

Evaluation of the Dutch Decree on emission limit values for medium- sized combustion installations – five potential restrictions

Nice
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- NO_x: environmental issue in the Netherlands
- Stationary engines – short background
- NO_x and C_xH_y ELV for gas engines
- NO_x and dust ELV for diesel engines
- Conclusions

Environmental legislation in the Netherlands

- In April 2010, the Dutch Decree on emission limit values (ELVs) on medium-sized combustion installations ($< 50 \text{ MW}_{\text{th}}$) (in Dutch: Bems) entered into force
- The Dutch government aims to simplify environmental legislation
 - Shift several decrees into one Activities Decree
 - Set more common rules for companies
 - Less permits for companies are requested
- Since January 2013, the Bems decree has been incorporated into the Activities decree (§ 3.2.1)
- Evaluation of the Bems decree



Environmental legislation in the Netherlands

- The evaluation of the Bems decree was performed by ECN, Infomil, the Dutch Ministry of Infrastructure and Environment and several stakeholders
- The evaluation tackled various scopes
- Special attention to five potential further restrictions, which were considered at the time of commencement of the Bems decree

Environmental legislation in the Netherlands

Five potential further restrictions

- NO_x ELV for natural gas and biogas engines (< 1 MW_e/2,5 MW_{th}) at 100 mg/Nm³ at 3% O₂ (currently: 340)
- C_xH_y ELV for natural gas engines (≥ 1 MW_e/2,5 MW_{th}) at 1200 mg/Nm³ at 3% O₂ (currently: 1500) → “methane ELV”
- Currently no C_xH_y ELV for natural gas and biogas engines (< 1 MW_e/2,5 MW_{th}).
The Ministry: are there arguments to set an ELV?
- PM ELV for diesel engines at 15 mg/Nm³ at 3% O₂ (currently: 50)
- NO_x ELV for diesel engines at 140 mg/Nm³ at 3% O₂ (currently: 450)

Environmental legislation in the Netherlands

- Natural gas engines relevant in NL:
 - ~4250 stationary gas engines
 - of which, ~3000 ($< 1 \text{ MW}_e / 2,5 \text{ MW}_{th}$)
 - of which, ~1650 in Agricultural sector, ~450 in Health care sector, ~450 in Services sector

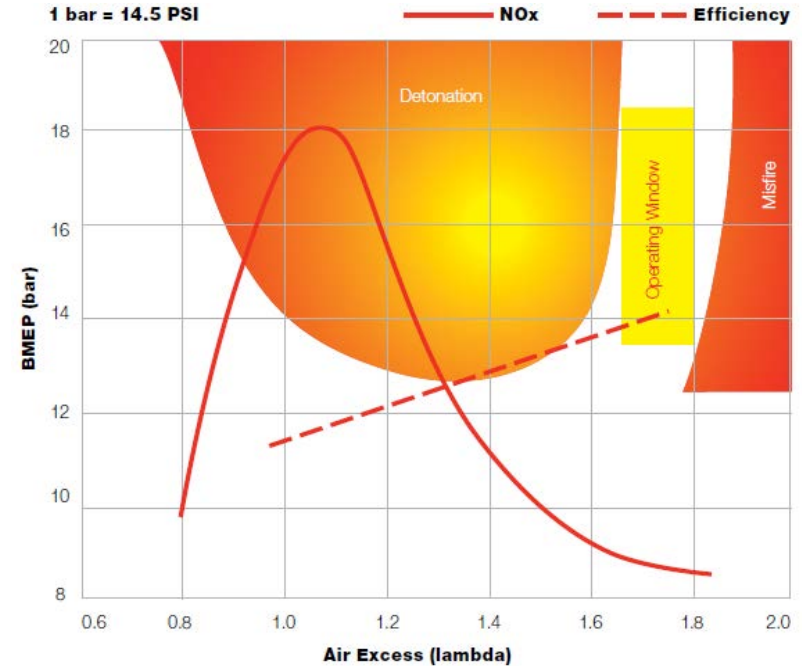
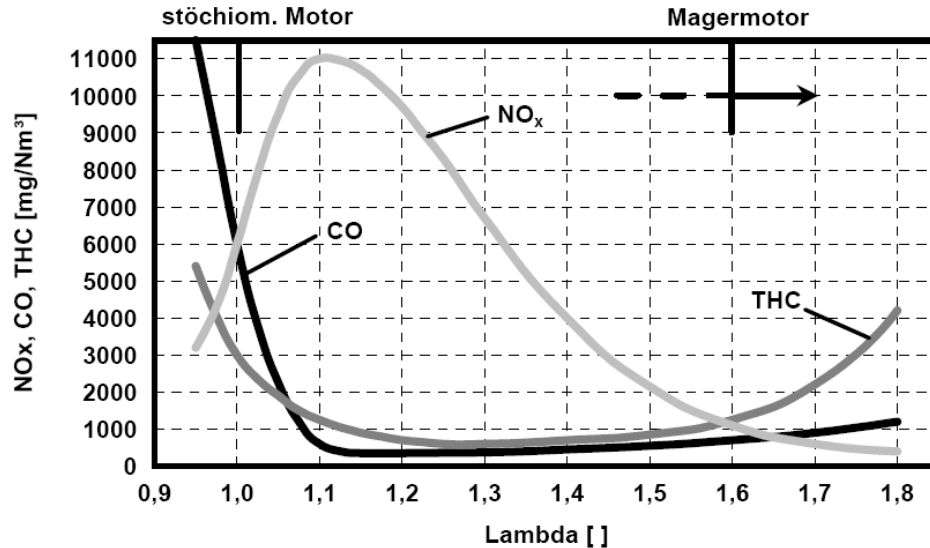




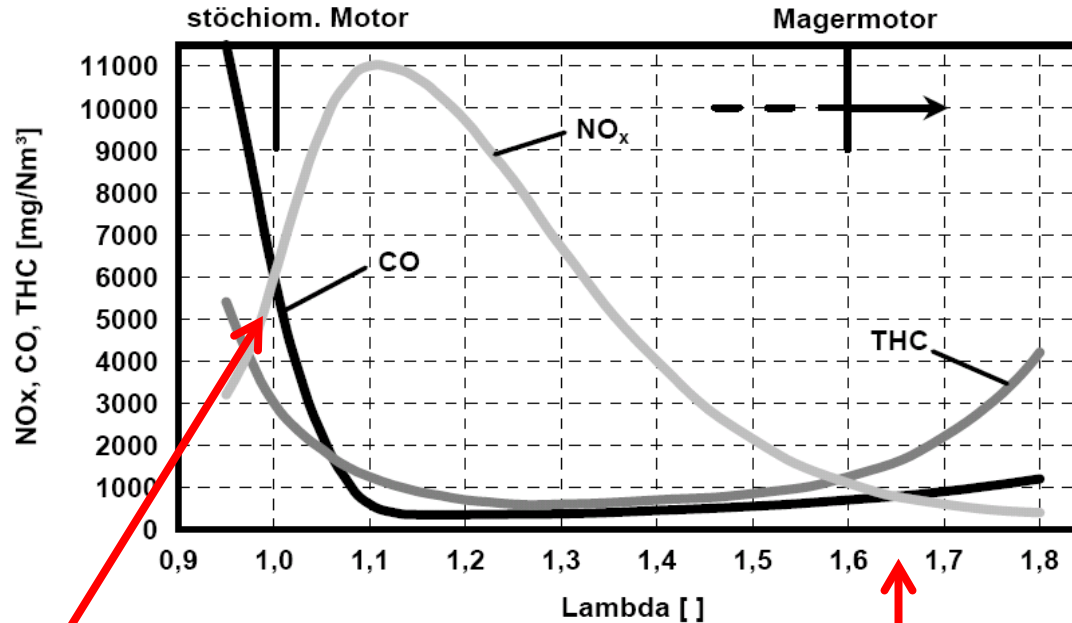
NO_x: environmental issue in the Netherlands

- Dutch NO_x emissions in 2010: 274 kton (NEC definition; source: CBS, ECN & PBL)
 - Of which: 59% due to traffic, 12% and 11% due to Energy and Industry sectors, 4% combustion installations in greenhouse horticulture
- In 2010: Dutch NO_x-emissions were above the NEC ceiling. Other NEC emissions were below NEC ceiling.
- In 2012: NO_x hotspots in NL above 40 µg/m³, i.e. above European standards

Stationary engines – short background



NO_x ELV for gas engines



Alternative: run engine stoichiometric:

- 3-way catalyst (cheap!)
- Efficiency improvement via new technology: cooled EGR

Majority of engines at high lambda to increase (mechanical) efficiency. Potential after-treatment: SCR.

- Not cheap
- But: applied several times in horticulture
- Moreover: prices have gone down

NO_x ELV for gas engines

→ Catalytic after-treatment with SCR or 3-way catalysts commercially available

- Proposed further restriction: from 340 to 100 mg NO_x/Nm³ at 3% O₂
- Already similar ELVs in Californian regions and Swiss regions
- Achieving 100 mg NO_x/Nm³ technically difficult with 3-way catalyst
- Advise: consider ELV at 140 mg NO_x/Nm³ at 3% O₂

→ For engines running on particular biogases:

- Contaminants may affect the after-treatment catalysts, e.g. siloxanes in sewage treatment biogas
- Activated carbon filters commercially available
- Advise: consider similar ELVs biogas engines as compared to natural gas engines

C_xH_y ELV for gas engines

- C_xH_y ELV for natural gas engines ($\geq 1 \text{ MW}_e / 2,5 \text{ MW}_{th}$) from 1500 to 1200 mg/Nm³ at 3% O₂ → “methane ELV”
- Currently no C_xH_y ELV for natural gas and biogas engines ($< 1 \text{ MW}_e / 2,5 \text{ MW}_{th}$). The Ministry: are there arguments to set an ELV?

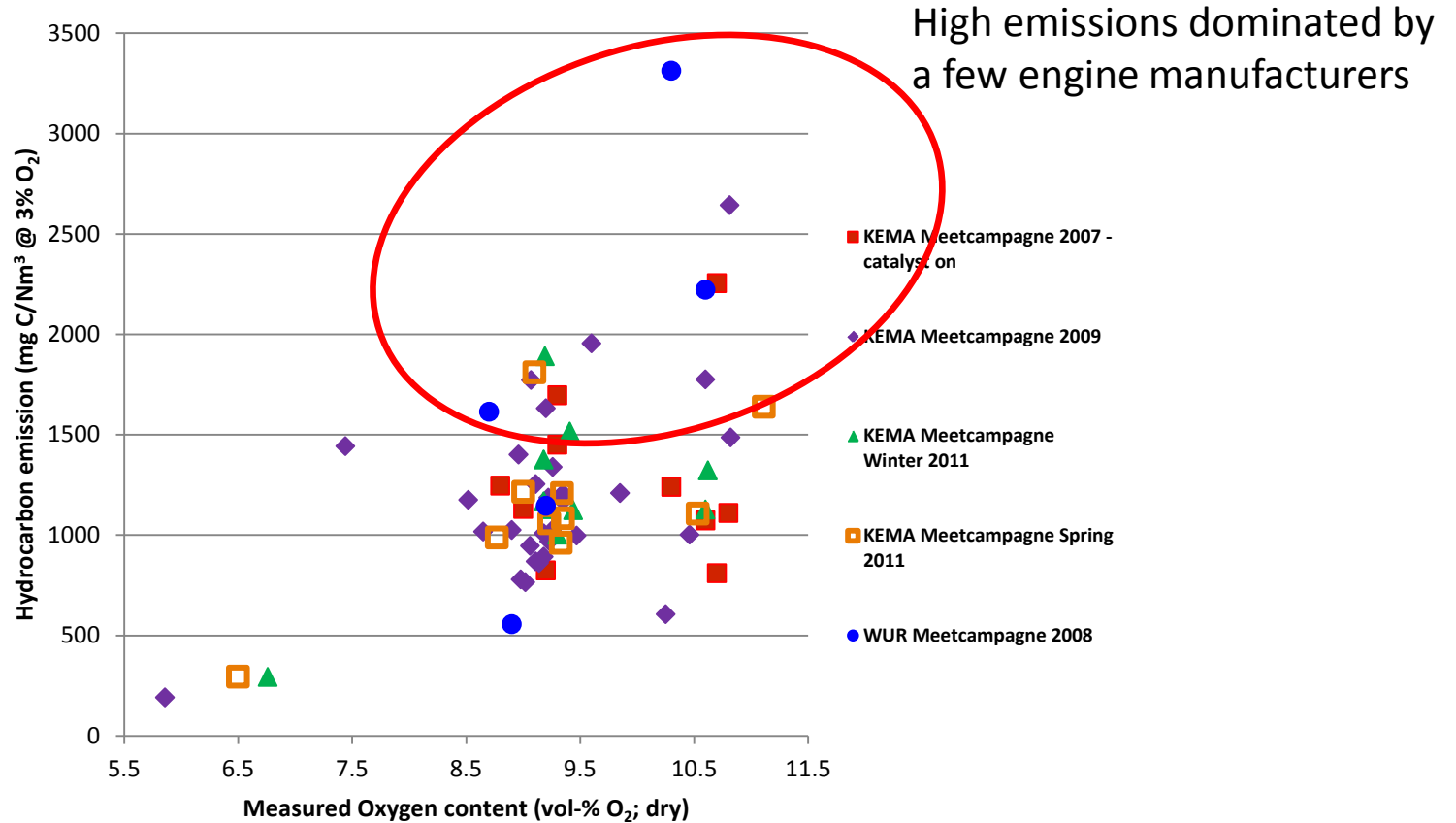
→ Application of gas engine as CHP saves CO₂ emissions

→ Methane slip partly counteracts realized CO₂ savings

| | CO ₂ reduction without methane slip | CO ₂ reduction at CH ₄ emission of 1200 mg C/Nm ³ | CO ₂ reduction at CH ₄ emission of 1500 mg C/Nm ³ |
|------------------------------|--|--|--|
| Case large gas engine | 26% | 15% | 12% |
| Case small gas engine | 20% | 8% | 5% |

Case large gas engine: 41%_{electrical efficiency}, 49%_{thermal efficiency}
 Case small gas engine: 34%_{electrical efficiency}, 52%_{thermal efficiency}
 Reference electrical efficiency: 50.5%
 Reference heat efficiency: 90%

C_xH_y ELV for gas engines

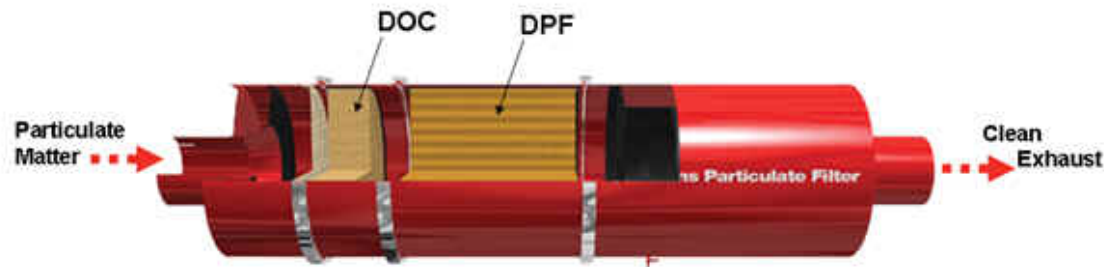


C_xH_y ELV for gas engines

- New engines can already meet the proposed ELV
 - Some manufacturers: change engine design or cannot sell
 - For existing engines aftertreatment is commercially available
 - Advise: consider the proposed ELV for new engines and consider a transitional arrangement for existing engines
-
- Small gas engines and biogas engines emit substantial less methane
 - Stricter NO_x -ELVs may result in leaner operation of small gas engines
 - Advise: consider the current C_xH_y ELV also for small gas engines to restrict potential increasing methane emissions due to leaner operation

Dust ELV for diesel engines

- Proposed further restriction: from 50 to 15 mg PM/Nm³ at 3% O₂
- (Commercially available) filter technology needed
- Dust filters require relative high-quality diesel (ULSD)
- Germany has similar ELV as proposal
- In USA, stricter ELVs will phase in from 2015 onwards
- Advise: consider implementation ELV at the same time as USA



NO_x ELV for diesel engines

- Proposed further restriction: from 450 to 140 mg NO_x/Nm³ at 3% O₂
- Proposed ELV near Euro VI for diesel trucks → SCR commercially available
- Stationary diesel engines often large power capacity
- Low rpm, high cylinder volume → increase of NO_x emissions
- In USA, strict ELVs will phase in from 2015 onwards (variable in power, rpm and cylinder volume) → 150 till 1350 mg NO_x/Nm³ at 3% O₂
- Advise: consider ELV at 250 mg NO_x/Nm³ at 3% O₂

Keep timing in line with introduction USA ELV for diesel engines
<10 L per cylinder

Conclusions

- Current ELVs belong to strictest of Europe, but can be restricted further: techniques are commercially available
- It is recommended to restrict the ELVs, but not all original considered levels are recommended for technical reasons:
 - Small gas engines 140 instead of 100 mg NO_x/Nm³ at 3% O₂
 - Diesel engines 250 instead of 140 mg NO_x/Nm³ at 3% O₂
- Advise has been reported
- Implementation of stricter ELVs is pending at the Dutch Ministry of Infrastructure and Environment
 - EC considers to regulate medium-sized combustion installations
 - Implementation not opportune yet



Thank you for your attention
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Recalculation of Dutch ELVs to other units

| Installation type | Substance | ELV-mg/Nm ³ at 3% O ₂ | ELV-mg/Nm ³ at 15% O ₂ | ELV in g/GJ |
|-------------------|------------------------------------|---|--|--|
| Gas engine | NO _x | 100 | 33 | 28 (fuel: natural gas of 31.65 MJ/Nm ³) |
| Gas engine | NO _x | 140 | 46 | 40 (fuel: natural gas of 31.65 MJ/Nm ³) |
| Gas engine | NO _x | 340 | 113 | 95 (fuel: natural gas of 31.65 MJ/Nm ³) |
| Gas engine | C _x H _y as C | 1200 | 398 | 336 (fuel: natural gas of 31.65 MJ/Nm ³) |
| Gas engine | C _x H _y as C | 1500 | 497 | 420 (fuel: natural gas of 31.65 MJ/Nm ³) |
| Diesel engine | PM | 15 | 5 | 4 (fuel: diesel of 42.7 MJ/kg) |
| Diesel engine | PM | 50 | 17 | 14 (fuel: diesel of 42.7 MJ/kg) |
| Diesel engine | NO _x | 140 | 46 | 40 (fuel: diesel of 42.7 MJ/kg) |
| Diesel engine | NO _x | 250 | 83 | 72 (fuel: diesel of 42.7 MJ/kg) |
| Diesel engine | NO _x | 450 | 149 | 129 (fuel: diesel of 42.7 MJ/kg) |

Dutch Bems ELVs, since April 2010

| Installation | NO _x | Dust | SO ₂ | C _x H _y |
|---|-----------------|------|-----------------|-------------------------------|
| Boiler (s,l) ≥1 MW _(n) | 100 | 5 | 200 | |
| Boiler (Biomass) <5 MW _{th} | 200 | 20 | 200 | |
| Boiler (Biomass) ≥5 MW _{th} | 145 | 5 | 200 | |
| Boiler (g) ≥1 MW _(n) | 70 | | 200 | |
| Diesel engine (l) | 450 | 50 | 200 | |
| Gasengine (g) | 100 | | 200 | 1500 |
| Gasengine (biogas or <2,5MW _{th}) | 340 | | 200 | |
| Gasturbine (l) | 140 | 15 | 200 | |
| Gasturbine (g) | 140 | | 200 | |

Emission limit values: s:mg/Nm³ @ 6 vol%O₂; l+g:mg/Nm³ @ 3 vol% O₂

MW_{th}: Thermal input rate in MW; MW_n: Nominal heat output in MW (source: website Infomil)

Adjustments of Dutch Bems ELVs to Activities decree, since January 2013

| Installation | NO _x | Dust | SO ₂ | C _x H _y |
|--|-----------------|------|-----------------|-------------------------------|
| Boiler (l) ≥1 MW _(n) | 120 ±100 | | | |
| Boiler (l) (>0.4-<1 MW _{th}) | 120 | 20 | 200 | |
| Boiler (Biomass) (>0.4-<1 MW _{th}) | 300 | 5 | 200 | |
| Boiler (g) (>0.4-<1 MW _{th}) | 70 | | 200 | |
| Boiler (Biomass) (≤0.4 MW _{th}) | 300 | 40 | 200 | |

Emission limit values: s:mg/Nm³ @ 6 vol%O₂; l+g:mg/Nm₃ @ 3 vol% O₂

MW_{th}: Thermal input rate in MW

MW_n: Nominal heat output in MW (source: Dutch Activiteis decree, §3.2.1)

Note: until January 2015, a transitional arrangement is in place for biomass-fired boilers for <1 MW_{th} due to potential EC regulation:

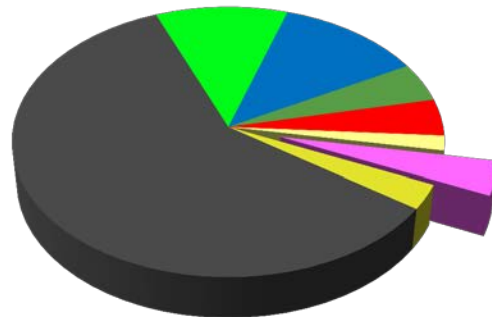
Boiler (Biomass) (>0.4-<1 MW_{th}) → only dust ELV: 75

Boiler (Biomass) (≤0.4 MW_{th}) → only dust ELV: 150

Environmental legislation in the Netherlands

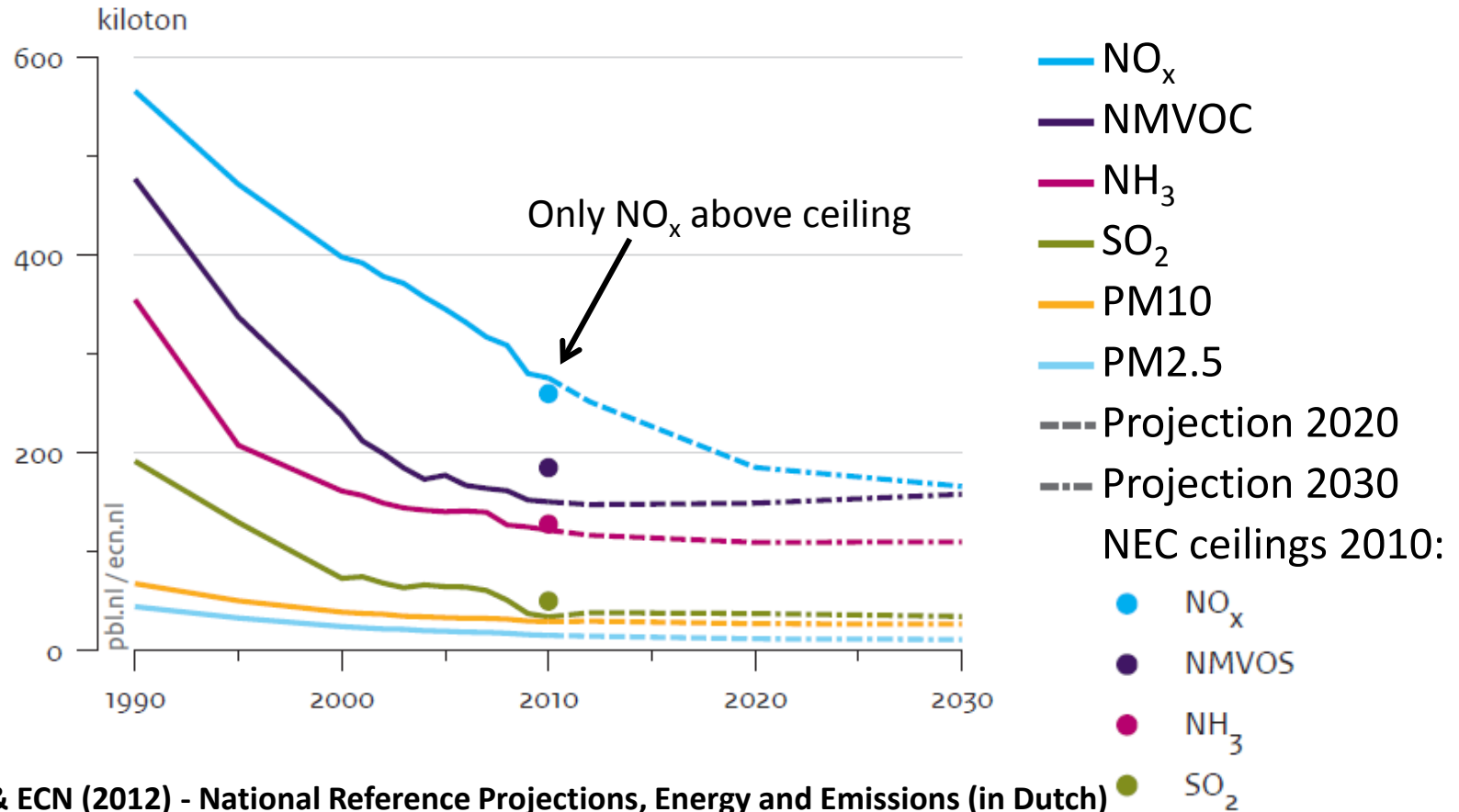
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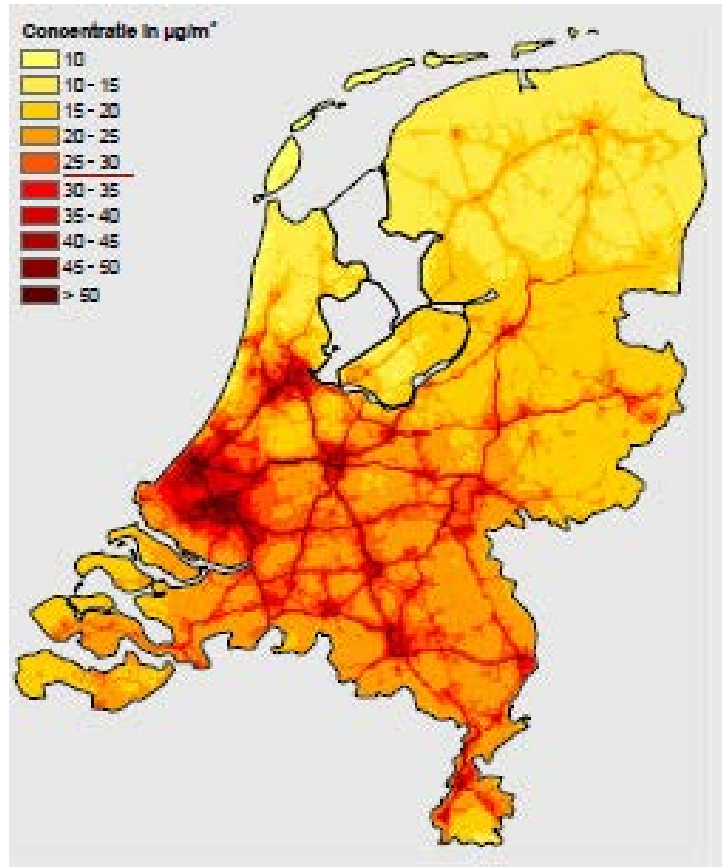


- Agriculture | combustion installations greenhouse horticulture
- Agriculture other activities and other combustion installations
- Traffic total according to NEC (without marine traffic)
- Industry total
- Energy total
- Consumers total
- Services total
- Waste incineration total

NO_x: environmental issue in the Netherlands



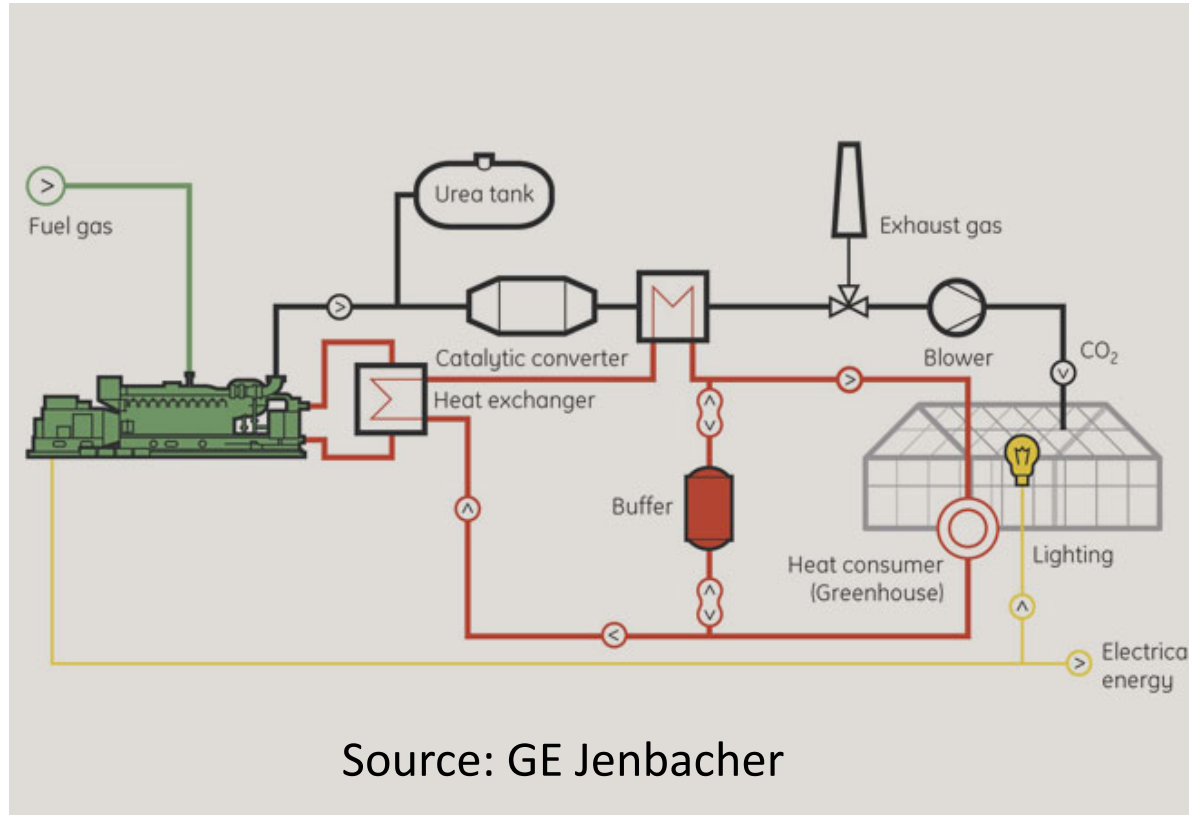
NO_x: environmental issue in the Netherlands



- Annual NO_x concentration in the Netherlands in 2012
- Hotspots
- Substantially traffic induced
- Decrease of background concentration

Source: RIVM (2012) – Annual Report Air Quality (in Dutch)

Stationary engines – short background



Source: GE Jenbacher

Stationary engines – short background

CO₂, H₂O, NO_x, C_xH_y, evt PM ←

