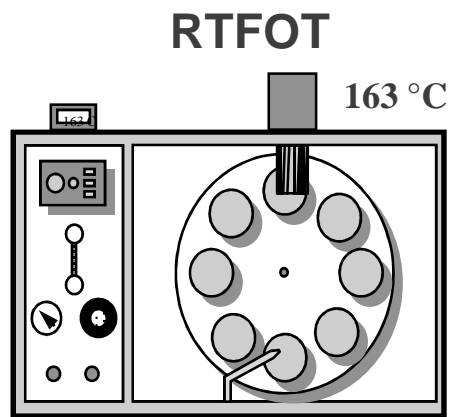
	A	B	C	D	E
Penetration	42	64	52	52	67
Softening Point	51.3	47.7	49.8	49.0	46.8
PI	-1.3	-1.2	-1.2	-1.4	-1.4
Fraass Breaking Point	-15	-14	-17	-14	-17
EN Grade	40/60	50/70	50/70	50/70	50/70



- ▶ On RTFOT-PAV aged sample a constant load is applied, the deformation is followed with time.
- ▶ Stiffness 'S' and slope of the creep curve 'm' (after 60s)
- ▶ To prevent fracture; a low stiffness and/or a large m-value are preferred
- ▶ More recently ΔT_c is measured

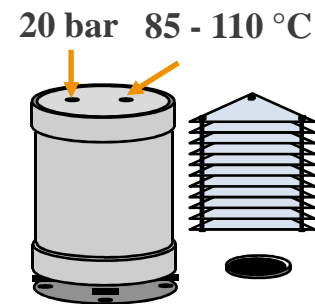


Laboratory ageing of bitumen



Short Term Ageing

+ PAV (1 cycle = 20 hours)



Long Term Ageing



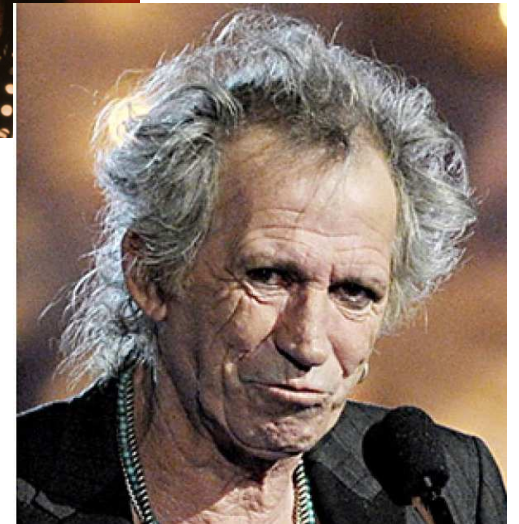
Ageing is a Process



Fresh

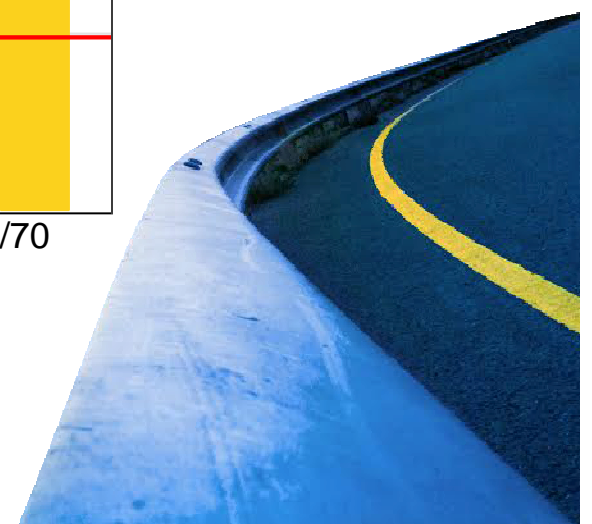
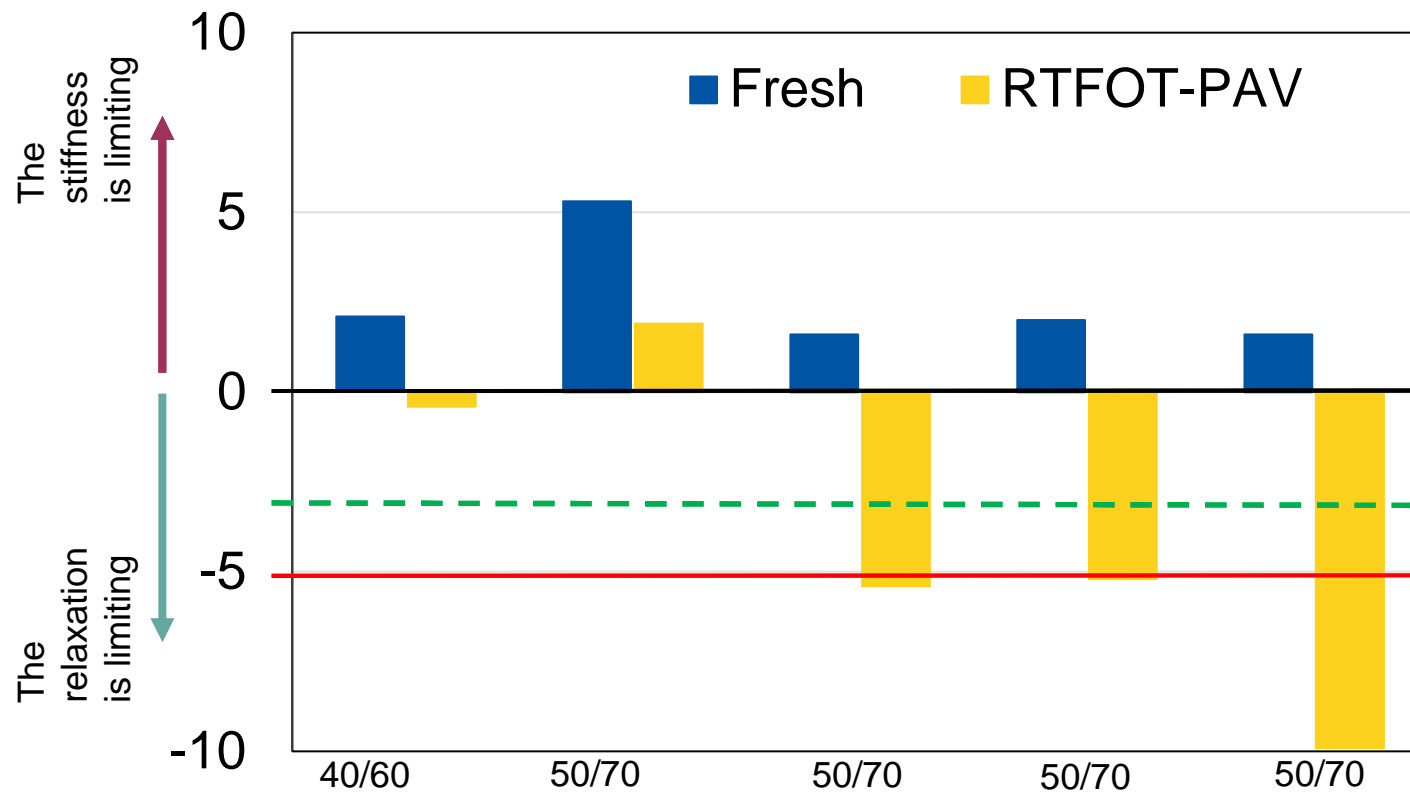


Short Term Aged

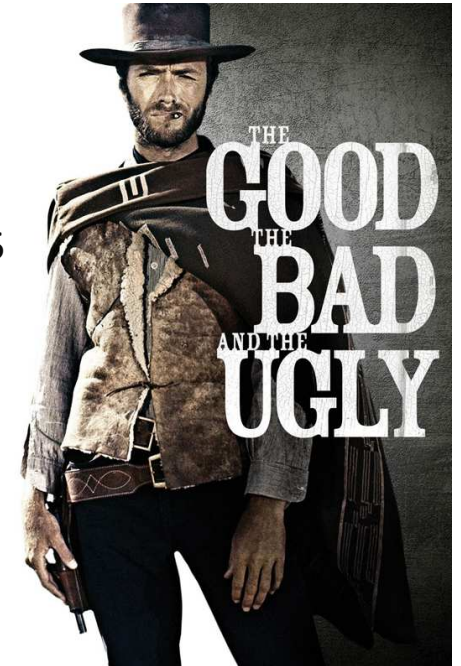
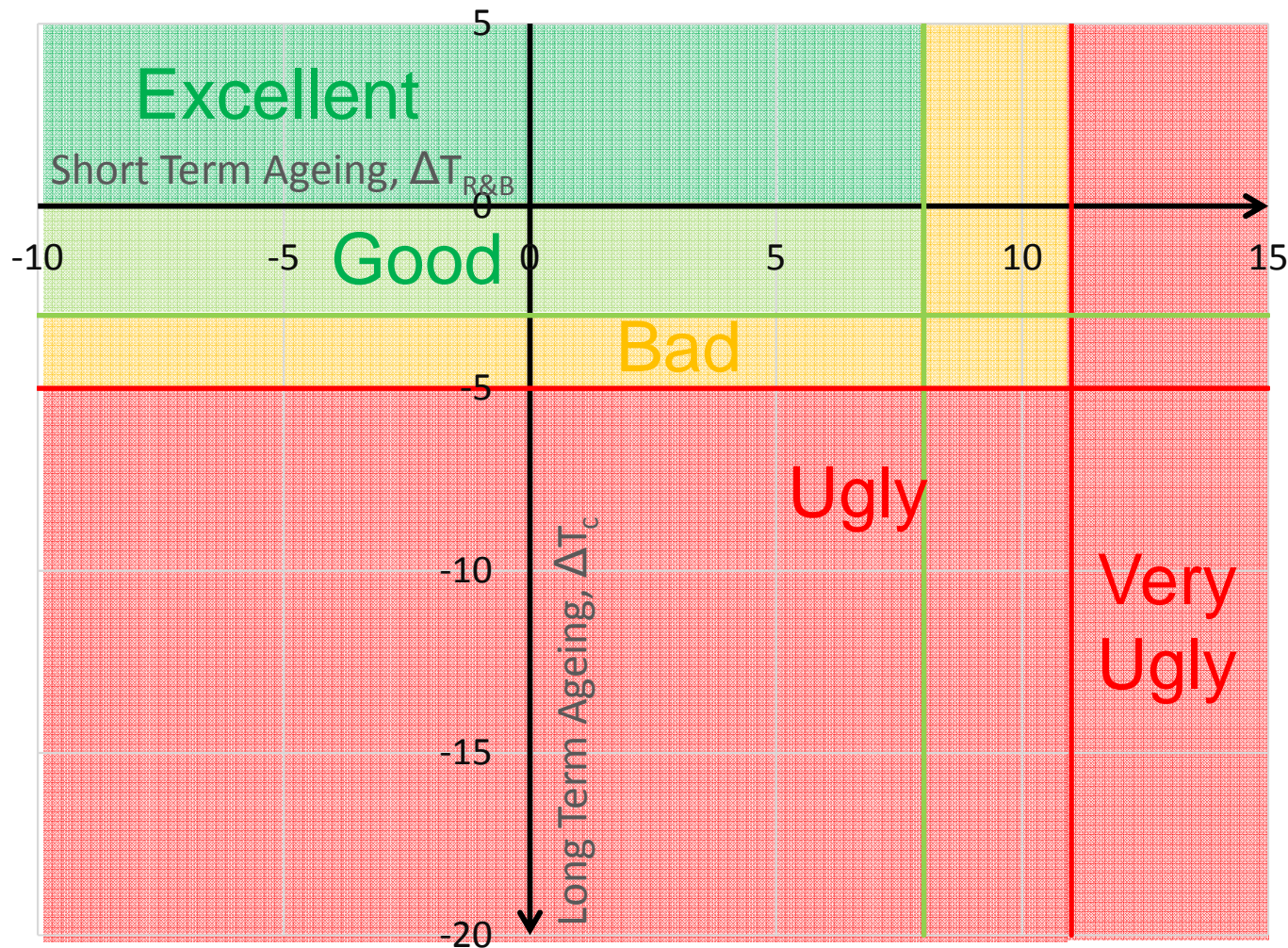


Long Term Aged

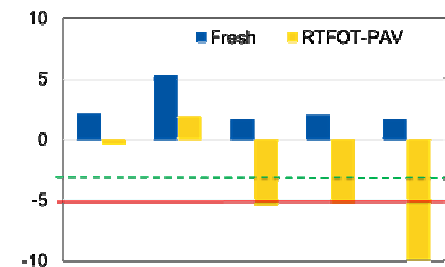
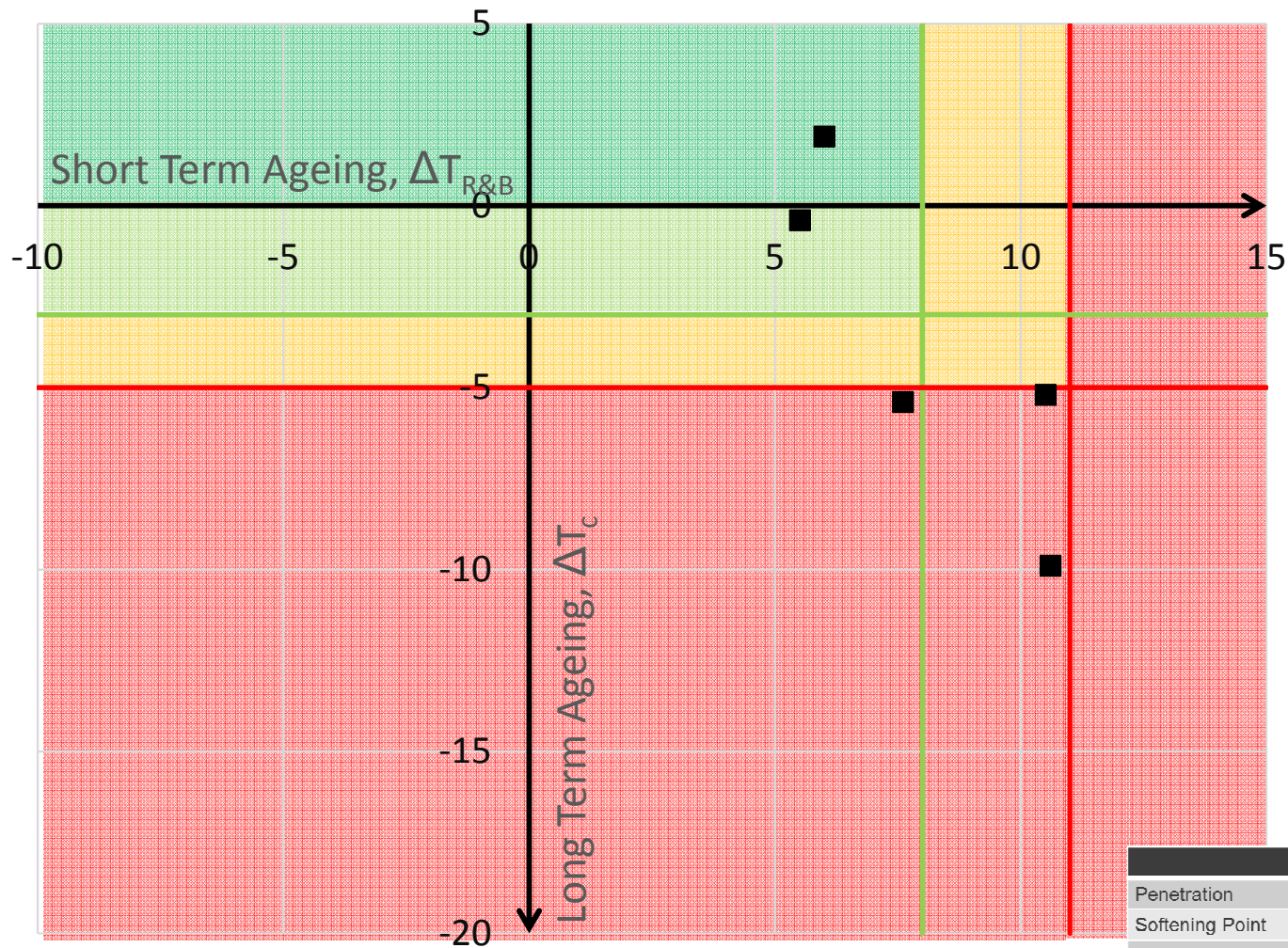
Effect of Ageing on: ΔT_c (BBR): LST - LmT



Short and Long Term Ageing

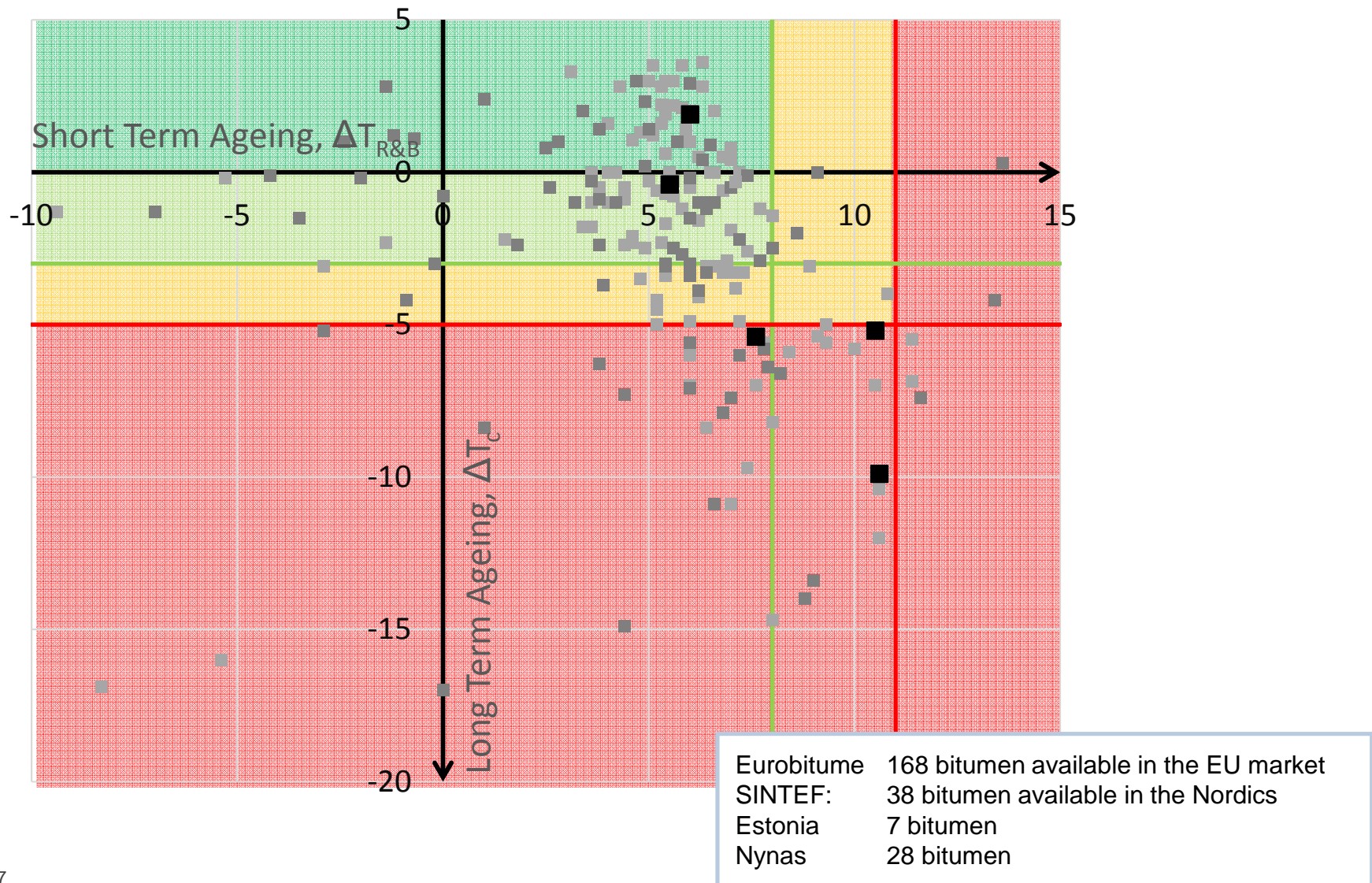


Short and Long Term Ageing



	A	B	C	D	E
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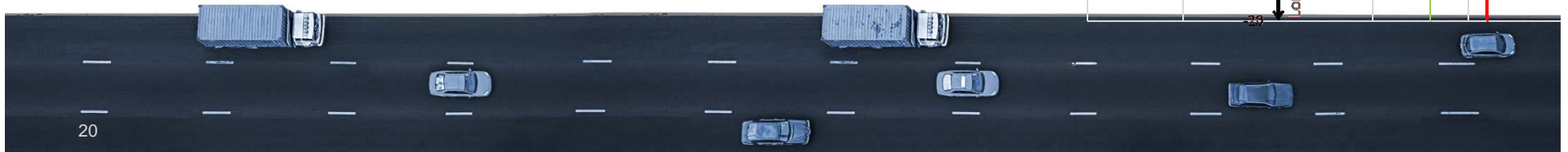
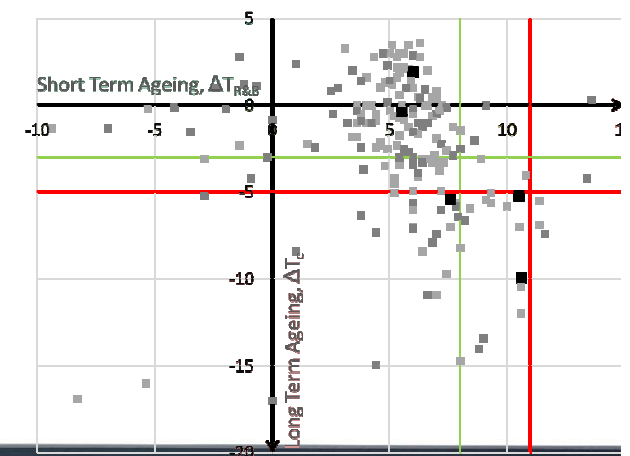
Short and Long Term Ageing



Conclusions

- ▶ Bitumen “travels further” today than it used to, giving more diversity in source and supply chain operations
- ▶ Specifications must reflect performance including the long term durability
- ▶ Wide variations observed in ΔT_c of bitumen available Europe
- ▶ Long term performance expected to be very different
- ▶ Further work recommended to validate ΔT_c (and G-R) concept
- ▶ Selection of bitumen all the more important

Not just black but many shades of black and grey



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