

Primary Emissions of Carbonaceous Particles in Europe

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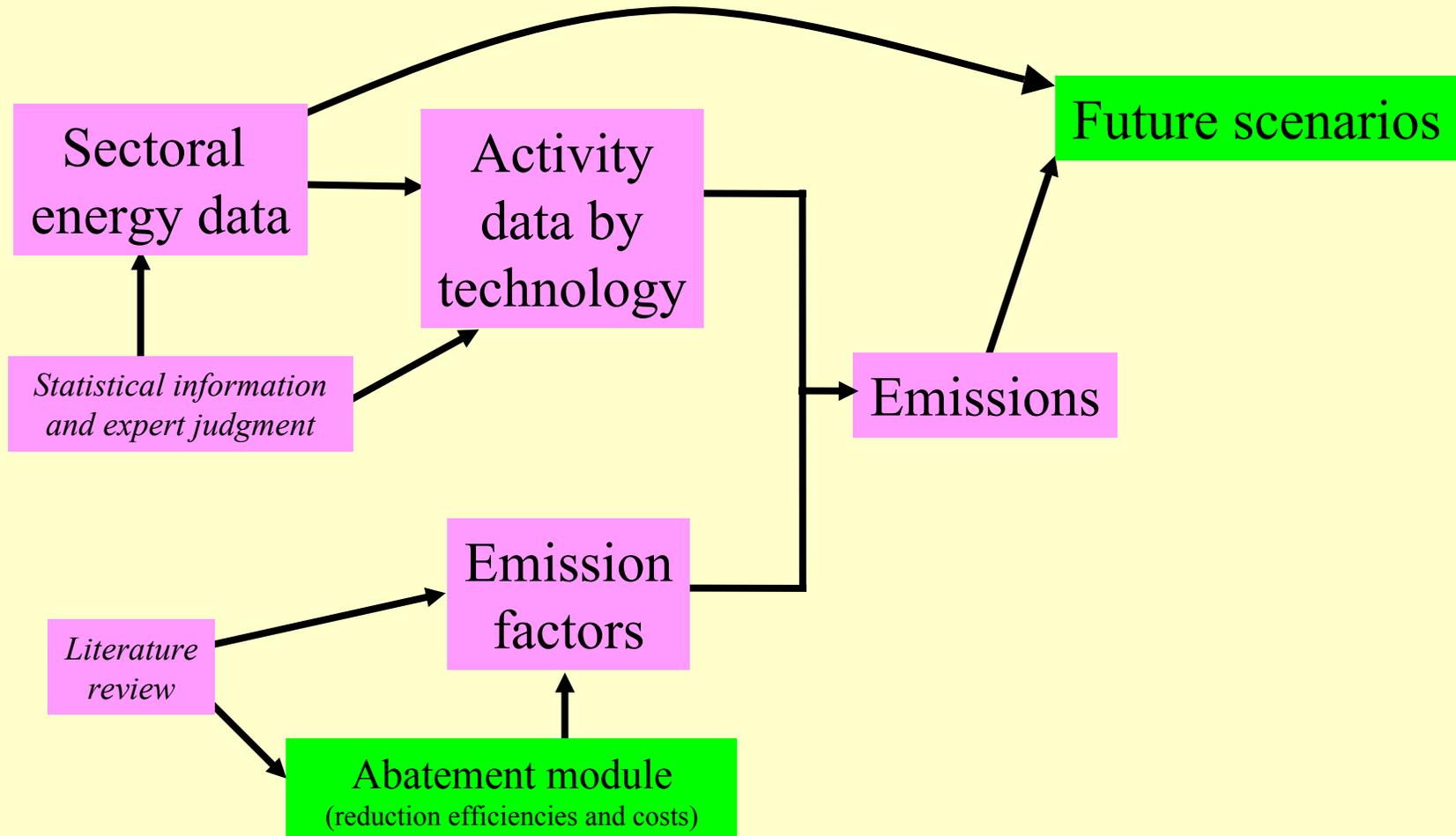
Method (1)



- **Current RAINS-PM module developed further to include BC and OC,**
- **Emissions are calculated for anthropogenic sources# from 1990 to 2030,**
- **Activity data (intl. [IEA, OECD] and national stats and energy models),**
- **Literature review of emission factors; emission factors tied to regionally-specific technology and checked for consistency with the RAINS-PM database.**

about 400 sectors (nearly 1500 categories when control technologies are considered)

Method (2)

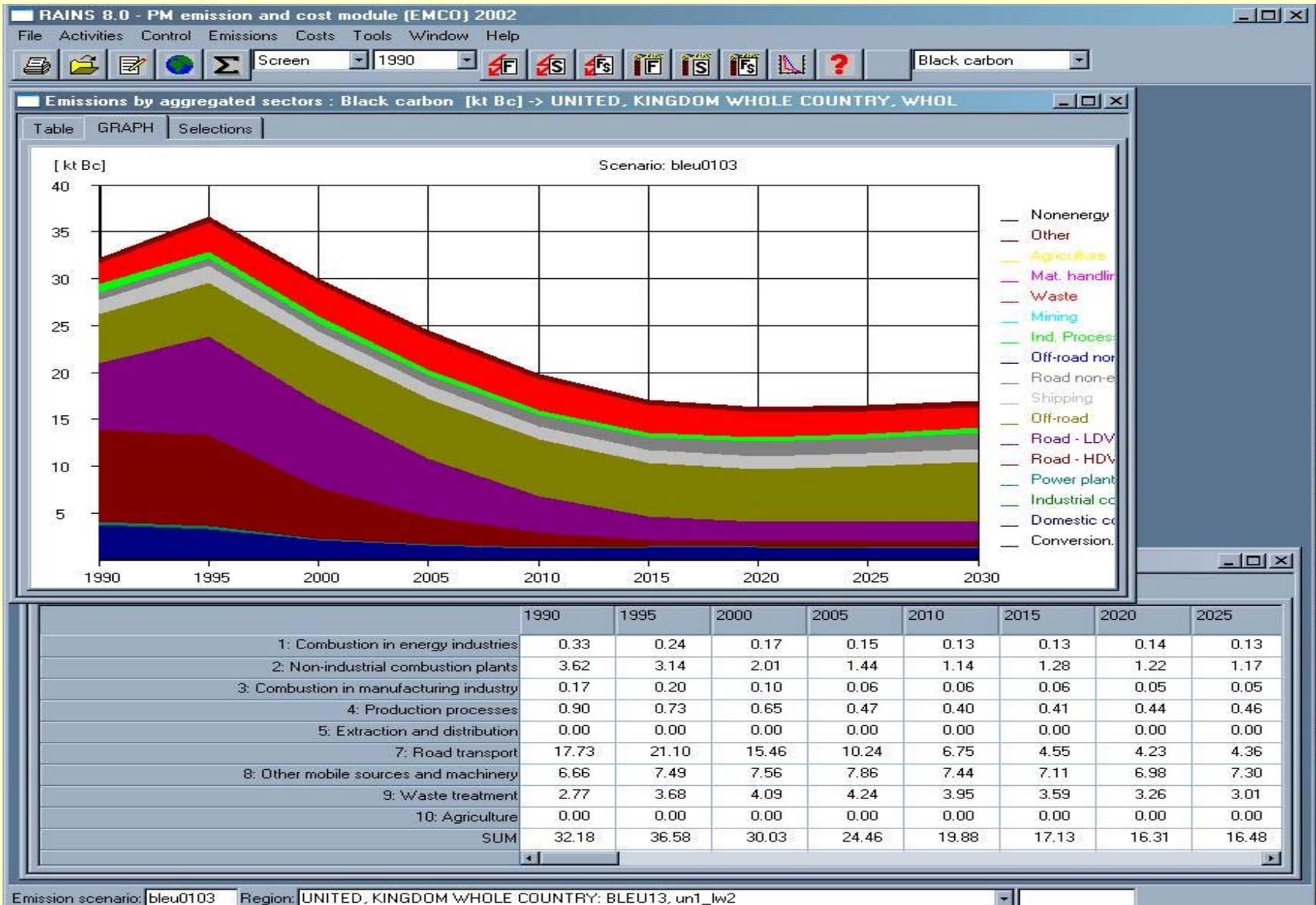


Crucial parameters and their availability



- **Activity data** *(available for major categories but not for several sub-categories, e.g., boiler type; residential sector)*
- **‘Uncontrolled’ emission factors**
(often not available; need to be estimated)
- **Size and chemical speciation**
(if available then mostly for abated combustion sources)
- **Efficiency of control options**
(some data for road vehicles)
- **Rate of application of control technologies**
(availability varies dramatically between countries and sectors)
- **‘Real-life’ efficiency, i.e., probability of failure and its impact** *(hardly ever available)*

Snapshot - RAINS

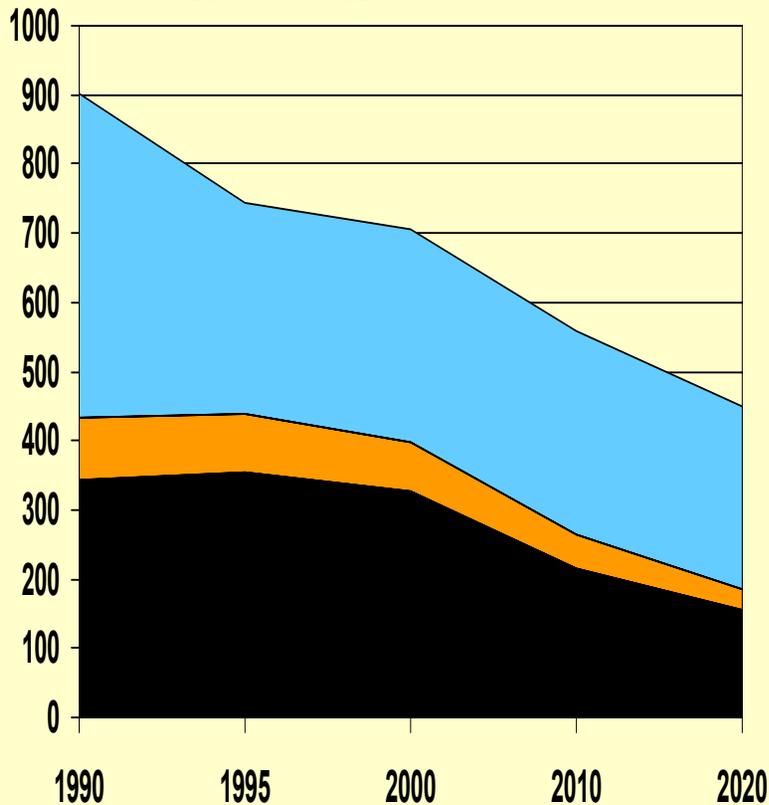


BC, OC emissions in Europe (by region)

RAINS Current Legislation Scenario [Gg]

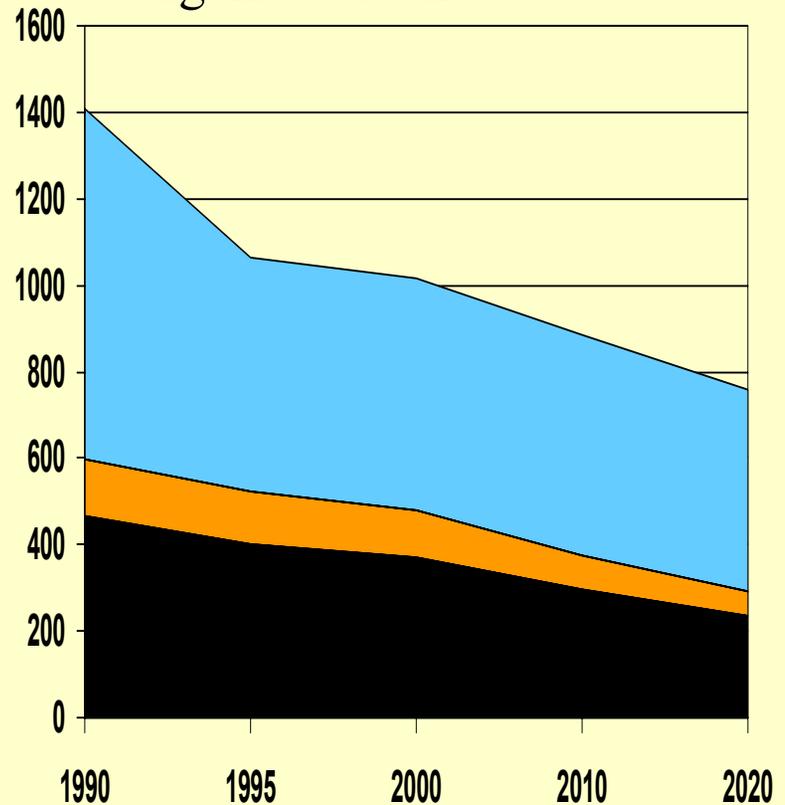


black carbon



■ EU-15 ■ New EU Member States ■ Non EU Europe

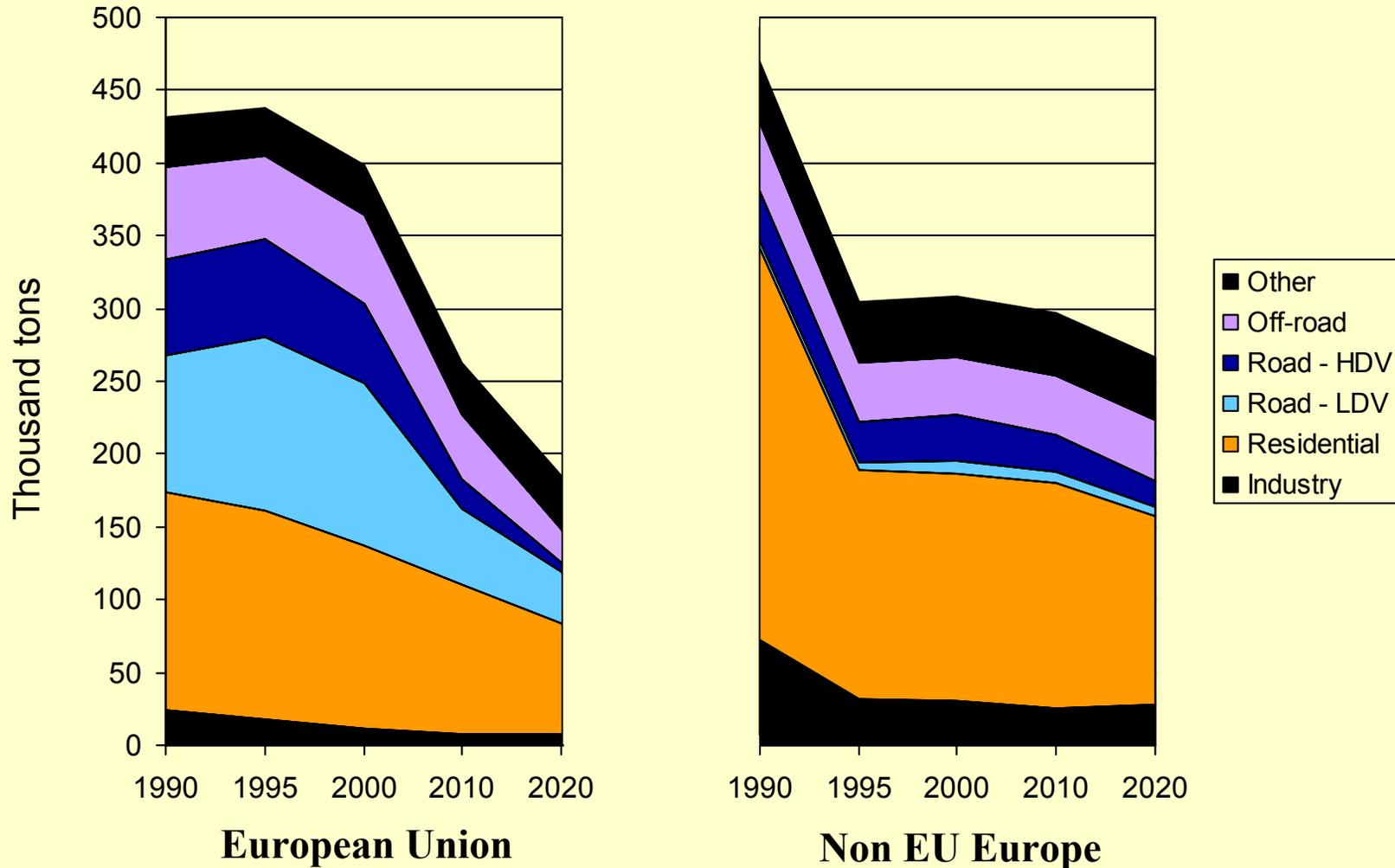
organic carbon



■ EU-15 ■ New EU Member States ■ Non EU Europe

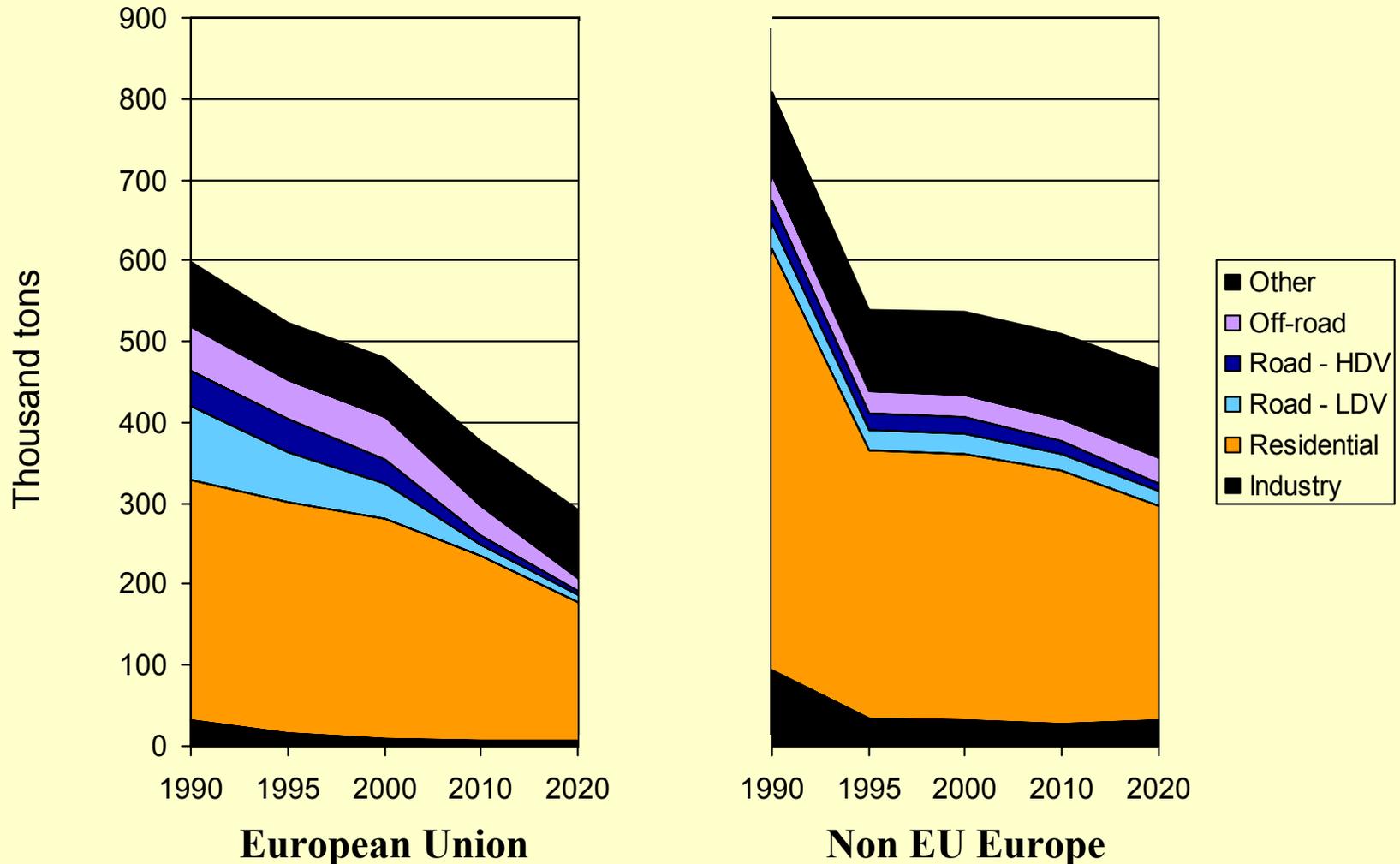
Black carbon emissions in Europe (by sector)

RAINS Current Legislation Scenario [Gg]



Organic carbon emissions in Europe (by sector)

RAINS Current Legislation Scenario [Gg]



Comparison of BC and OC estimates for Europe [Gg/year]



Source	Year	Black carbon	Organic carbon
Cooke <i>et al.</i> , 1999	1996	1546	2981
Bond <i>et al.</i> , 2004	1996	678 (508-1399)	947 (616-1796)
This study	1995	743	1063
Derwent <i>et al.</i> , 2001	1995-98	482-511±140	n.a.

- Recent work indicates that BC/OC emissions might be significantly smaller than previously believed,
- Large differences, but... not always the same sources are included and geographic coverage of “Europe” varies.

Uncertainty



- **Emission factors - Carbonaceous aerosol emission profile depend on combustion conditions,**
 - what factors have an effect and how significant it is; e.g., fuel, operation, stove design, engine technology
 - measurement method – are the methods comparable?
- **Large sets of measurements needed to get a coherent picture**
(typically not the case for carbonaceous species)
- **Other sources of uncertainties than emission factors**
 - Activity data, e.g., biomass in residential sector, off-road transport;
 - Detailed split of coal and biomass consumption in residential sector, i.e., fireplaces, stoves, boilers, etc.;
 - Poor information (*read NO information*) on how efficient are currently applied 'PM' control technologies in removing carbonaceous particles,
 - Interpretation and use of reported measurement data

Uncertainty (2)

Are the measurements comparable?



- **The measurement methods vary, do they measure the same thing?**
 - optical (BC or LAC) → absorption
 - thermal (EC/OC) → thermal evolution of carbonaceous species
 - thermal with an optical correction (EC/OC) → thermal evolution of carbonaceous species
 - solvent extraction (OC) → soluble organic species
- **Examples:**
 - carbon black: integrating sphere (optical) overestimated by 21% vs. a thermal method (Hitzenberg et al., 1999. *Atm. Env.* 33, 2823-)
 - ambient samples: integrating sphere (optical) agreed within 5% vs. a thermal optical method (Hitzenberg et al., 1999)
 - diesel exhaust: different thermal evolution protocols of the thermal optical method agree within TC $\pm 5\%$ and EC $\pm 20\%$ (Chow et al., 2001. *Aerosol Sci. Tech.* 34, 23-)

There is a need for emission measurements or their publication!



BC/OC source	Remarks
Road traffic, exhaust	<i>Several studies, mainly US</i>
Off road and machinery, exhaust	<i>Few studies or no data at all</i>
Domestic combustion, wood	<i>Few studies, mainly US</i>
Domestic combustion, coal	<i>Few studies, some very old</i>
Domestic combustion, oil	<i>Few old studies</i>
Power plants & industry, solid fuels	<i>Several studies, however, of abated emissions</i>
Power plants & industry, oil & gas	<i>Few old studies</i>
Industrial processes	<i>Few studies</i>
Dust (traffic, agriculture, etc.)	<i>Few studies</i>

Conclusions



- Emissions from transport and residential combustion dominate “contained” emissions.
- Emissions from open burning are typically more important for OC than BC.
- Western Europe dominates BC emissions while Central and Eastern Europe has a higher share in OC.
- European emissions are calculated to decline in the future - primarily due to measures in Western Europe.
- Large uncertainties of estimates.
- More work needed in order to reduce uncertainties and fill in the gaps.
- Awaiting feedback from atmospheric modelers...