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

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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 $MW_{th}$) (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/$Nm^3$ at 3% $O_2$ (currently: 340)

→ $C_xH_y$ ELV for natural gas engines (≥ 1 $MW_e$/2,5 $MW_{th}$) at 1200 mg/$Nm^3$ at 3% $O_2$ (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/$Nm^3$ at 3% $O_2$ (currently: 50)

→ $NO_x$ ELV for diesel engines at 140 mg/$Nm^3$ at 3% $O_2$ (currently: 450)

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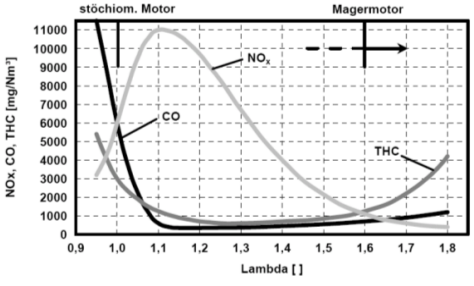
## Environmental legislation in the Netherlands

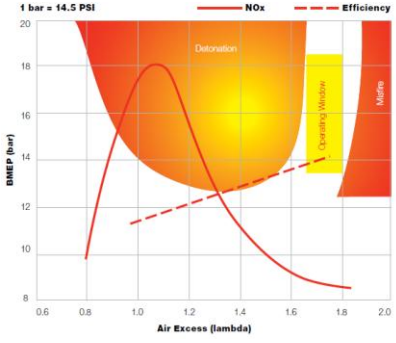
- Natural gas engines relevant in NL:
  - → ~4250 stationary gas engines
  - → of which, ~3000 (< 1 $MW_e$/2,5 $MW_{th}$)
    - → of which, ~1650 in Agricultural sector, ~450 in Health care sector, ~450 in Services sector

## $NO_x$: environmental issue in the Netherlands

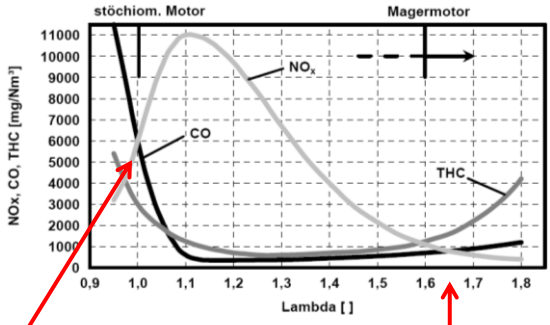
- Dutch $NO_x$ emissions in 2010: 274 kton (NEC definition; source: CBS, ECN & PBL)
  - Of which: 59% due to traffic, 12% and 11% due to Energy and Industry sectors, 4% combustion installations in greenhouse horticulture
- In 2010: Dutch $NO_x$-emissions were above the NEC ceiling. Other NEC emissions were below NEC ceiling.
- In 2012: $NO_x$ hotspots in NL above 40 µg/m$^3$, 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 $NO_x/Nm^3$ at 3% $O_2$
- Already similar ELVs in Californian regions and Swiss regions
- Achieving 100 mg $NO_x/Nm^3$ technically difficult with 3-way catalyst
- Advise: consider ELV at 140 mg $NO_x/Nm^3$ at 3% $O_2$

→ 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 (≥ 1 $MW_e$/2,5 $MW_{th}$) from 1500 to 1200 mg/$Nm^3$ at 3% $O_2$ → "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?

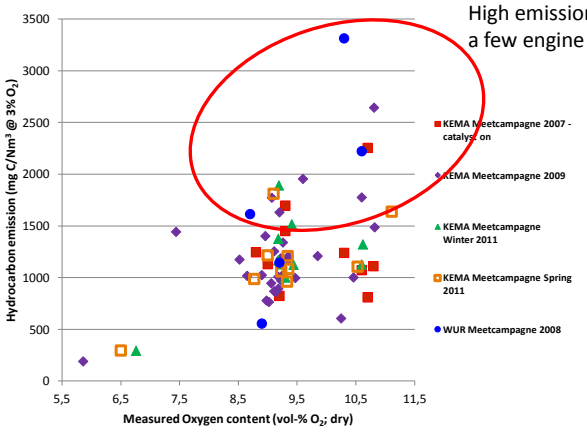
→Application of gas engine as CHP saves $CO_2$ emissions
→Methane slip partly counteracts realized $CO_2$ savings

| | $CO_2$ 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% $_{\text{electrical efficiency}}$, 49% $_{\text{thermal efficiency}}$
Case small gas engine: 34% $_{\text{electrical efficiency}}$, 52% $_{\text{thermal efficiency}}$
Reference electrical efficiency: 50.5%
Reference heat efficiency: 90%

# $C_xH_y$ ELV for gas engines

High emissions dominated by a few engine manufacturers



## $C_xH_y$ 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

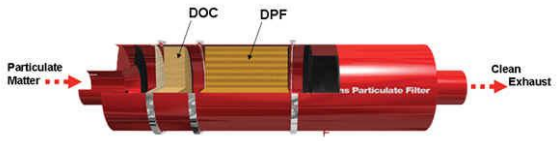
→ Advise: consider the proposed ELV for new engines and consider a transitional arrangement for existing engines

- 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/$Nm^3$ at 3% $O_2$
- (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 $NO_x/Nm^3$ at 3% $O_2$
- 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 $NO_x/Nm^3$ at 3% $O_2$
- Advise: consider ELV at 250 mg $NO_x/Nm^3$ at 3% $O_2$
  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 $NO_x/Nm^3$ at 3% $O_2$
  - Diesel engines 250 instead of 140 mg $NO_x/Nm^3$ at 3% $O_2$
- 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


## Recalculation of Dutch ELVs to other units

| Installation type | Substance | ELV-mg/Nm³ at 3% $O_2$ | ELV-mg/Nm³ at 15% $O_2$ | ELV in g/GJ |
|---|---|---|---|---|
| Gas engine | $NO_x$ | 100 | 33 | 28 (fuel: natural gas of 31.65 MJ/Nm³) |
| Gas engine | $NO_x$ | 140 | 46 | 40 (fuel: natural gas of 31.65 MJ/Nm³) |
| Gas engine | $NO_x$ | 340 | 113 | 95 (fuel: natural gas of 31.65 MJ/Nm³) |
| Gas engine | $C_xH_y$ as C | 1200 | 398 | 336 (fuel: natural gas of 31.65 MJ/Nm³) |
| Gas engine | $C_xH_y$ as C | 1500 | 497 | 420 (fuel: natural gas of 31.65 MJ/Nm³) |
| 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) |

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# Dutch Bems ELVs, since April 2010

| Installation | $NO_x$ | Dust | $SO_2$ | $C_xH_y$ |
|---|---|---|---|---|
| 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 <2,5$MW_{th}$) | 340 | | 200 | |
| Gasturbine (l) | 140 | 15 | 200 | |
| Gasturbine (g) | 140 | | 200 | |

Emission limit values: s:mg/$Nm^3$ @ 6 vol%$O_2$; l+g:mg/$Nm^3$ @ 3 vol% $O_2$
$MW_{th}$: Thermal input rate in MW; $MW_n$: Nominal heat output in MW (source: website Infomil)

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

| Installation | $NO_x$ | Dust | $SO_2$ | $C_xH_y$ |
|---|---|---|---|---|
| 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/$Nm^3$ @ 6 vol%$O_2$; l+g:mg/$Nm_3$ @ 3 vol% $O_2$
$MW_{th}$: 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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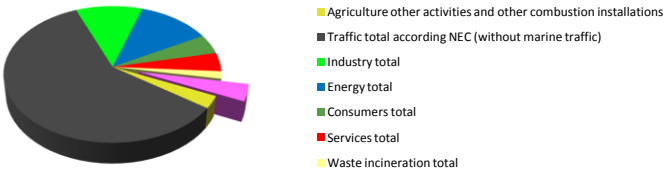
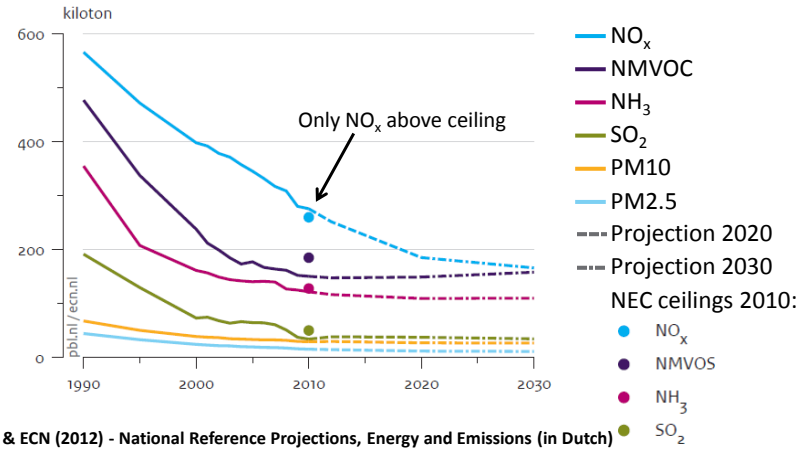
**$NO_x$ emissions in 2010: 274 kton** (NEC definition; source: CBS, ECN & PBL)

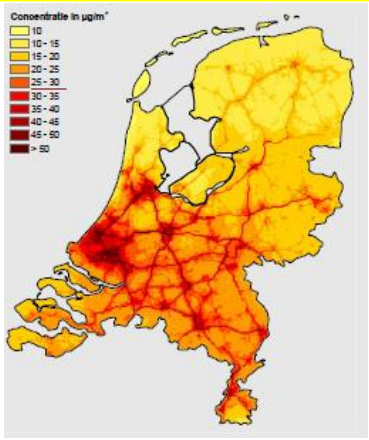



## $NO_x$: environmental issue in the Netherlands




Source: PBL & ECN (2012) - National Reference Projections, Energy and Emissions (in Dutch)

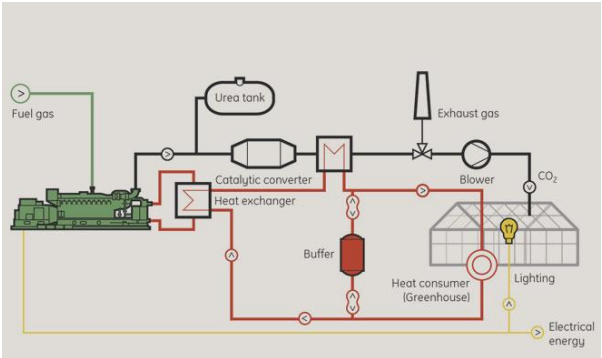
## $NO_x$: environmental issue in the Netherlands




- 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