Nitrous oxides (NO_X) and Trigeneration: Is this "green" technology causing a new problem for occupants and facility managers?

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An Introductory Thought

*In the period from 1992 to 2008, nitrous oxides emissions from industry in Sydney have increased by 51%. They are **projected to grow a further 13% over the next 8 years** to 2016. This scenario DOES NOT include any shifts in the location of electricity generation (such as cogeneration) which would exacerbate the challenge of reducing ozone levels.*

NSW OEH Nitrogen Oxide Policy for Cogeneration

Annual NO_X emissions are estimated to be in the range

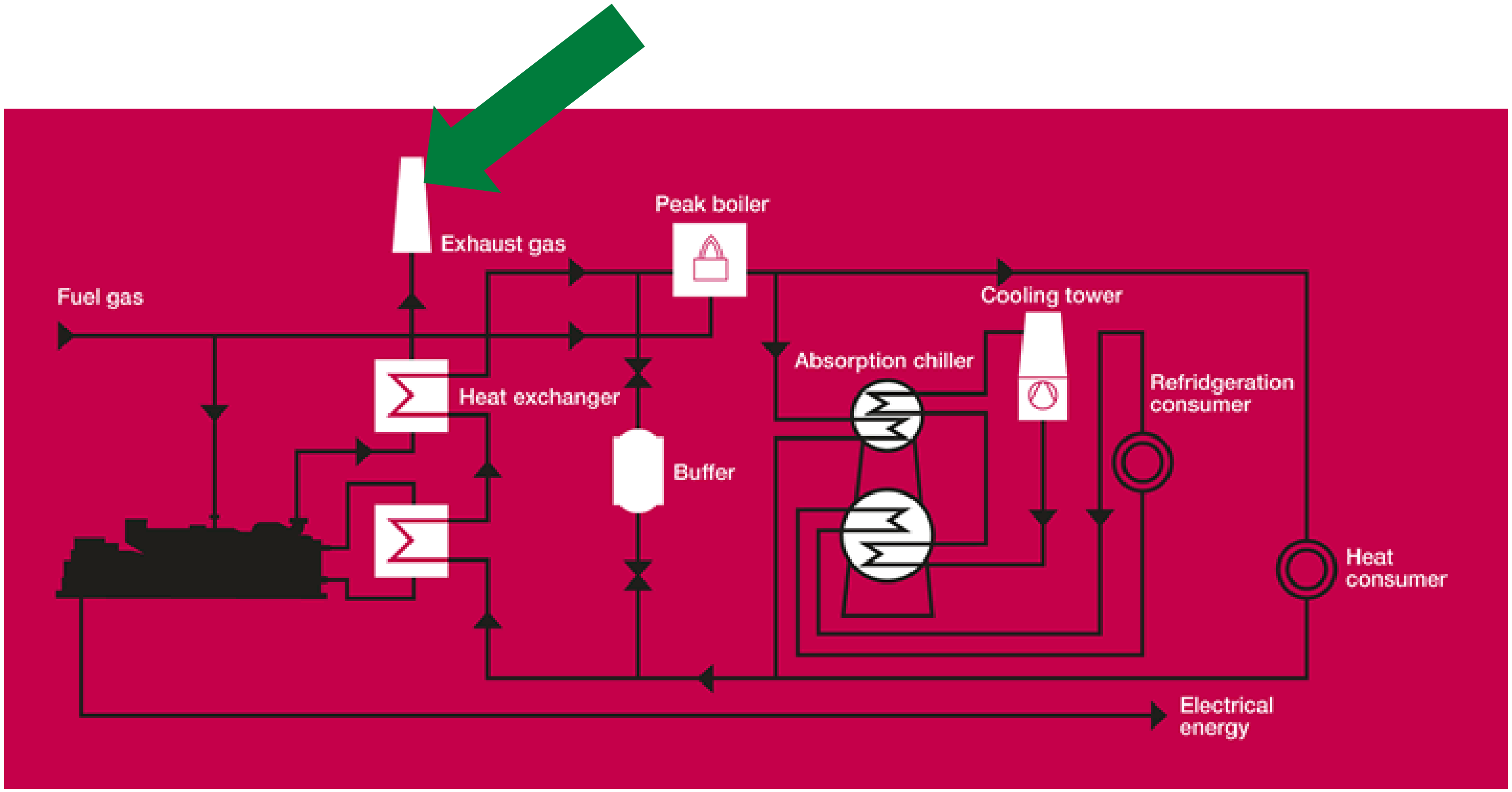
82.6 ktpa to 117.4 ktpa

Australian Government Department of the Environment, Water, Heritage and the Arts – Environ Report 2010

The Agenda

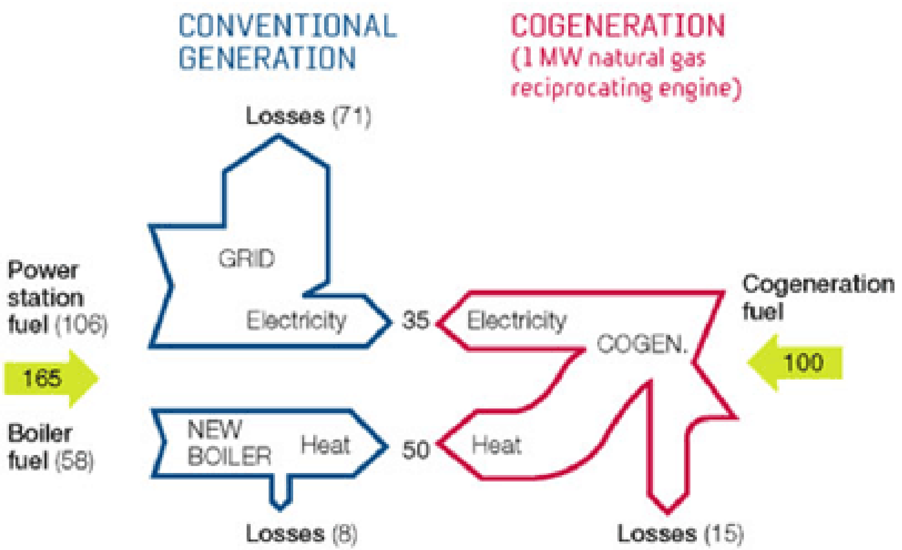
- Trigeneration Systems
- The Advantages
- The Disadvantages
- Nitrous Oxides
- Health Implications
- Current Standards
- Case Study
- A Need To Redirect Focus

Cogeneration and Trigeneration Systems



The Advantage of Cogen/Trigen

Energy Efficiency - Cogeneration will usually provide an overall energy conversion efficiency somewhere in the range of 70–75%, if all useable heat is recovered. This compares to the 25–30% conversion efficiency of a typical single-cycle centralised power station. (ResourceSmart Business, Sustainable Manufacturing, 2006)



The Disadvantage of Cogen/Trigen

Capital Cost

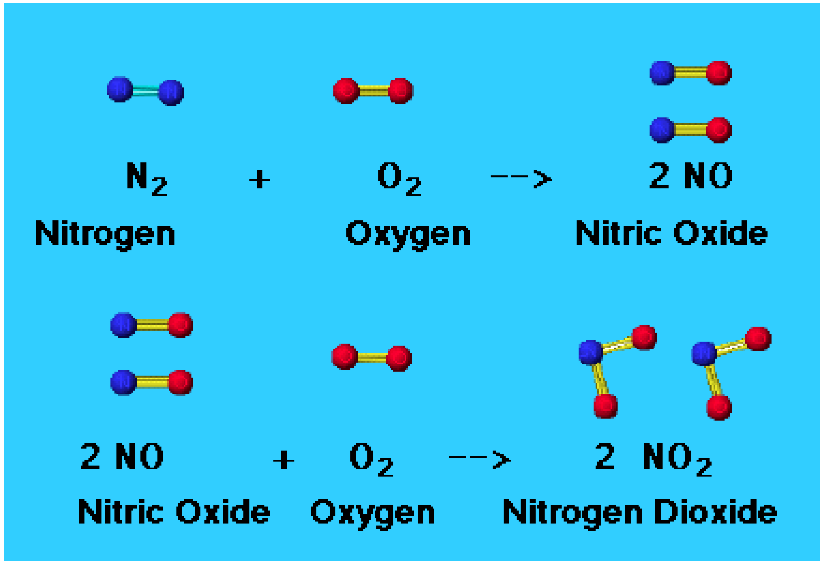
National electricity rules and an inefficient connection process

Emissions → Nitrous oxides (NO_X) and affect indoor environment quality and wellbeing

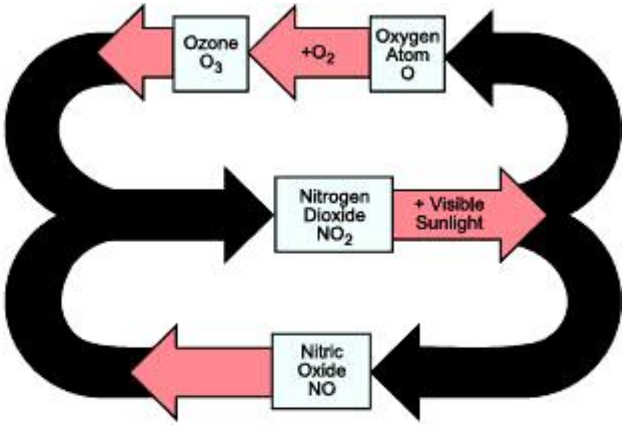
Nitrous Oxides (NO_X) and Nitrogen Dioxide

Refers to oxides NO converted to NO_2 (nitric oxide and nitrogen dioxide), produced from the reaction of nitrogen and oxygen gases in the air during combustion, especially at high temperatures.

By-product of cogeneration and trigeneration systems (exhaust) with levels further exacerbated in levels of high traffic



NO_X and "Bad" Ozone in Troposphere



Ozone production from NO_X pollutants: Oxygen atoms freed from nitrogen dioxide by the action of sunlight attack oxygen molecules to make ozone. Nitrogen oxide can combine with ozone to reform nitrogen dioxide, and the cycle repeats.

NO_X, CO, and VOCs are called ozone precursors

Health Implications

- Nitrogen dioxide is known to affect the throat and the lung. The main effects are emphysema and cellular damage which reduce the efficiency of breathing. In levels encountered in polluted air, people with respiratory problems, particularly infants, may be affected.

- The current standard limit for nitrogen dioxide is 0.12 parts per million (ppm) for one hour and 0.03ppm for one year (EPAV)

- *Health effects*
  Epidemiological studies have shown that symptoms of bronchitis in asthmatic children increase in association with long-term exposure to NO_2.

- Reduced lung function growth is also linked to NO_2 at concentrations measured (or observed) in cities of Europe and North America.

- Indoor air pollution → approximately 2 million premature deaths.

- Urban outdoor air pollution → approximately 1.3 million deaths.

World Health Organisation

Current Standards (Airborne)

	Victorian Environmental Protection Agency	National Environment Protection Council Australia	Queensland Government (DERM)	US Environmental Protection Agency	European Guidelines (as set by the World Health Organisation)
Period of an hour	0.12ppm	0.12ppm	0.5 (healthy individuals)* 0.16 (children)	-	0.2 mg/m3 (~ 0.4ppm)
Period of a year (annual)	0.03ppm#	0.03ppm	-	0.053ppm	0.021 to 0.026ppm

A safety factor of between three and four has been adopted here for normal children.
 # http://www.epa.vic.gov.au/air/issues/air_nox.asp

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Beyond the Standards

- Important to consider and risk assess the occupants

What is the dosage?

How often are they occupying the building ?

(office vs. Hospital vs. Hotel etc.)

Risk Assessment

What are their characteristics and history?

Severely immuno-comprimised individuals need to be considered as the current standard does not consider this – therefore an appropriate safety factor may need to be applied

Case Study

- Wind modelling used to identify potential levels at air intakes and balconies of a major building after implementation of a trigeneration system
- Levels projected to be above EPAV guidelines, even not considering other emission sources (nearby traffic, diesel generators tested periodically etc.)
- A safety factor was applied to projected and validated results following a risk assessment of the occupants

Modelled One Minute Mean Maximum Concentration measured at specific air intakes. Units in parts per million of stack concentration.

Ranges:

All sources

10,000 – 100 ppm_v

Trigen (hot and warm emissions)

1,000 – 500 ppm_v

NO_X: 0.1 – 0.6 ppm

NO_2: 0.05 – 0.25 ppm (40% conversion)

Various stack heights modelled –
higher stacks ≠ more favourable results

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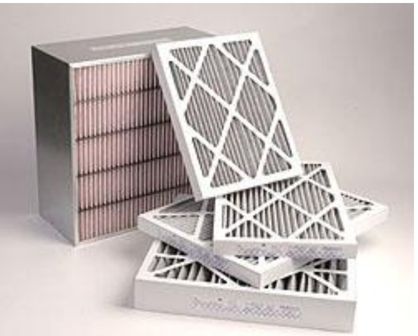
- Tested under various wind conditions
- Handheld instantaneous readings AND measurements taken over a period of time using air sampling equipment. Included NO_X and NO_2.
- Levels of NO_X up to 0.05ppm and levels of NO_2 up to 0.05ppm. Levels still above proposed limit despite other sources not considered.
- NO_X to $N0_2$ conversion at 80-90% (as opposed to 40% modelled, considered)
- Further testing considering cumulative effects of other emission sources still in progress

Conclusions and Implications

Projected modelled results were validated with air monitoring studies following construction

Recommendation to retrospectively install gaseous filtration at all affected air intakes (additional capital costs) and implement control measures for balcony use

Imperative to consider emission sources, environmental conditions, initial design specifications, occupant wellbeing, health implications, additional capital costs, and ongoing maintenance costs



Ongoing need for a holistic approach and more focus on indoor environment quality (IEQ)

Why focus on IEQ?

- People are the key concern, cost and function of buildings
- Energy 5%, People 85% of costs

Further Implications – Facilities Managers

Fuel

Fire Risk	VOCs

↓

Start Up

$PM_{2.5}$

↓

Breakdown

Power Interruptions (OHS, computers, etc.)

↓

Air Intake Filtration

Installation	Maintenance

↓

Emission Scrubbers

Installation	Maintenance

Further Implications – Noise

"...when the plant was in full operation it exceeded maximum noise levels for neighbouring buildings. This was then rectified quickly with the installation of an extra silencer, taking it to 1 year from installation before it was operating successfully."

Olivia Tattam, EPA Victoria, EPA Victoria's Green Building 1st Birthday

Further Implications - Environment

How can the facility manager control emissions from their facility and the impact on the overall pollution to the city?

"...widespread development of CHP projects (Cogen/Trigen) would essentially relocate the source of some of the NO_X emissions produced by the power generating sector from a few, very large point sources outside the city to many, small point sources inside the city. Implementation of CHP changes both the amount AND geographical distribution of NOx emissions..."

Houston Advanced Research Centre, 2008

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