Reactive and Non-reactive Species of Nitrogen in Atmospheric Emission Inventories – A Review

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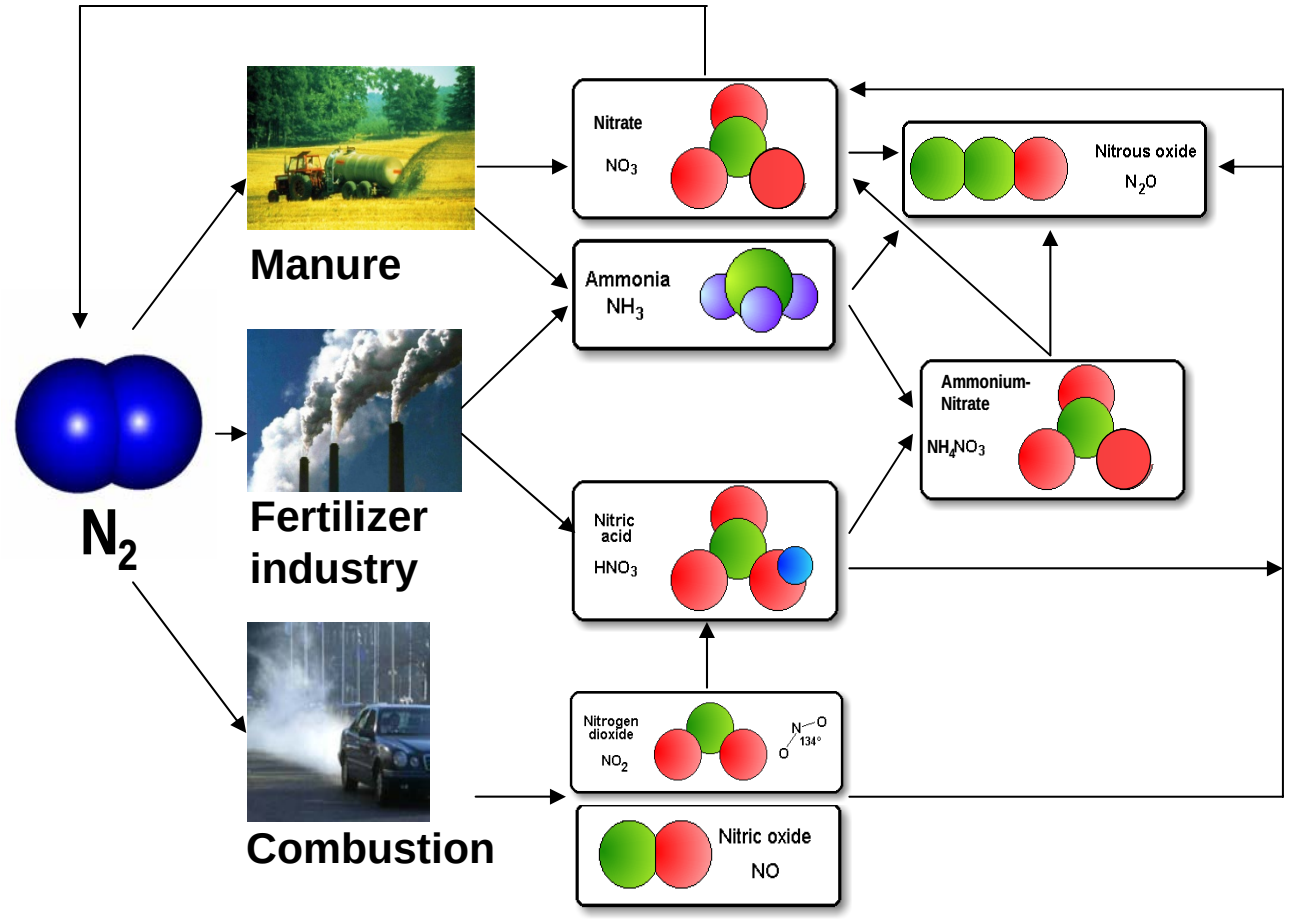
Nitrogen pollution starts with N_2



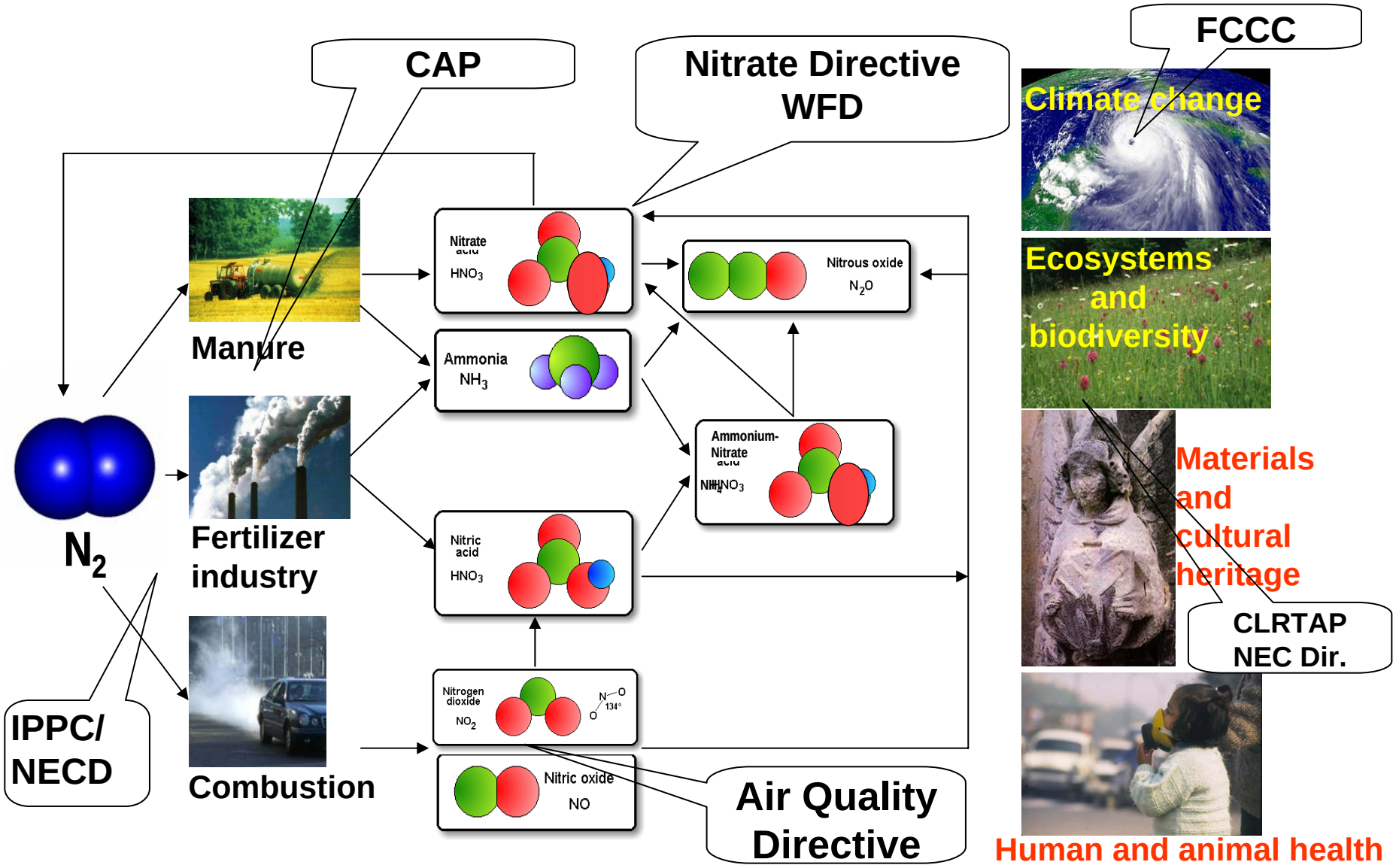
Materials and cultural heritage

Human & animal health

Sources **Chemical/physical interactions** **Effects**

I don't have any solution, but I certainly admire the problem.
Ashleigh Brilliant

Nitrogen pollution: integral approach

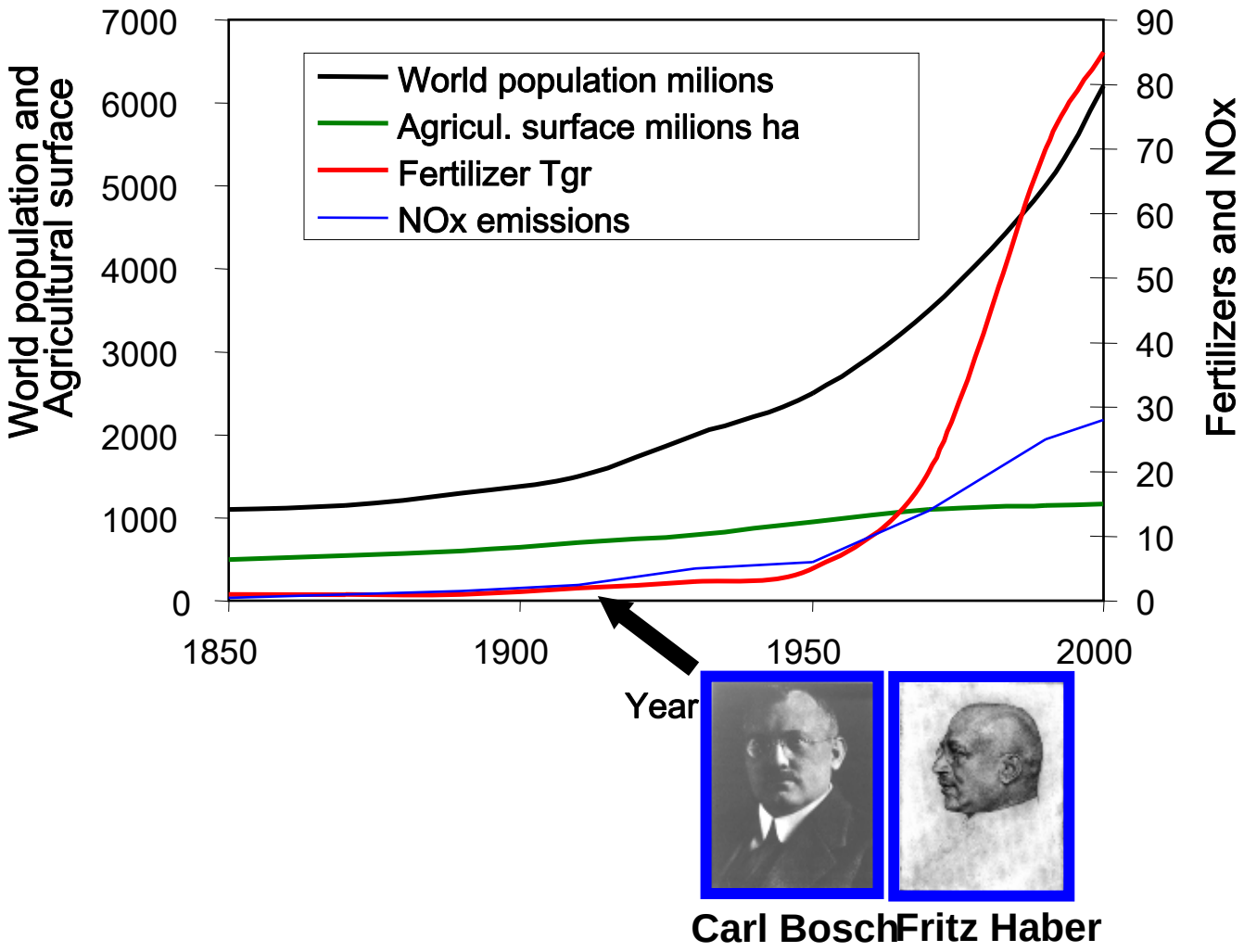


Overview of the main sources and sinks of nitrogen-containing species

Sources	N_2	NH_3	NO_x	N_2O
Biogenic emissions from the terrestrial & marine biosphere		X	X	X
Decomposition of proteins and urea from animals		**X**		
Biomass burning and fossil fuel consumption	**X**	**X**	**X**	
Agricultural nitrate fertilisation				**X**
Lightning			X	
Sinks				
Wet deposition		X	X[1]	
Dry deposition		X	X	
Chemical breakdown in the stratosphere				X

[1] as NO_3^-

N = food; Energy = N



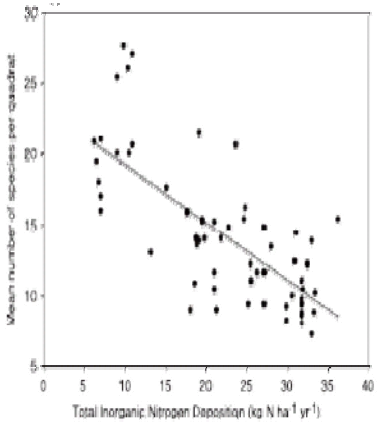
Slide courtesy of: Jan Willem Erisman, ECN/Netherlands

Effects of reactive nitrogen in the environment



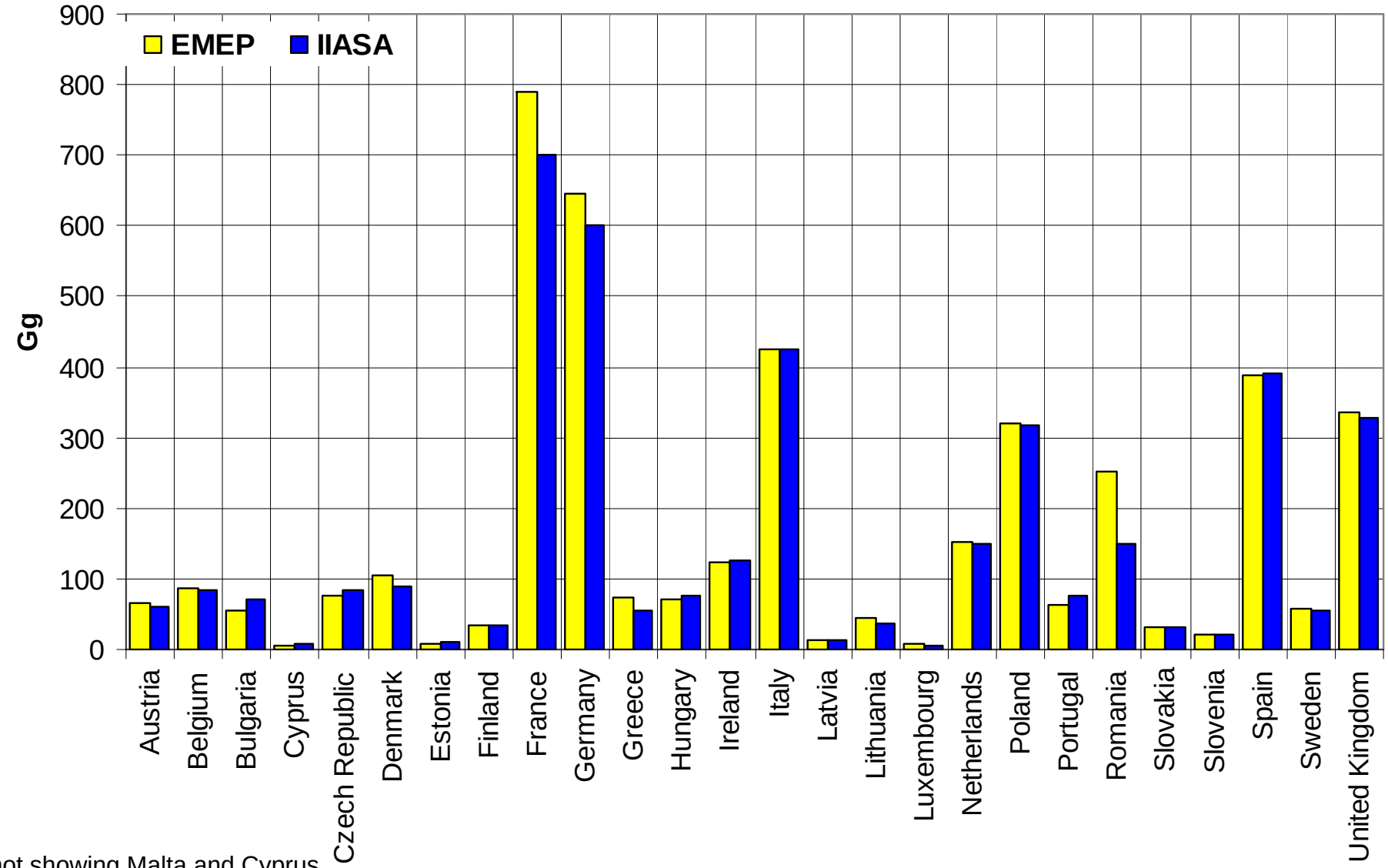






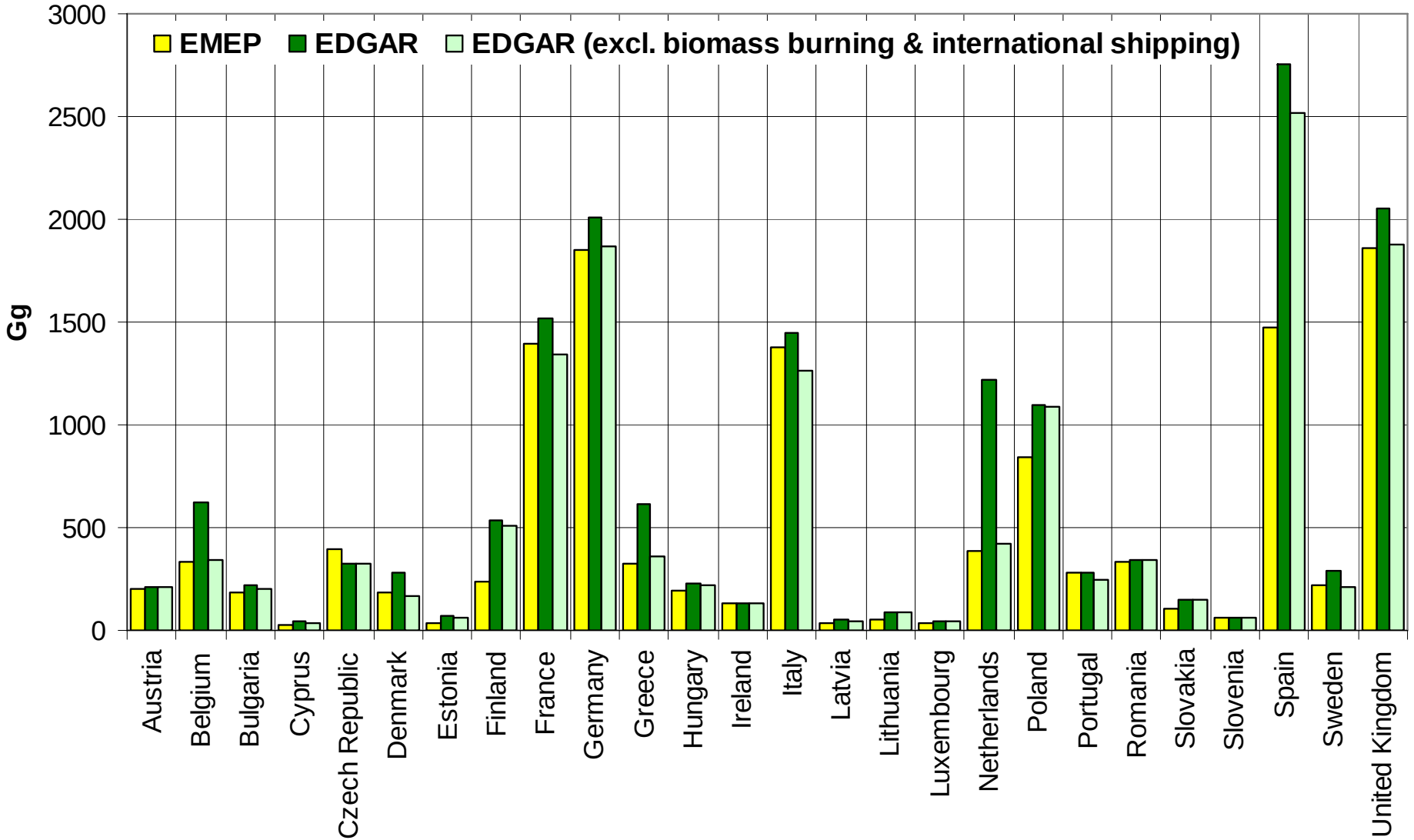
Slide courtesy of: Jan Willem Erisman, ECN/The Netherlands

Comparison of EU27[1] emissions of NH_3 reported to EMEP and compiled by IIASA for the year 2000



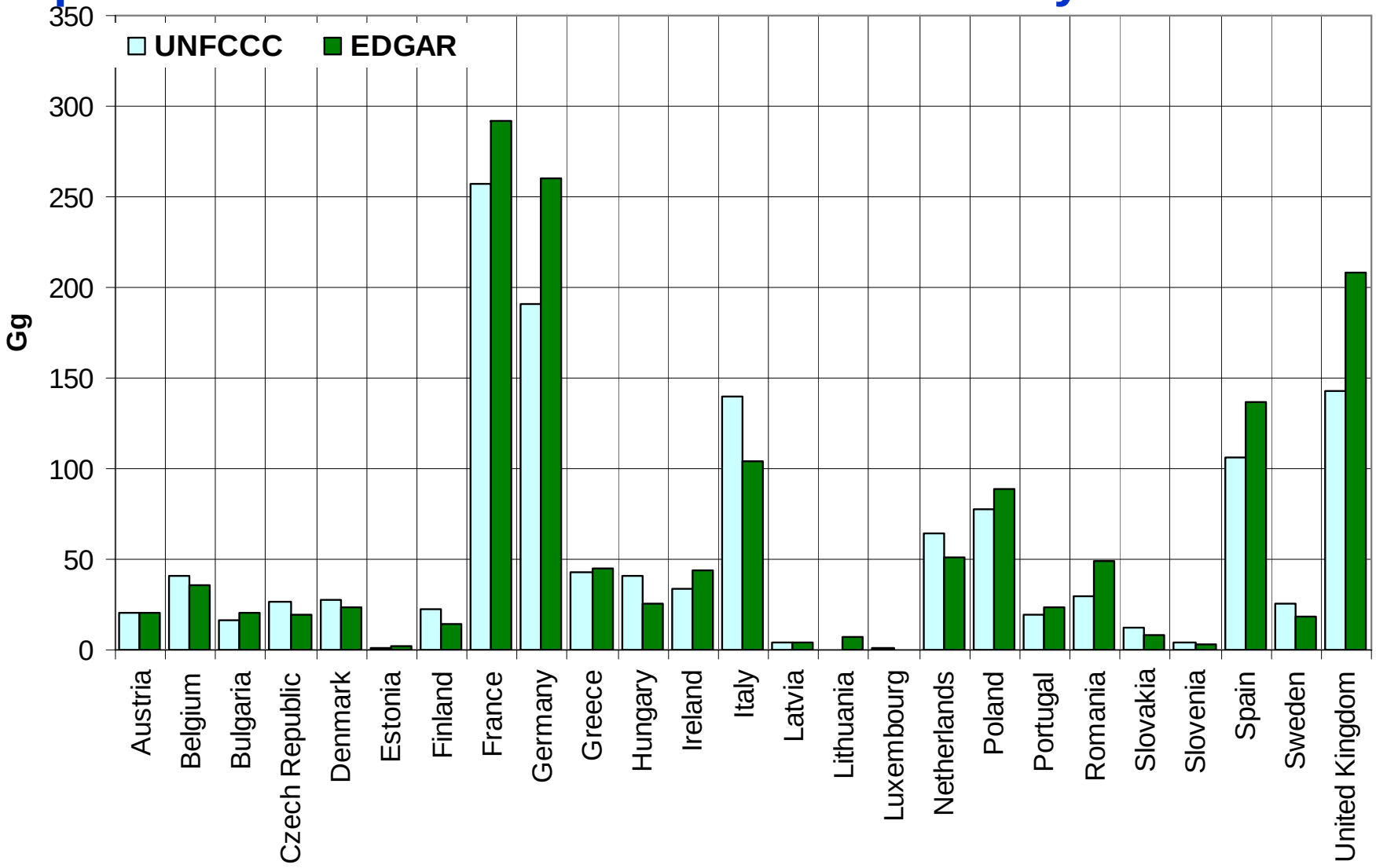
1) not showing Malta and Cyprus

Comparison of EU27[1] emissions of NO_x reported to EMEP and presented in the EDGAR database for the year 2000



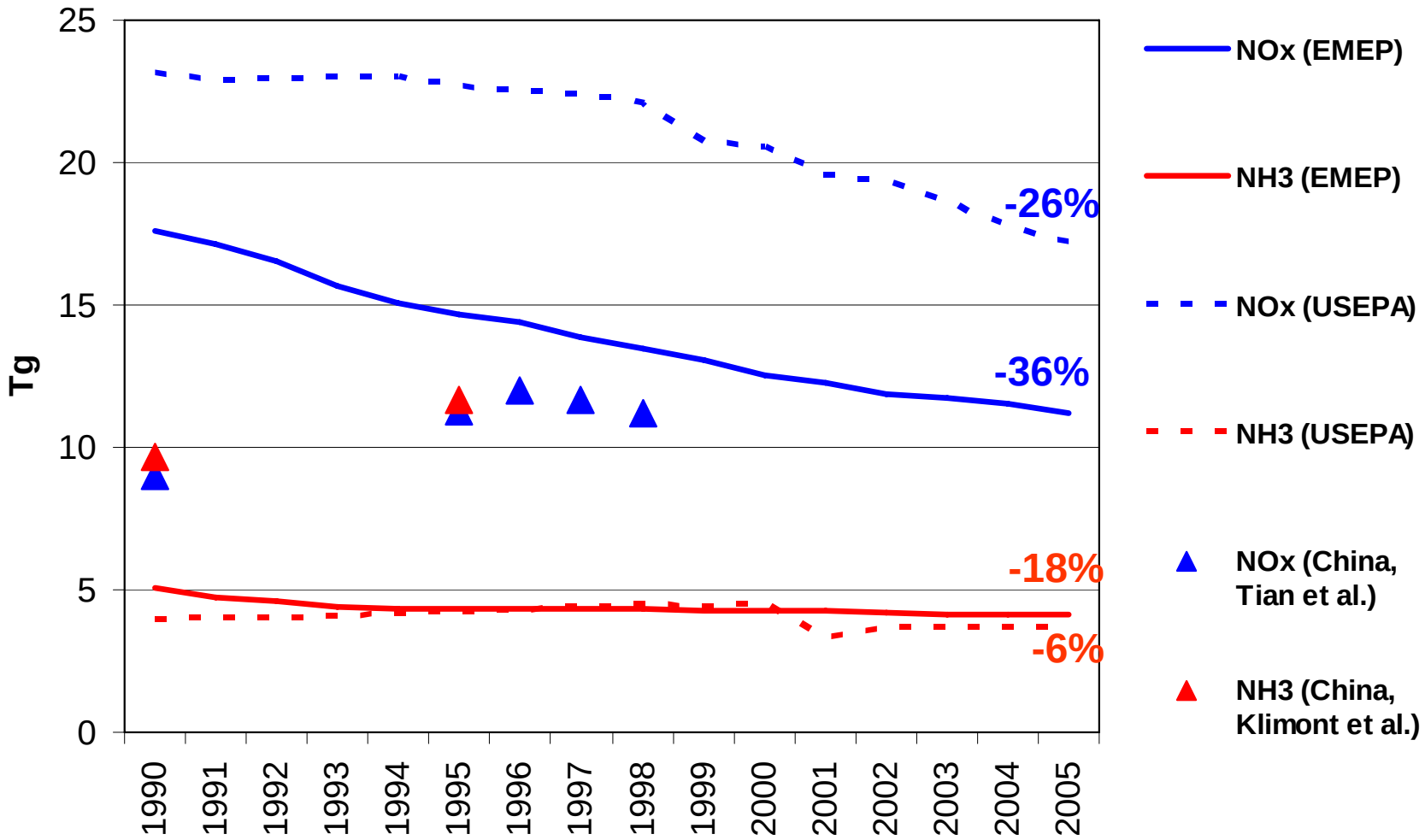
1) not showing Malta and Cyprus

Comparison of EU27[1] emissions of N_2O reported to UNFCCC and presented in the EDGAR database for the year 2000



1) not showing Malta and Cyprus

Regional trends in NO_x and NH_3 emissions based on EMEP (*gap-filled 'expert emissions' for the EU27*), US EPA (*NEI Tier1 emissions*) and literature assessments for China



Indication of uncertainty estimates for greenhouse gases

(Source: Olivier et al., 1999)

		Emission Factor			Total Emissions		
Emission source category	**Activity data**	**CO_2**	**CH_4**	**N_2O**	**CO_2**	**CH_4**	**N_2O**
Fossil fuel use							
Fossil fuel combustion	S	S	M	M	S	M	M
Fossil fuel production	S	M	M	-	M	M	-
Industry/solvent use							
Iron & steel production	S	-	S	-	-	S	-
Non-ferro production	S	-	S	-	-	S	-
Chemicals production	S	-	S	L	-	S	M
Cement production	S	S	-	-	S	-	-
Solvent use	M	-	-	-	-	-	-
Miscellaneous	V	-	-	-	-	-	-
Landuse/waste treatment							
Agriculture	S	-	L	L	-	L	L
Animals (excreta/ruminants)	S	-	M	L	-	M	L
Biomass burning	L	S	M	L	L	L	L
Landfills	L	-	M	-	-	L	-
Agricultural waste burning	L	-	L	L	-	L	L
Uncontrolled waste burning	L	-	-	-	-	-	-
All sources	**-**	**-**	**-**	**-**	**S**	**M**	**L**

S = small (10%); **M** = medium (50%); **L** = large (100%); **V** = very large (>100%) "**-**" not applicable/negligible

Evaluation

❑ Sectoral structure and inventory compilation

- Some historic differences in sectoral structures for air pollutants and GHGs
- Inventories compiled due to reporting obligations (EMEP, UNFCCC) often differ from independent compilations (e.g. EDGAR) in methods and completeness

❑ Different regional trends

- Since the 1990s, downward trends were observed for NO_x *(-26%/-36%)* and moderate reductions of NH_3 *(-6%/-18%)* in the US and in Europe
- Some indication of decoupling of energy demand increase and NO_x emissions in China, but based on few figures available

❑ Temporal and spatial resolution

- Spatial resolution for air pollutant inventories reflects their regional scale (EMEP 50 × 50 km, EDGAR 1° × 1°)
- Temporal resolution not addressed in inventories

Summary and Conclusions (I)

- **"Official" vs. "expert estimates"**
  - Question which dataset is 'better' depends on the purpose
  - Official emission reporting to comply with obligations to national/international protocols and directives
  - Timely delivery, completeness and correctness varying between countries
  - Independent estimates can support validation and uncertaintiy assessment, based on transparent methodologies and using best available knowledge on emission factors, activity rates etc.
  - Datasets for modelling need to be gap filled and of known quality, resp. with quantifiable uncertainty ranges for validation/verification purposes
  - Inventory quality needs to be fit for the purpose

Summary and Conclusions (II)

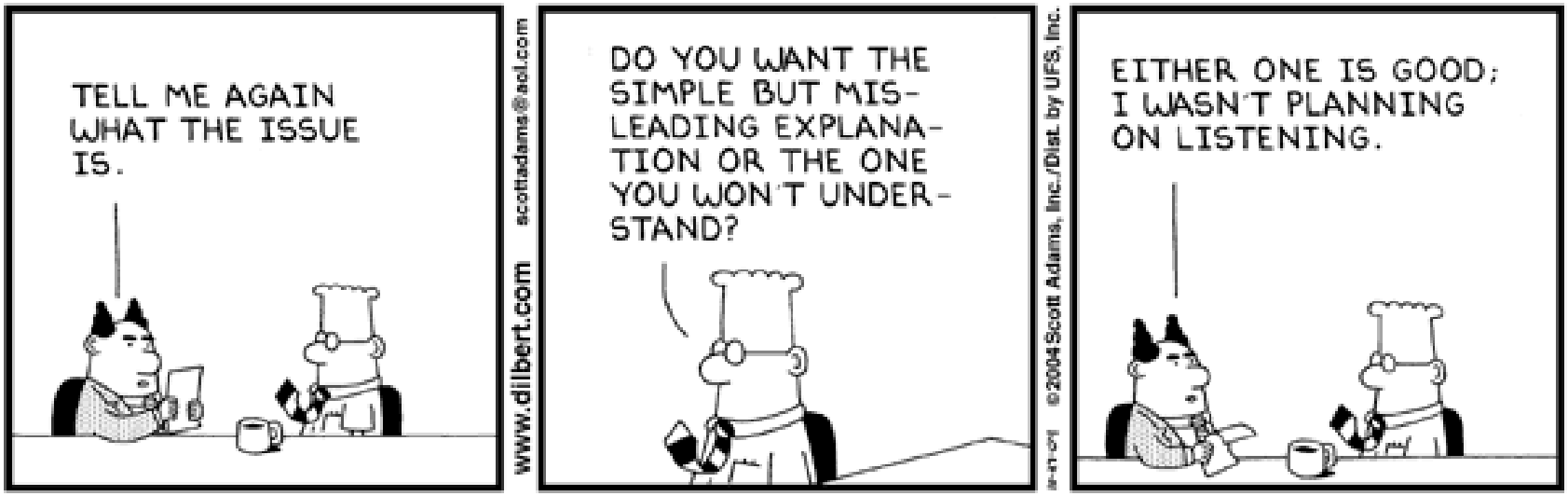
❑ Past emission trends and uncertain future developments

- While downward trends in US and Europe are projected to continue, developments in power generation may lead to future increases in NO_x *(e.g. use of domestic coal vs. gas/oil imports)*
- Moderate reductions (US, Europe) and increases in NH_3 emissions (China) highlight the relevance of NH_3 control strategies, with its increasing contribution to acidification and eutrophication
- Current plans in Europe to increase shares of bio-fuels in the energy mix may lead to reduced CO_2 emissions, but N_2O emissions could increase and (more than?) offset GWP savings (see *Crutzen et al., 2008*)

Summary and Conclusions (III)

❑ Towards a full nitrogen balance?

- Significant uncertainties still exist in quantifying emissions in particular from biogenic and natural sources (NO_x and N_2O from soils, vegetation etc.)
- For a fully integrated assessment of nitrogen effects, it is paramount to close the gaps in understanding the nitrogen cycle
- Research underway (NitroEurope IP, European Nitrogen Assessment, INI, ...) with the aim to achieve this
- Closing the N balance is the key challenge in order to make progress towards integrated management of the nitrogen cycle



Thank you for your attention

Acronyms and links

EMEP	European Monitoring and Evaluation Programme	www.emep.int
UNECE	United Nations Economic Commission for Europe	www.unece.org
CLRTAP	UNECE Convention on Long-Range Transboundary Air Pollution	www.unece.org/env/lrtap/ExecutiveBureau/welcome.html
NEC(D)	EC National Emission Ceilings (Directive)	http://ec.europa.eu/environment/air/pollutants/ceilings.htm
EC	European Commission	http://ec.europa.eu
IIASA	International Institute for Applied Systems Analysis	www.iiasa.ac.at
UNFCCC	United Nations Framework Convention for Climate Change	http://unfccc.int
EDGAR	International Institute for Applied Systems Analysis	www.mnp.nl/edgar
NitroEurope Integrated Project, EC 6th Framework Prog.		www.nitroeurope.eu
INI	International Nitrogen Initiative	www.initrogen.org
ENA	European Nitrogen Assessment Report *(in preparation)*	www.nine-esf.org