



Sustainable  
United Nations

## Sustainable Procurement Guidelines

# GENERATORS & BATTERIES BACKGROUND REPORT



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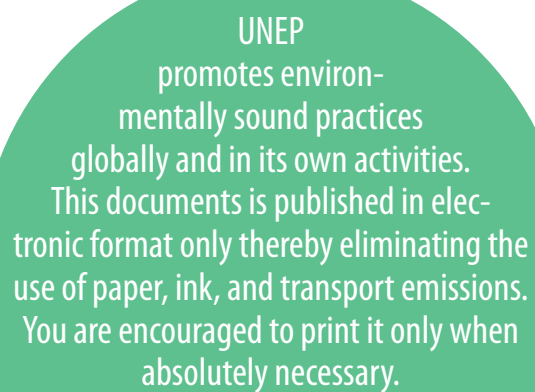
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## *Messages from the United Nations and UNEP*

"I would like to make a public commitment. We are already moving towards making our Headquarters in New York climate-neutral and environmentally sustainable. I would like to see our renovated headquarters complex eventually become a globally acclaimed model of efficient use of energy and resources. Beyond New York, the initiative should include the other UN headquarters and offices around the globe.

We need to work on our operations too, by using energy more efficiently and eliminating wasteful practices. That is why, today, I am asking the heads of all UN agencies, funds and programmes to join me in this effort. And I am asking all staff members throughout the UN family to make common cause with me."



**Ban Ki-moon**  
UN Secretary General  
New York, 5 June 2007  
World Environment Day



**Achim Steiner**  
Executive Director, UNEP  
Geneva, 8 October 2007  
117<sup>th</sup> Assembly of the Inter-Parliamentary Union

"Ban Ki-moon is determined to put global warming at the top of the global political agenda and determined to build the trust so urgently needed if we are to succeed in combating climate change. Under his leadership, the UN is also determined to demonstrate its 'sustainability credentials' by action on the ground and by good housekeeping at home.

Reviews are underway across all agencies and programmes to establish a strategy for a carbon neutral UN and to make the refurbishment of the UN headquarters in New York a model of eco-efficiency.

UNEP is committed to take part in the fight for climate change and in showing leadership. We are committed to become carbon neutral by reducing our energy consumption and carbon footprint and by offsetting emissions."

## *Acknowledgements*

UNEP gratefully acknowledges the time and effort spent by those involved in producing and commenting on these Sustainable Procurement Guidelines for Generators and Batteries.

These guidelines were prepared by Knud Erik Poulsen under the supervision of the UNEP Division for Technology Industry and Economics (DTIE).

On the UNEP side, the work was coordinated by Isabella Marras and Cécile Bordier, team members of the Sustainable United Nations (SUN) Unit.

The set of guidelines were developed thanks to the valuable input and technical advice of UN colleagues, in particular Bibiana Sánchez, Pablo Panadero, Alicja Brynier (UNICEF), Stefano DiFilippo (FAO), Monica Siles (UNOPS), Bennie Mushumbusi (UN), Georgina Stickels, Andy Cole, Bill Campbell, Ryan Twitney (WFP), Robert Werzi (CTBTO), Louisa Chan, Anne Fernqvist (UNDP), Robert Dubuis (ILO), Niels Ramm (UNOPS) and experts outside of the UN, Kurt Østergaard (KVA-diesel.dk) Jesper Saklko (Scanpocon.dk), Electropedia.org, Grontmij.com and Thad Mermer (design).

## *Purpose of these guidelines*

### *What is Sustainable Procurement?*

“Sustainable Procurement practices integrate requirements, specifications and criteria that are compatible and in favour of the protection of the environment, of social progress and in support of economic development, namely by seeking resource efficiency, improving the quality of products and services and ultimately optimizing costs.”<sup>1</sup>

Sustainable Procurement practices should be introduced progressively and in full respect of the right of access to the UN market for suppliers from developing countries and countries with economies in transition.

### *How to use the Sustainable Procurement Guidelines?*

The main goal of the Guidelines is to facilitate the implementation of sustainable procurement by providing criteria that may be used by UN staff for the requisition and procurement of goods, civil works and services.

In practice, this means thinking carefully about what the true needs are, as a first step. Then, basing purchasing decisions (for products, services and works) on the lowest environmental impact and most positive social impact which make the most economic sense over the lifetime of the product. Therefore, the guidance covers the following: key environmental impacts, key social considerations, most appropriate means of verification and information on the availability of sustainable products and lifetime costs (where available).

As with local product availability, prices, costs and relevant legislation may vary considerably between regions. The way sustainable procurement is practiced should be adapted to local conditions and markets, and depends on how ambitious the purchasing organization is in terms of sustainable development,

For these reasons, the UN Sustainable Procurement Guidelines comprise of the following for each of the addressed products and services:

- a detailed **background report**, and
- a practical **product sheet**.

The main role of the **background report** is to provide staff involved in procurement with more comprehensive information on the rationale behind the sustainable procurement guidelines presented in the product sheets. The background reports cover various issues related to purchasing a product and service in an environmentally-friendly and socially-responsible way, such as: identifying the key environmental impacts and social considerations at purchase, as well as taking into consideration the whole of life costs of the system (including operating costs, fuel consumption, maintenance and disposal costs), listing the most appropriate schemes for verification, most relevant legislation regarding the environment and social considerations, and providing an indication of the availability on the market of sustainable products.

The **product sheets** provide sustainability criteria designed specifically for the various phases or steps of the UN procurement cycle. These are: detailing the subject matter of tenders, technical specifications (or terms of reference for services), sourcing suppliers, evaluation criteria and contractual clauses. Guidance is also provided on how compliance with the criteria should be verified. The criteria are also presented in check-list form for use by requisitioners and a weighting matrix is provided.

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<sup>1</sup> Definition adopted by the High Level Committee on Management Procurement Network.

## *Regional differences*

As market conditions vary from region to region, the potential for sustainable procurement may also vary. Therefore, for certain product groups different product sheets may be produced for different regions. The region for which each product sheet is produced for will be clearly indicated on the document itself and also on the SUN Greening the Blue website and the UNGM SP knowledge centre where they can be downloaded.

## *Differences in ambition*

Additionally UN procurers must decide whether they wish to apply the “basic” or “advanced” criteria:

- **Basic sustainability criteria** address the most significant environmental and social impacts and require minimum effort in verification and minimal increases (if any) in price
- **Advanced sustainability criteria** are intended for use by procurers who seek to purchase the most advanced environmentally-friendly and socially-responsible products available on the market, and may require additional administrative effort or result in a price increase as compared to other products fulfilling the same function.

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## 1. Introduction

Diesel generators are widely used in many areas where electrical power is unreliable or non-existent. There, generators are used as a supplement to the main power supply, or as the main power supply as well as emergency backup for hospitals, for computer data-storage, server applications, etc. Diesel generators that are only used a few hours each year will not be a problem for the environment, but if used more extensively they cause major problems locally, regionally and on the global plan.

Generators have long lifetimes and can be sold for other purposes than originally intended. It is therefore important to purchase diesel generators that meet modern standards and with minimum emissions of pollutants.

Diesel generators are often utilized as they can be a cheaper alternative, however as global fuel prices rise and alternative technologies become more widespread, many UN agencies are considering renewable energy systems such as solar, solar hot water, wind or bio-energy, to supplement or replace diesel generators. For the purposes of this document, it is assumed that the purchasing agency has already considered these alternatives and any opportunities to reduce demand for electricity on the site, which could significantly reduce the size of the generator required and the overall fuel consumption.

This background report, together with the practical product sheet, constitutes the sustainable procurement guidelines for generators and batteries for the UN system. These guidelines are aimed at UN agencies and the UN WEBBUY<sup>2</sup> system operated by The United Nations Office for Project Services (UNOPS).

The main objective of this background report is to give comprehensive information on the rationale behind the sustainable procurement recommendations made in the product sheet and to familiarize the reader with the generator and battery sustainability issues at hand. This covers aspects such as “key environmental impacts”, “key social considerations”, legislation to control emissions and disposal of harmful substances.

## 2. Scope

### 2.1. General information about generators

#### *The diesel generator set*

A diesel generator consists of a number of components, often called a diesel generator set or more popular a “genset” that includes:

- Diesel engine
- Electrical generator, also called alternator
- Fuel tank
- Start-battery/start engine
- Cooling system for engine and generator
- Heat exchanger/radiator
- Control system
- Battery charging system
- Self protection system
- Housing and other noise reduction systems
- Flue gas stack

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<sup>2</sup> Please see: [www.unwebbuy.org/](http://www.unwebbuy.org/) participating agencies can obtain a password to enter site

# GENERATORS AND BATTERIES

- Flue gas cleaning (normally optional)
- Remote control system (normally optional)

The specific construction and equipment will depend upon what the generator is to be used for, its location and other relevant parameters.

## *Usage*

A generator can be used as an energy producing unit in itself producing DC or more commonly AC voltage. The typical use is to deliver electrical power at places where the main power supply is unstable or non-existent. Such generators may be in operation from a few hours each month to 24 hours a day.

The use of a generator can also be combined with the use of a large battery backup system. The purpose of the battery system is to function as an immediately ready source of electrical energy for emergency use. Examples could be special functions at a hospital, computer servers, etc.

If electrical power failure cannot be accepted, even for a few seconds, a generator can be combined with an Uninterrupted Power Supply (UPS) system.

UPS systems are based on a high capacity battery system which converts DC to AC by means of an AC-DC converter. There are different designs, depending on the required reliability and whether or not power supply must never fail. For demanding applications the battery system is continuously charged from the main power supply. If the power supply fails, the UPS will supply electricity instantly provide power during the short time it takes for the generator to start (be it an automatic start or manual start). Once the generator is started it will provide the power supply and also charge the batteries. In such a system the batteries will be under constant charging and must be designed for that. The batteries, the UPS unit and the charger unit form a combined system designed to work together. It also means that changing one component may require replacement of other components to ensure full reliability/compatibility.

A generator may have a lifetime of more than 20 years. Batteries may have lifetimes in the range of 5 years. If batteries are replaced by other types than the originals, it may be expected that it will also be necessary to replace the UPS, the battery charger system and other controlling electronics. This may not always be necessary but this highlights the importance of designing the entire system correctly from the beginning. The system design (generator, UPS, batteries etc.) will depend on the specific needs but also on what is available at the specific location.

## **2.2. General information about batteries**

A battery is a group of one or more electrochemical cells. An electrochemical cell consists of a positive charged anode, a negative charged cathode, an electrolyte that transfers current by positive and negative ions and a mechanical system that separates the two electrodes from internal short-circuiting. The two electrodes (anode and cathode) consist of different metals or metal oxides.

The difference in electrochemical potential between the electrodes will start a redox process (reduction and oxidation) when the outer terminals are connected and a current will flow. The voltage of the cell will depend on the electrochemical system but is typically between 1.2 Volt and 3.7 Volt. If large voltage is needed batteries are coupled in series. If large capacity is required, batteries are coupled in parallel. Large systems are usually constructed as a combination of cells in series and cells in parallel.

Batteries can be constructed as primary batteries or as secondary batteries. Primary

batteries cannot be recharged and must be disposed off after use. Examples of traditional dry cells are Zn-Manganese batteries or as alkaline batteries.

In secondary batteries the current can be reversed and the battery can be recharged. Traditional batteries of such type are the Lead-acid battery used in automobiles and the Ni-Cd (Nickel-Cadmium) battery used in portable electrical tools.

The market today consists of a large number of different battery types based on many different electrochemical systems and variations hereof. Annex 1 provides a description of rechargeable batteries relevant for use in emergency backup systems or as power supply for remote location operations. Battery life can vary, depending on the type of battery chosen, how it is used and the climate in which it is used. Battery life might be significantly shortened when the battery is fully discharged often, especially in very hot climates. Batteries will normally need to be replaced at least once over the life-span of a generator.

Battery systems are commonly used in tandem with renewable energy-powered generation systems, in addition to diesel generators and mains or grid-powered systems.

### **2.3. Use of generators and batteries in the UN**

The consultation of procurement practitioners as well as engineers in the UN system from a variety of UN duty stations worldwide has assisted in developing a set of guidelines which should be practical and applicable for the majority of users.

This guideline covers generators and batteries defined as follows; the maximum power for generators is set to 560 kW. This is the power range regulated by EU and EPA for non road generators. Generators with a higher power capacity are generally only relevant for diesel locomotives, large ships and power plants.

#### **Generators**

Usage: Small to medium size power supply for emergency backup use for hospitals, clinics, remote location power supply and emergency situations.

Fuel: Diesel, bio-fuel (diesel) or petrol. Generators operating on gas or other fuels are not included.

Power range: 5 kW – 560 kW

#### **Large battery systems**

Usage: Batteries included in the emergency generating sets or UPS systems for backup power (hospitals, computers etc.).

Voltage: > 12 Volt

Power range: 0.5 kW – 80 kW

#### **Small battery systems**

Usage: Power supply for electronics, for example communications systems at remote places. Batteries are generally purchased as an integrated unit together with solar panels and/or small wind-generators. Only the battery pack is included in this guideline.

Voltage: 12-24 Volt

Capacity: 0 Ah – 220 Ah

### 3. Key environmental impacts of generators and batteries

#### 3.1. Impacts from generators

##### *Life cycle impacts*

From a life cycle perspective, diesel generators have a variety of impacts on the environment, here among impacts from:

1. Extraction of raw materials
2. Use of raw materials and transport of raw materials for producing the generator
3. Impacts from production of generator
4. Transport of generator from production site to supplier and to site where used
5. Production of fuel and transport of fuel
6. Operation of generator
7. Service and maintenance (including transport)
8. Disposal of oil and used spare parts
9. Decommissioning and disposal

If a generator is never or very seldom used it will be the impacts from 1-4 that are most relevant for the total environmental life cycle impact. However, from a procurement perspective, all life cycle impacts need to have a cost associated relative to anticipated use, even if this use is to be considered minimal.

If the generator is used more frequently or often, it will be the operation of the generator that is more important in terms of environmental impacts.

##### *Emission of harmful pollutants*

The impact in the operation phase is primarily related to the emission of harmful pollutants. Diesel generators are among the highest polluting energy producing units. The primary pollutants are:

- Nitrogen oxides (NO<sub>x</sub>)
- Sulphur dioxide (SO<sub>2</sub>)
- Carbonmonoxide (CO)
- Hydrocarbons/ Polycyclic Aromatic Hydrocarbons (HC/PAH)
- Particles (PA)
- Carbon dioxide (CO<sub>2</sub>)

The visible pollution generated by burning diesel contains elemental carbon. The typical odour comes from polycyclic aromatic hydrocarbons, which also are cancer causing components. As seen from table 3.1 below, many components have the same impacts and are responsible for both local and regional impacts.

**Table 3.1 Major environmental impacts form emissions from generators**

Pollutant	Local effects		Regional effects			
	Local respiratory diseases	Cancer	Acidification of lakes	Building degradation	Eutrophication	Tropospheric ozone and smog
NO <sub>x</sub>	X		X	X	X	X
SO <sub>2</sub>	X		X	X		X
CO	X					
HC	X	X				X
PA	X	X		X		X

Fuel spillage poses an additional risk of contaminated soil, groundwater and possibly waterways. A generator system will normally include some means of storing and transferring the fuel: selecting tanks that are easy to maintain will minimise the risk of fuel leaking into the ground. Pumping systems and nozzles will reduce the risk of fuel spills during fuel delivery and transfer.

### *Emission of nitrogenoxides and particles*

A typical diesel generator emits from 5 to 50 times as much nitrogen oxides (NO<sub>x</sub>) and other pollutant per MW as compared with a modern Large Combustion Plant. This is due to higher efficiencies at large combustion plants, the use of boilers instead of motors and the use of effective flue gas cleaning.

Table 3.2 compares typical emissions from a modern large power plant with emissions from a diesel generator.

**Table 3.2 Emissions from a modern power plant compared to emissions from a diesel generator**

Pollutant	Modern Large Power Plant mg/m <sup>3</sup>	Typical diesel generator mg/m <sup>3</sup>
NO <sub>x</sub>	400	4000
Particles	< 50	100

Use of a generator for energy production is an environmentally unfriendly technique. It should therefore always as a first step seriously be considered if a generator is needed or if other types of energy producing systems could be used, such as wind, solar power, solar hot water, bio-energy and geothermal. Use of batteries may be the right solution if the question is to ensure backup of data or similar purposes. However, if the purpose is to be able to run a hospital in an emergency situation for a longer period, a diesel generator is the right solution.

The emission of nitrogen oxides is a serious problem and is often overseen. Nitrogen oxides are as seen in table 3.1 responsible for a number of negative impacts on the environment.

Neighbours to a generator will be affected by an elevated concentration of nitrogen oxides. Nitrogen oxides contain different oxides of nitrogen, the most important being nitrogenmonoxide (NO) and nitrogen dioxide (NO<sub>2</sub>). Nitrogen dioxide is a respiratory irritant and is responsible for a number of respiratory diseases. People with sensitive respiratory systems are especially affected.

The described problem can partly be solved by use of a sufficiently high stack to disperse the flue gas from the generator. However, in areas with large topographical variations, this will often require unrealistic stack heights.

Another major problem with nitrogen oxides is that they together with Volatile Organic Compounds (VOC) and sunlight form ozone in the lower troposphere. The photochemical reaction is:

$\text{NO}_x + \text{VOC} + \text{Sunlight} \Rightarrow \text{ozone (O}_3) + \text{other photooxidants}$

Ozone + other photochemical compounds + particles  $\Rightarrow$  photochemical smog

Ozone is responsible for damage on vegetation, loss of agricultural crop and respiratory problems.

The VOC come from industrial sources, traffic, household articles and from natural sources. A generator produces VOC in the form of hydrocarbons (UHC) and large amounts of odour.

$\text{NO}_x$  and VOC are so called ozone precursors. The reduction of the emission of both  $\text{NO}_x$  and VOC are major focus points in most nations in regulation of air pollution on regional level.

Other impacts and effects from the release of  $\text{NO}_x$  are acidification of lakes and degradation of buildings. This is caused by formation and deposition of nitric acid during rainfall. Deposition of nitrogen compounds can also lead to eutrophication (excessive nutrients in a lake or in sensitive land area) and thus result in loss of biodiversity.

### *Climate change, energy efficiency and bio diesel*

A typical diesel generator uses about 2-3 times as much energy to produce the same amount of energy as a modern public Large Combustion Plant (LCP). It means that the release of the greenhouse gas carbon dioxide ( $\text{CO}_2$ ) is up to 3 times higher than compared to energy delivered from a modern power plant.

Energy efficiency is of high importance for generators that operate many hours each year both with regard to economy and the release of carbon dioxide and other pollutants. The emission of carbon dioxide is directly related to the amount of fuel used. High efficiency is therefore important to reduce the amount of released carbon dioxide and consequently to reduce the global greenhouse effect.

Datasheets for generators do not always specify the emission of carbon dioxide. In such case the carbon dioxide emission can be calculated by use of an emission factor for the fuel used.

The emission of  $\text{CO}_2$  can be reduced by the use of bio diesel and the emission of air pollution components can be reduced by use of filters and catalysts. Emission control in the form of filters and catalysts is however expensive and requires service as other components. Use of catalyst to reduce emissions will also require use of fuel with very low sulphur content as not to destroy the catalyst.

In theory bio diesel is  $\text{CO}_2$  neutral. In practice this is not the case. Bio fuel can be made on the basis of agricultural crop (1<sup>st</sup> generation bio fuel) or on the basis of industrial or domestic waste (2<sup>nd</sup> generation bio fuel). Research during the last years has documented that 1<sup>st</sup> generation bio fuel only helps little (if any) in reduction of  $\text{CO}_2$  emissions as a lot of energy is lost during the production process. Furthermore, crop for bio fuel production takes up land that could be used for food production.

2<sup>nd</sup> generation bio fuel does not have the same disadvantages and can, compared to use of traditional diesel, reduce the emission of  $\text{CO}_2$ .

# GENERATORS AND BATTERIES

If the generator is to be used as an emergency backup generator, use of bio diesel can not be recommended. Bio diesel degrades faster than ordinary diesel and generators using bio diesel have less efficiency than generators operating on ordinary diesel. The environmental benefits from using bio diesel for such purpose will be close to zero.

If bio diesel is to be used as fuel it is mandatory that the generator is designed and specified for such use. Only motors with preheating chamber can normally be used.

It will generally be acceptable to add up to 5 % of bio diesel to standard diesel fuel, but again this must be confirmed by the generator supplier.

Generators designed for use with bio diesel can normally without any modifications be used for traditional diesel.

Generators running on petrol have higher emissions of CO<sub>2</sub> than systems running on diesel. Generators that operate on petrol, are mostly small transportable units.

## Noise

A diesel generator can generate high noise levels. The noise will have an impact on the personnel working close to the generator and on people living in the close neighbourhood. All generators should therefore be shielded by an effective noise reducing housing. Very effective shielding can be obtained if the generator also is placed inside a solid building. The shielding should always be so effective that personnel working close to the generator should not observe noise levels higher than 80 dB (A) (general recommended maximum noise level for workers health and safety). People living close to a generator should be protected from unnecessary noise, especially during evening and night time. Local noise regulations should always be observed.

## Decommissioning and disposal

Worn-out generators must be taken down and all parts must be disposed or reused in accordance with the recommendations from the supplier and with the local regulations. It is very important that a worn-out generator is not resold for uncontrolled use at another site as this may result in uncontrolled impact on the environment.

**Table 3.3 General recommendations for reducing environmental impacts from generators**

Issue	Recommendation
Generator effect	The generator must be operated at an effect where fuel consumption/KW is at a minimum. To make this possible the generator must be specified properly when ordering.
Sizing of generator	When ordering a generator it is very important to analyze the needed power, both in the present situation both also in the years to come as not to purchase a generator with insufficient power. Generators are rated according to ISO 8528 for different kinds of usage, continuous power, prime power, limited time running power and emergency standby power. All generators are rated for operation at normal air pressure at sea level. At higher altitudes air pressure is reduced and this will reduce the power of the generator. Other local conditions that may influence the performance of the generator is extreme heat, resulting in reduced cooling and hereby reduced output. Such special conditions must be specified to the potential supplier.  Attention must be paid to list all sources that may use power (machinery, heat generation, light, pumps, emergency

	equipment, etc.). It is important to remember that a generator has a very long lifetime (10-20 years) and that energy demand may increase during this period. Most generators are most effective at around 75 % load. This may also give an idea about sizing. Correct sizing of a generator must be done in close cooperation and dialog with the supplier. Many technical issues must be observed, for example voltage drop under start up of heavy motors. Suppliers have specific knowledge, experience and software for correct sizing.
Type of fuel	Use of 2 <sup>nd</sup> generation biodiesel can dramatically reduce the emission of the greenhouse gas CO <sub>2</sub> . Use of biodiesel is not relevant and not recommended for pure emergency systems.
Fuel delivery	Use fuel with easy access and which does not require separate delivery.
Combined heat and power	If the generator is delivered with a heat recovery system the generated heat can replace use of energy from other sources.
Flue gas cleaning option	Use of flue gas cleaning can reduce the emissions of harmful air pollution components.
Stack height	Stack must be at an appropriate height that flue gas components can be effectively dispersed.
Testing	Perform testing according to test procedure. Test only for the specified period.
Operation	Always operate the generator according to the recommendations from the supplier. Operators must have the necessary education and training. Sizing of generator is very important, correct size will mean maximum efficiency of generator.
Service and maintenance	Service and maintenance are very important as to have a generator to run efficiently and with least possible environmental impact when needed. Poorly maintained generators use up to 20% too much fuel, and may fail completely, leading to early replacement and additional cost. In areas with poor fuel quality, poor maintenance may reduce operating life by 80%.

### 3.2. Impacts from batteries

The environmental impacts of batteries are related to the various life cycle stages:

- Use of raw materials and transport of raw materials for producing the batteries
- Impacts from production of batteries
- Transport of batteries from production site to supplier and to site where used
- Service and maintenance (including transport)
- Disposal of used batteries

These stages can be further broken down. In each stage a number of different environmental impacts can be listed, including:

- Reduction in available raw materials
- Emission of greenhouse gas
- Ozone depletion
- Tropospheric ozone generation and photochemical smog
- Eutrofication and acidification of lakes
- Respiratory health effects on people

- Agricultural crop reduction
- Corrosion and degradation of buildings and of the cultural world treasures
- Pollution of soil and water

Studies have shown that there is no simple answer how to purchase “green” batteries with low environmental impact. A battery may have a low environmental impact by the way it is produced but may for example require a room with temperature control to ensure good performance during use. Small variations in the use of batteries can easily destroy a green designed battery. As batteries must be chosen with respect to their use it is not possible to give specific advice but rather provide general guidelines. It is therefore recommended as a first step to look for batteries that fit best into the environment where they are to be used.<sup>3</sup> As an example, use of batteries that can easily dry out should never be used in high temperature environment, unless regular and qualified service and maintenance is available.

Next step will be to handle and use the batteries with focus on reducing the environmental impact in a life cycle perspective.

**Table 3.4 General recommendations for reducing environmental impacts from batteries**

Issue	Recommendation
Correct battery for its use	Choosing the right battery may prolong lifetime and thus environmental impact from the production chain
Service and maintenance	Service and maintenance is very important as to have a battery system to run efficiently and with least possible replacement of batteries and related environmental impacts
Replacement	Only purchase batteries from a source that can ensure that used batteries can be returned for environmental friendly recycling. Alternatively replaced batteries must be recycled locally.

## 4. Key social considerations of generators and batteries

It is of high importance that the life cycle impact from use of generators and batteries has the least possible negative social effects. This can partly be controlled by purchasing from suppliers that can document compliance with one or more international standards that focus on social responsibility and by proper operation and service. For use and service of generators and batteries, it is very important that supplier instructions on safety are followed. Unauthorized disposal and reuse of machine parts, oil, batteries etc. represent in many areas an income source for local people. Such unauthorized systems must however be avoided, as they very often do not comply with good standards for health and environment.

The following chapters give an overview of international standards and conventions in relation to social considerations.

### 4.1. International labour standards

The International Labour Conference, which comprises tripartite delegations (from governments, employers and workers) of all ILO Member States, meets annually and adopts two types of international labour standards: Conventions, which are binding for Member States that ratify them, and Recommendations that often complete the Conventions and provide additional guidance. They are globally designated as international labour standards, which are the legal component of the ILO’s strategy for governing globalization, promoting

<sup>3</sup> Source: Recharge. [www.rechargebatteries.org/ECOLABELLING\\_PRB\\_August\\_2010\\_FL.pdf](http://www.rechargebatteries.org/ECOLABELLING_PRB_August_2010_FL.pdf)

sustainable development, eradicating poverty, and ensuring that women and men worldwide enjoy decent work. Today, international labour standards have grown into a comprehensive system of instruments concerning work and social policy and cover a broad range of subjects, from working conditions to employment policy, and from occupational safety and health to social security to take only a few examples. They are backed by a supervisory system designed to address all sorts of problems in their application at the national level.

Mention will be made here only of a Convention and a Recommendation that deal explicitly with the social dimension of public procurement, and of the eight so-called core ILO Conventions, covering the four categories of fundamental principles and rights at work to which extensive reference is made in other instruments such as the Global Compact or codes of conduct.<sup>4</sup>

### *Labour clauses in public contracts*

The Labour Clauses (Public Contracts) Convention (No. 94) and Recommendation (No. 84), 1949 respond specifically to the concerns around the potentially negative social impact of public procurement operations.<sup>5</sup> Convention No. 94 is about good governance, it addresses socially responsible public procurement by requiring bidders/contractors to align themselves with the locally established prevailing pay and other working conditions as determined by law or collective bargaining. Its aim is to remove wages and working conditions from the price competition necessarily involved in public tendering.

Convention No. 94 requires bidders to be informed in advance, by means of standard labour clauses included in tender documents, that, if selected, they would have to observe in the performance of the contract wages and other labour conditions not less favourable than the highest minimum standards established locally by law, arbitration or collective bargaining. The same rules apply to their subcontractors as well as to assignees of the public procurement contract. Bidders should prepare their offers accordingly.

The Convention proposes a common level playing field – in terms of labour standards – for all economic actors, and thus promotes fair competition and socially responsible procurement. Most importantly, the Convention enables contracting authorities to evaluate bids based on objective criteria, such as the efficiency of production methods, the quality of materials, or long-term benefits including technology transfer, which ultimately leads to cost-effective public procurement operations and contributes to sound economic development.

Convention No. 94 provides for two specific types of measures in cases where the labour clauses are not fully respected (without prejudice to other available remedies such as judicial proceedings): first, contracting authorities must take measures, such as the withholding of payment due under the contract, so that the workers concerned can receive the wages to which they are entitled; second, contracting authorities must provide for adequate sanctions, such as the withholding of contracts.

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<sup>4</sup> Additional information on international labour standards may be found at: [www.ilo.org/global/standards/lang--en/index.htm](http://www.ilo.org/global/standards/lang--en/index.htm). The full text of all ILO Conventions and Recommendations, as well as their status of ratification, can be found at: [www.ilo.org/ilolex/english/index.htm](http://www.ilo.org/ilolex/english/index.htm).

<sup>5</sup> For detailed information on the content of Convention No. 94 and Recommendation No. 84, as well as on national legislation and practice and the current trends in this area, see the General Survey on Labour clauses in public contracts prepared by the ILO Committee of Experts on Conventions and Recommendations, ILC, 97<sup>th</sup> session, Geneva, 2008, available at [www.ilo.org/ilc/ILCSessions/97thSession/reports/lang--en/docName--WCMS\\_091400/index.htm](http://www.ilo.org/ilc/ILCSessions/97thSession/reports/lang--en/docName--WCMS_091400/index.htm). In addition, the International Labour Office has published a practical guide on Convention No. 94, available at: [www.ilo.org/wcmsp5/groups/public/@ed\\_norm/@normes/documents/publication/wcms\\_099699.pdf](http://www.ilo.org/wcmsp5/groups/public/@ed_norm/@normes/documents/publication/wcms_099699.pdf).

*Conventions on fundamental rights at work*

The ILO Conference has also adopted eight core Conventions, almost universally ratified, on freedom of association, forced labour, equality in employment, and the elimination of child labour. A brief summary is presented below.<sup>6</sup> One of the major challenges is to monitor the implementation of these Conventions at each level of the global supply chain, including in the context of public procurement operations.

*Freedom of association and collective bargaining*

The *Freedom of Association and Protection of the Right to Organize Convention, 1948 (No. 87)* provides that workers and employers must have the right to establish and join organizations of their own choosing without previous authorization. Their respective organizations must be free to organize themselves and their activities without undue interference from the public authorities. They must also have the right to establish and join federations and confederations, which themselves must be free to affiliate with international organizations of workers and employers.

The *Right to Organize and Collective Bargaining Convention, 1949 (No. 98)* provides that workers must enjoy adequate protection against acts of anti-union discrimination, including requirements that a worker not join a union or relinquish trade union membership for employment, or dismissal of a worker because of union membership or participation in union activities. Workers' and employers' organizations must also enjoy adequate protection against any acts of interference by each other. Finally, measures appropriate to national conditions must be taken, where necessary, to encourage and promote collective bargaining.<sup>7</sup>

*Forced labour*

The *Forced Labour Convention, 1930 (No. 29)* prohibits the use of forced or compulsory labour in all its forms, defined as “all work or service which is exacted from any person under the menace of any penalty and for which the said person has not offered himself voluntarily.”

The *Abolition of Forced Labour Convention, 1957 (No. 105)* prohibits forced or compulsory labour as a means of political coercion or education or as a punishment for holding or expressing political views or views ideologically opposed to the established political, social or economic system; as a method of mobilizing and using labour for purposes of economic development; as a means of labour discipline; as a punishment for having participated in strikes; and as a means of racial, social, national or religious discrimination.<sup>8</sup>

*Equality in employment*

The *Equal Remuneration Convention, 1951 (No. 100)* requires Member States that ratify it to promote the application to all workers of the principle of equal remuneration for men and women workers for work of equal value, and to ensure its application where the State is

<sup>6</sup> For a more detailed presentation, see ILO, *Fundamental rights at work and international labour standards*, Geneva, 2003.

<sup>7</sup> To date, Convention Nos. 87 and 98 have been ratified by 150 and 160 States respectively. For more information, see the General Survey on freedom of association and collective bargaining, ILC, 81<sup>st</sup> session, 1994 : [www.ilo.org/public/libdoc/ilo/P/09661/09661\(1994-81-4B\).pdf](http://www.ilo.org/public/libdoc/ilo/P/09661/09661(1994-81-4B).pdf). See also the Digest of decisions and principles of the Committee on Freedom of Association, 5th (revised) edition, 2006: [www.ilo.org/wcmsp5/groups/public/@ed\\_norm/@normes/documents/publication/wcms\\_090632.pdf](http://www.ilo.org/wcmsp5/groups/public/@ed_norm/@normes/documents/publication/wcms_090632.pdf).

<sup>8</sup> To date, Convention Nos. 29 and 105 are ratified by 174 and 169 States respectively. For more information on the application of these Conventions, see the General Survey on forced labour, ILC, 96<sup>th</sup> session, 2007: [www.ilo.org/wcmsp5/groups/public/@ed\\_norm/@relconf/documents/meetingdocument/wcms\\_089199.pdf](http://www.ilo.org/wcmsp5/groups/public/@ed_norm/@relconf/documents/meetingdocument/wcms_089199.pdf). See also ILO, *Combating forced labour : a handbook for employers and business*, 2008, available at: [www.ilo.org/sapfl/Informationresources/ILOPublications/lang--en/docName--WCMS\\_101171/index.htm](http://www.ilo.org/sapfl/Informationresources/ILOPublications/lang--en/docName--WCMS_101171/index.htm).

involved in wage fixing. The Equal Remuneration Recommendation, 1951 (No. 90), which complements Convention No. 100, makes express reference to the desirability of ensuring application of the principle of equal remuneration for men and women workers for work of equal value for work executed under the terms of public contracts.

The *Discrimination (Employment and Occupation) Convention*, 1958 (No. 111) requires ratifying States to declare and pursue a national policy designed to promote, by methods appropriate to national conditions and practice, equality of opportunity and treatment in respect of employment and occupation, with a view to eliminating any discrimination in these fields. Discrimination is defined as any distinction, exclusion or preference made on the basis of race, colour, sex, religion, political opinion, national extraction or social origin, which has the effect of nullifying or impairing equality of opportunity or treatment in employment or occupation. The *Discrimination (Employment and Occupation) Recommendation*, 1958 (No. 111), which complements Convention No. 111, provides that eligibility for contracts involving the expenditure of public funds should be made dependent on observance of the principles of non-discrimination.<sup>9</sup>

### Child labour

The *Minimum Age Convention*, 1973 (No. 138) provides that the general minimum age for admission to work or employment must not be less than the age of completion of compulsory schooling and, in any case, must not be less than 15 years. Where the economy and educational facilities are insufficiently developed, the minimum age can be initially set at 14 years. The minimum age for hazardous work is set at 18 (16 under certain strict conditions). For light work, the minimum age is 13 years (12 years if the general minimum age is set at 14 years).

The *Worst Forms of Child Labour Convention*, 1999 (No. 182) requires ratifying States to take immediate and effective measures to secure the prohibition and elimination of the worst forms of child labour as a matter of urgency. “Child” is defined as a person under 18 years of age. The worst forms of child labour include all forms of slavery or practices similar to slavery (such as the sale and trafficking of children, debt bondage and serfdom and forced or compulsory labour, including forced or compulsory recruitment of children for use in armed conflict); child prostitution and pornography; using children for illicit activities, in particular for the production and trafficking of drugs; and work which is likely to harm the health, safety or morals of children.<sup>10</sup>

### **Other relevant ILO instruments**

The *ILO Declaration on Fundamental Principles and Rights at Work*<sup>11</sup>, adopted in 1998, proclaims that all Member States, even if they have not ratified the eight core Conventions mentioned above, have an obligation arising from the very fact of membership in the Organization to respect, to promote and to realize, in good faith, the principles concerning the four corresponding categories of fundamental rights, namely:

- freedom of association and the effective recognition of the right to collective bargaining;
- the elimination of all forms of forced or compulsory labour;
- the effective abolition of child labour; and
- the elimination of discrimination in respect of employment and occupation.

The Declaration makes it clear that these rights are universal and must be respected in all

<sup>9</sup> To date, Conventions Nos. 100 and 111 have been ratified by 168 and 169 States respectively.

<sup>10</sup> To date, Conventions Nos. 138 and 182 have been ratified by 157 and 173 States respectively.

<sup>11</sup> For additional information on the 1998 Declaration, including its full text, see [www.ilo.org/declaration/lang--en/index.htm](http://www.ilo.org/declaration/lang--en/index.htm).

States, regardless of their level of economic development. It stresses however that labour standards should not be used for protectionist trade purposes.

The *ILO Tripartite Declaration of principles concerning multinational enterprises and social policy*<sup>12</sup>, adopted in 1977 and last amended in 2006, recognizes that multinational enterprises play an important part in the economies of most countries and in international economic relations. Its aim is to encourage the positive contribution which multinational enterprises can make to economic and social progress and to minimize and resolve the difficulties to which their various operations may give rise. The Declaration sets out principles in the fields of employment, training, conditions of work and life and industrial relations which governments of host and home countries, employers' and workers' organizations and multinational enterprises are recommended to observe on a voluntary basis. Its provisions do not affect obligations arising out of ratification of ILO Conventions. It provides inter alia that all parties concerned should contribute to the realization of the ILO Declaration on Fundamental Principles and Rights and Work of 1998.

## 4.2. Other international instruments

### *UN Global Compact*

The UN Global Compact<sup>13</sup> is an initiative launched in 1999 by the Secretary-General of the United Nations during the World Economic Forum meeting at Davos. It is both a policy platform and a practical framework offered to businesses for the development, implementation, and disclosure of sustainability policies and practices around 10 principles in the areas of human rights, labour, environment and anti-corruption. It is not a regulatory instrument but rather a voluntary initiative to which companies around the world are invited to participate through a formal commitment to support the Global Compact and its principles. The four principles related to labour issues are derived from the ILO Declaration on Fundamental Principles and Rights and Work of 1998.

The Global Compact asks companies to embrace, support and enact, within their sphere of influence, a set of core values in the areas of human rights, labour standards, environment, and anti-corruption. Businesses must respect (even if it is not a regulatory instrument) the following 10 principles:

- Support and respect the protection of internationally proclaimed human rights;
- Ensure that they are not accomplices in human rights abuses;
- Protect the freedom of association and the effective recognition of the right to collective bargaining;
- Elimination of all forms of forced and compulsory labour;
- Abolition of child labour;
- Discrimination-free employment and occupation;
- Support a precautionary approach to environmental challenges;
- Undertake initiatives to promote environmental responsibility;
- Encourage the development and diffusion of environmentally friendly technologies;
- Fight against corruption in all its forms, including extortion and bribery.

Global Compact membership is still limited among UN suppliers in developing countries, with

<sup>12</sup> The text of the 1977 Declaration is available at: [www.ilo.org/empent/Whatwedo/Publications/lang--en/docName--WCMS\\_094386/index.htm](http://www.ilo.org/empent/Whatwedo/Publications/lang--en/docName--WCMS_094386/index.htm).

In addition, the ILO has established a Helpdesk for Business that provides free and confidential assistance service and is available for company managers and workers, as well as government agencies, employers' and workers' organizations and other interested organizations. The Helpdesk can be contacted at :

<sup>13</sup> [www.ilo.org/empent/Areasofwork/business-helpdesk/lang--en/index.htm](http://www.ilo.org/empent/Areasofwork/business-helpdesk/lang--en/index.htm).  
[www.unglobalcompact.org/](http://www.unglobalcompact.org/)

the large majority of orders from the UN placed with Global Compact members located in developed countries and especially in Europe. UN procurement from Global Compact members as a percentage of orders of USD 30,000 or more increased from 12.32 % in 2006 to 14.15 % in 2008.<sup>14</sup>

### *UN Supplier Code of Conduct*

The UN Code of Conduct<sup>15</sup> provides the minimum standards expected of suppliers to the UN. It is the expectation of the UN that suppliers adhere to all laws, rules and regulations, and strive to exceed both international and industry best practices. The Code of Conduct has been developed with recognition of the importance of the ILO Core Labor conventions and the ten principles of the UN Global Compact, and is viewed as an important means of integrating the Compact's principles into the operations of the UN.

The UN recognizes that reaching the standards established in this Code of Conduct is a dynamic rather than static process and encourages suppliers to continually improve their workplace conditions.

While a number of UN organizations have adopted the UN Supplier Code of Conduct (SCC), others, like ILO, are still to adopt a Code of Conduct. ILO intends to publish such a Code that will contain some provisions which differ from those of the UN SCC, particularly with respect to labour issues.

### *The OECD Guidelines for multinational enterprises*

The OECD Guidelines for multinational enterprises<sup>16</sup> pursue the same goal at the ILO Tripartite Declaration of 1977. They contain recommendations addressed to multinational enterprises operating in or from adhering countries (the 34 OECD countries plus 8 non-OECD countries: Argentina, Brazil, Egypt, Latvia, Lithuania, Morocco, Peru and Romania). These recommendations are directly addressed to multinational enterprises and not to workers' and employers' organizations, since the OECD is not a tripartite organization like the ILO. The recommendations on employment and industrial relations make reference in concise terms to freedom of association, the abolition of child labour and forced or compulsory labour, as well as non-discrimination with respect to employment or occupation. The commentaries that accompany these guidelines recognize that the ILO is the competent body to set and deal with international labour standards, and to promote fundamental rights at work as recognized in its 1998 Declaration on Fundamental Principles and Rights at Work. They stress that the provisions of the guidelines on employment and industrial relations echo relevant provisions of the 1998 Declaration, as well as the 1977 Tripartite Declaration.

### *Other Codes of Conduct*

In addition to the above-mentioned instruments that were adopted under the auspices of intergovernmental organizations, a number of codes of conduct were developed, either at the sectoral level or at a broader scale. Some of them are relevant for the social dimension of public procurement.

The NGO Social Accountability International (SAI)<sup>17</sup> developed the *SA8000 standard* that makes express reference to a number of ILO Conventions, including the eight core Conventions. Nonetheless, the ILO is not linked in any manner to the development and supervision of the implementation of the SA8000 standard. A voluntary certification procedure for companies has also been put in place.

<sup>14</sup> 2008 Annual Statistical Report on United Nations Procurement, UNOPS

<sup>15</sup> [www.un.org/depts/ptd/pdf/conduct\\_english.pdf](http://www.un.org/depts/ptd/pdf/conduct_english.pdf)

<sup>16</sup> [www.oecd.org/dataoecd/56/36/1922428.pdf](http://www.oecd.org/dataoecd/56/36/1922428.pdf)

<sup>17</sup> [www.sa-intl.org/](http://www.sa-intl.org/)

In September 2010, the International Organization for Standardization (ISO) adopted the *International Standard ISO 26000:2010, Guidance on social responsibility*. *Contrary to other standards developed by the ISO, this standard cannot be used for certification purposes*. It is more comprehensive than the SA 8000 standard and provides guidance for organizations that voluntarily want to strengthen their social responsibility regarding in particular human rights (including fundamental rights at work) and working conditions. A Memorandum of Understanding was concluded between the ISO and the ILO to ensure consistency of the new standard with ILO standards.

## 5. Legislation impacting the procurement of generators and batteries

### 5.1. Emission standards for generators

Many countries regulate emissions from generators. This is done by specifying maximum allowable concentrations of certain pollutants in the flue gas. The limit values depend typically on the size of the generator. Most stringent limits are usually given for large power units.

The purpose of emissions standards is to ensure that operation of certain equipment does not contribute unnecessarily to emission of harmful substances to the environment.

There is today understanding that standards are necessary to reduce air pollution especially in areas where the pollution is already high.

The most stringent rules are those of the United States Environmental Protection Agency (EPA) and those governed by EU directives. Industrial organizations emphasize the need for harmonized standards worldwide and regulations are tending in that direction. The regulations from US EPA and EU are coordinated. Other countries have adopted similar systems or have made modified standards for emission control, for example China, India, Japan, Korea, Turkey, Canada and Chile.

#### *Regulations in the United States*

Emission of air pollutants from diesel generators is in The United States regulated by Environmental Protection Agency "Control of Emissions of Air Pollution From Non-road Diesel Engines and Fuel"

The USA EPA rules distinguish between stationary units, stationary standby units and emergency standby generators. Emergency standby generators are defined as generators not used more than 100 hours per year for testing purposes. Units are to be labelled for emergency use only.

When the US rules are fully implemented the emissions of NO<sub>x</sub> and particles will be reduced by up 90% in the United States. The EPA has estimated that the reduction in the emission of NO<sub>x</sub> and particles by 2030 would annually prevent 12,000 premature deaths, 8,900 hospitalizations, and one million work days lost. Such figures show that on a global plan there is a great potential in focusing on the use of generators with reduced emission of harmful substances.

Detailed information on the regulation and background information can be found on US EPA Clean Air Act information page on Non-road Diesel Equipment.<sup>18</sup>

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<sup>18</sup> [www.epa.gov/nonroaddiesel/2004fr.htm](http://www.epa.gov/nonroaddiesel/2004fr.htm)

*Regulations in Europe*

The EU does not regulate emissions from stationary emergency generators that are only used a few hours each year. The European regulation deals with engines to be installed in non-road mobile machinery. The regulations set limit values for emission of harmful pollutants for generators between 19 and 560 KW.

In Europe, emissions from generators are regulated before they are placed on the market by four directives from the European Commission:

- DIRECTIVE 97/68/EC OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 16 December 1997 on the approximation of the laws of the Member States relating to measures against the emission of gaseous and particulate pollutants from internal combustion engines to be installed in non-road mobile machinery.<sup>19</sup>
- DIRECTIVE 2002/88/EC OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 9 December 2002 amending Directive 97/68/EC on the approximation of the laws of the Member States relating to measures against the emission of gaseous and particulate pollutants from internal combustion engines to be installed in non-road mobile machinery<sup>20</sup>
- DIRECTIVE 2004/ 26/EC OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 21 April 2004 amending Directive 97/68/EC on the approximation of the laws of the Member States relating to measures against the emission of gaseous and particulate pollutants from internal combustion engines to be installed in non-road mobile machinery<sup>21</sup>
- COUNCIL DIRECTIVE 2006/105/EC of 20 November 2006 adapting Directives 73/239/EEC, 74/557/EEC and 2002/83/EC in the field of environment, by reason of the accession of Bulgaria and Romania<sup>22</sup>

Detailed information on the EU regulation for generators is available at the European commission webpage for Directives on emissions from non-road mobile machinery.<sup>23</sup>

**5.2. Ambient air quality standards**

The purpose of the ambient air quality standards is to protect against harmful effects on human health and vegetation and ecosystems.

World Health Organisation (WHO) has set guideline concentrations for the most common air pollutants. The latest update on risk assessment is from 2005:

- WHO Air quality guidelines for particulate matter, ozone, nitrogen dioxide and sulphur dioxide<sup>24</sup>

In the United States, the EPA has set national ambient air quality standards for six principal pollutants:

<sup>19</sup> <http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:1998:059:0001:0085:en:PDF>

<sup>20</sup> <http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2003:035:0028:0081:EN:PDF>

<sup>21</sup> <http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2004:146:0001:0107:en:PDF>

<sup>22</sup> [http://eur-lex.europa.eu/LexUriServ/site/en/oj/2006/l\\_363/l\\_36320061220en03680408.pdf](http://eur-lex.europa.eu/LexUriServ/site/en/oj/2006/l_363/l_36320061220en03680408.pdf)

<sup>23</sup> [http://ec.europa.eu/enterprise/sectors/mechanical/documents/legislation/emissions-non-road/index\\_en.htm](http://ec.europa.eu/enterprise/sectors/mechanical/documents/legislation/emissions-non-road/index_en.htm)

<sup>24</sup> [http://whqlibdoc.who.int/hq/2006/WHO\\_SDE\\_PHE\\_OEH\\_06.02\\_eng.pdf](http://whqlibdoc.who.int/hq/2006/WHO_SDE_PHE_OEH_06.02_eng.pdf)

- Carbon Monoxide (CO)
- Lead (Pb)
- Nitrogen Dioxide (NO<sub>2</sub>)
- Ozone (O<sub>3</sub>)
- Particulate Matter (PM)
- Sulphur Dioxide (SO<sub>2</sub>)

Detailed information and links to regulations and implementation can be found at the EPA website<sup>25</sup>

In Europe ambient air quality is regulated by two directives:

- Directive 2008/50/EC of the European Parliament and of the Council of 21 May 2008 on ambient air quality and cleaner air for Europe.<sup>26</sup>
- DIRECTIVE 2004/107/EC OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 15 December 2004 relating to arsenic, cadmium, mercury, nickel and polycyclic aromatic hydrocarbons in ambient air.<sup>27</sup>

An overview of standards can be seen at the EC website.<sup>28</sup>

Most countries with major industry have today adopted or implemented standards for ambient air quality, many following the values given by WHO, EPA, EU. Examples of such countries are Japan, China, and India. Most countries only list standards for the most common pollutants, primarily pollutants originating from energy production and automobiles.

Ambient air quality standards are set as concentration values, typically in µg/m<sup>3</sup> (microgram = 10<sup>-6</sup> gram) in combination with a given average time and percentile in % or as a maximum number of hours per year where the limit value can be exceeded. This is common for substances with short time effects or acute effects. Limit values can also be given as annual average values. This is common for substances that have long time accumulation effects. A number of substances have both short time effects and long time effects and different limit values are thus often seen for a specific air pollution component.

One of the most important air pollution components originating from use of generators and other energy producing units is nitrogen dioxide (NO<sub>2</sub>). The EU and EPA ambient air quality limit value for NO<sub>2</sub> is 200 µg/m<sup>3</sup>, defined as a 1 hour value that must not be exceeded more than 18 times a year. This is equivalent to 0.2 % of the year or a 99.8 % percentile.

### 5.3. Immission contribution standards

The purpose of the immission contribution standards is to ensure that ambient air quality limit value in surroundings of an emission source are not exceeded. For components where ambient air quality standards do not exist it is the purpose to ensure that the concentration of a specific component is sufficiently low not to have negative effects on people living in the neighbourhood. Many countries have specified immission contribution values for a large number of pollutants including for odour.

Immission contribution values are normally set to around 25-50 % of the corresponding ambient air quality limit values. The reason for this is to have room for background concentration and contribution from other sources and activities in the neighbourhood.

<sup>25</sup> [www.epa.gov/ttn/naaqs/](http://www.epa.gov/ttn/naaqs/)

<sup>26</sup> <http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2008:152:0001:0044:EN:PDF>

<sup>27</sup> <http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2005:023:0003:0016:EN:PDF>

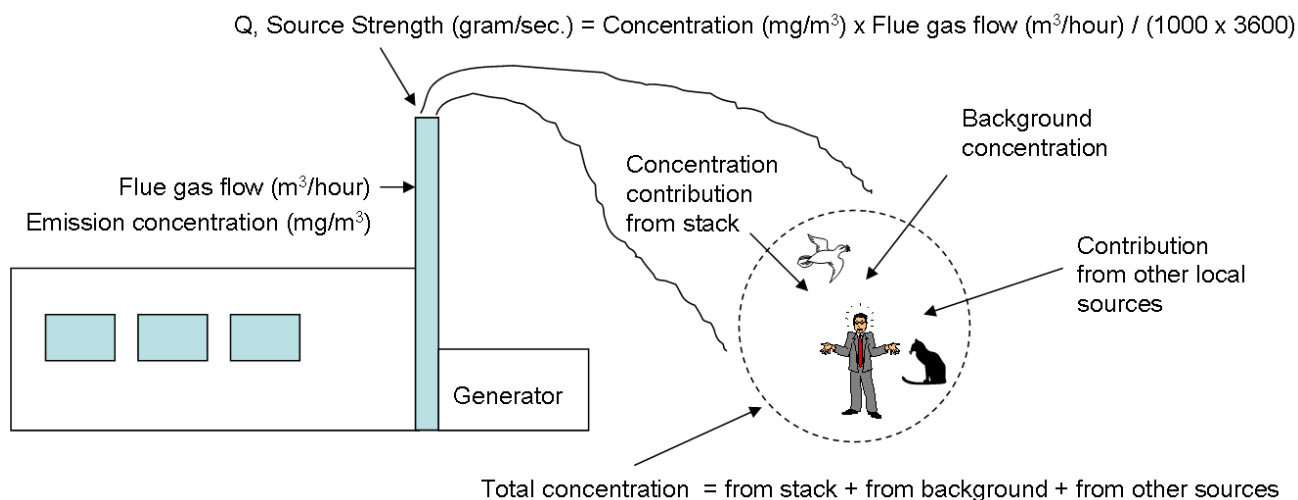
<sup>28</sup> <http://ec.europa.eu/environment/air/quality/standards.htm>

In most countries regulation of industrial activities and sources includes regulation of:

- Emission control of the specific source (process, engine, etc.)
- Immission control to control ambient air quality

Fig 5.1 illustrates how the regulation takes place.

**Figure 5.1 Regulation of air pollution emission, immission and ambient air quality**



Explanation to fig. 5.1:

National regulations set limit values for the concentration of harmful components in the flue gas expressed as  $\text{mg/m}^3$ . The Q-value – the source strength is expressed in quantity/time units, often in gram/second. The immission contribution from the stack depends on the Q-value, the stack height, topographical and meteorological conditions and on the distance from the stack. The total concentration at a given point in the surroundings is the sum of the three concentrations; the contribution from stack, the background concentration and pollutants from other local sources. The total sum must be less than the ambient air quality limit value for the given component. This is ensured by having the necessary stack height. The necessary stack height can be estimated by use of different calculation tools. See section 5.4.

Generators emit both particles and gases. It is a general experience that nitrogen oxides ( $\text{NO}_x$ ) is the most critical component.

One of the first countries to set immission contribution values for industrial pollutants was Germany by the Standard TA Luft.<sup>29</sup> The immission contribution limit value (German: S-werte) for  $\text{NO}_2$  is  $0.1 \text{ mg/m}^3 = 100 \text{ }\mu\text{g/m}^3$ , a value that is 50 % of the European ambient air quality limit. It is important to notice that the limit value is for component  $\text{NO}_2$ , and not for  $\text{NO}_x$ . It is only the  $\text{NO}_2$  part of the total  $\text{NO}_x$  that is toxic for humans. It is a general acceptance that only 50 % of  $\text{NO}_x$  will be present as  $\text{NO}_2$  where the plume from a stack reaches the ground.

Use of immission contribution values is not yet common in all countries but may be expected to become more frequently used in the future as enforcement of the ambient air quality standards becomes necessary to comply with the limit values.

<sup>29</sup> [www.bmu.de/files/pdfs/allgemein/application/pdf/taluft\\_engl.pdf](http://www.bmu.de/files/pdfs/allgemein/application/pdf/taluft_engl.pdf)

#### 5.4. Stack height for generators

The purpose of a stack is to disperse the pollutants to ensure compliance with the immission contribution limits. Many methods exist, some based on empirical formulas, others on nomograms and others again on use of advanced computerized meteorological dispersion modelling.

The German TA Luft contains nomograms to estimate necessary stack height to comply with the immission contribution values.

A freeware tool for estimation the necessary stack height is ALOHA, which can be downloaded from the EPA website.<sup>30</sup> As with other tools, ALOHA should not be used without the necessary background knowledge on air pollution and use of dispersion modelling.

Another program is AIRMOD from EPA. Information for EPA on AIRMOD and other models can be found at EPA's website.<sup>31</sup>

It is not possible without a detailed dispersion calculation to specify the necessary stack height. For very large emission sources it is recommended that calculation of stack height is based on local meteorological conditions.

The following general recommendations can however be given.

The minimum stack height must be at least 1 meter higher than the heights of building(s) where the generator is placed. If the stack is lower than this value free dispersion will not be possible and use of even small generators can result in unacceptable concentrations in the nearby surroundings.

For medium to large generators it will be necessary to have higher stacks.

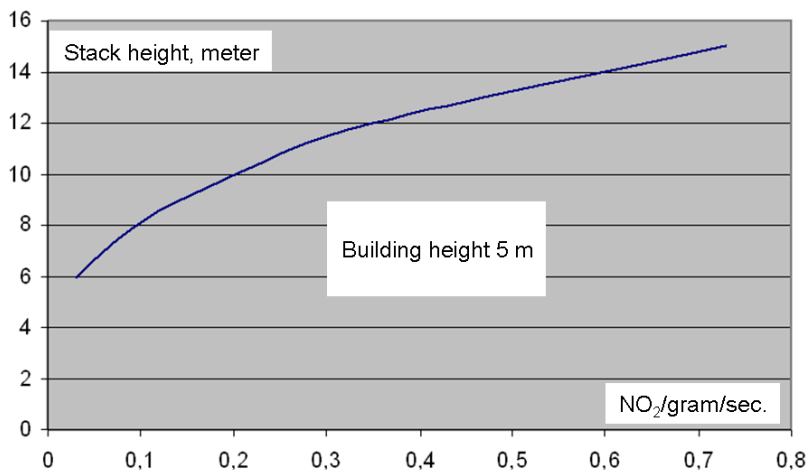
The following method can be used to obtain an indication of the necessary stack height:

1. Find the specific NO<sub>x</sub> emission for the generator in gram NO<sub>x</sub>/kWh. Values vary typically between 10 g NO<sub>x</sub>/kWh and 0.4 g NO<sub>x</sub>/kWh.
2. Calculate the NO<sub>x</sub> emission in gram/sec for the generator as follows: (Specific NO<sub>x</sub> emission) x (Effect in kW) / 3600. Example: Specific NO<sub>x</sub> emission = 5 g/kWh. Generator effect: 400 kW. NO<sub>x</sub> emission = 5 x 400 / 3600 = 0.56 g/sec.
3. Calculate the NO<sub>2</sub> part of the emission as follows: NO<sub>2</sub> part = 0.5 x NO<sub>x</sub> emission. = 0.5 x 0.56 = 0.28 g NO<sub>2</sub>/sec. Use figure 5.6.1 to achieve an idea of the necessary stack height.

<sup>30</sup> [www.epa.gov/oem/content/cameo/aloha.htm](http://www.epa.gov/oem/content/cameo/aloha.htm)

<sup>31</sup> [www.epa.gov/scram001/dispersion\\_prefrec.htm#aermod](http://www.epa.gov/scram001/dispersion_prefrec.htm#aermod).

**Figure 5.4.1. Typical correlation between emission from a generator and stack height. NO<sub>2</sub> is given as 50 % of NO<sub>x</sub>. Immission contribution value is 100 µg/m<sup>3</sup>, 99.8 % percentile.**



It must be noticed that fig. 5.4.1 not can be used for determining the stack height in an actual case. Official and authority approved methods must here be applied.

### 5.5. Environmental permits

In many countries it will be required to submit an environmental application and to have an environmental permit before installation and operation of a generator can take place. The rules vary from country to country. Some countries only require permits for very large facilities, other countries for even very small units. Information on local rules will normally be given from the local municipality, county or the national Environmental Protection Agency.

### 5.6. Chemicals and harmful substances

Manny batteries contain harmful substances. If disposed in nature they can be a potential source for soil and groundwater pollution and affect flora and fauna. Countries over the world have established rules and regulations on environmentally controlled recycling of batteries.

In The United States rules are different from state to state. More information can be found at Call2recycle.<sup>32</sup>

The European Union has a directive that specifies rules for handling and disposal of batteries.

- DIRECTIVE 2006/66/EC OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 6 September 2006 on batteries and accumulators and waste batteries and accumulators and repealing Directive 91/157/EEC.<sup>33</sup>

Generally, there will exist local rules and regulations to control the disposal of batteries.

<sup>32</sup> [www.call2recycle.org/laws.php?c=1&d=79&e=104&w=2&r=Y](http://www.call2recycle.org/laws.php?c=1&d=79&e=104&w=2&r=Y)

<sup>33</sup> <http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2006:266:0001:0014:EN:PDF>

## 6. Future technology

### 6.1. The future generator market

Generators will in the future become more and more effective as motor and generator technology improves. Generators will also become more environmentally friendly and emit less particles and toxic gases. To be in compliance with the new EU and EPA emission limits it will however be necessary to introduce flue gas cleaning for particles and NO<sub>x</sub>. A great deal of development is currently taking place to improve filters and systems for reduction of NO<sub>x</sub> emissions among catalyst based systems. Use of catalyst will require high quality fuel with very low sulphur content. Many flue gas cleaning systems will require use of additional chemicals (for example ammonia). By adding extra systems the generator set will be more complex and also require increased expertise to operate and to maintain. It can be expected that the future generator set will be an advanced unit that must be used and serviced as such. Information on future flue gas cleaning can be found at Dieselforum.<sup>34</sup>

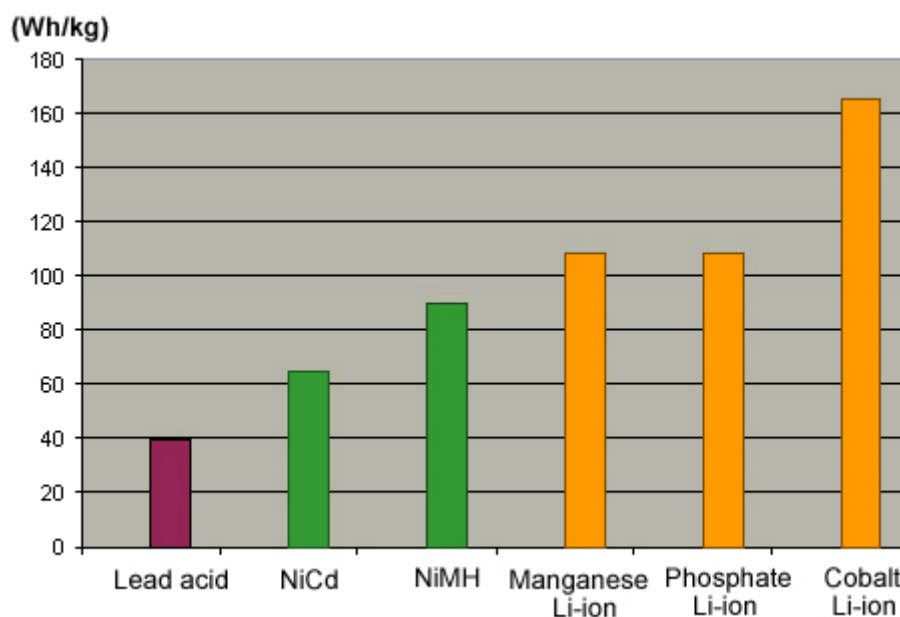
At the same time, ongoing development in the effectiveness, availability and cost of non-diesel based systems are also expected to improve. Increases in the cost of diesel fuel and expected continued declines in the cost of non-fossil fuel based generation (wind, solar etc) denote that a diesel generator should always be considered in competition with these other forms, which are expected to become more common over time.

### 6.2. The future battery market

A great of development is currently taking place in this market. The future trend is toward increasingly advanced batteries particularly the development on LI-batteries.

This development is illustrated by figure 6.3.1

Figure 6.3.1 Development of Li-batteries (Source: Battery University<sup>35</sup>)



Other batteries that are undergoing extensive research and development are the fuel cell and

<sup>34</sup> [www.dieselforum.org/uses/power-generation/news-center/pdfs/F-1464-CleanDieselGensets-Cummins.pdf](http://www.dieselforum.org/uses/power-generation/news-center/pdfs/F-1464-CleanDieselGensets-Cummins.pdf)

<sup>35</sup> [http://batteryuniversity.com/learn/article/the\\_high\\_power\\_lithium\\_ion](http://batteryuniversity.com/learn/article/the_high_power_lithium_ion)

the super capacitor cell.

A fuel cell is an electrochemical cell that converts energy from a fuel into electrical energy. Electricity is generated from the reaction between a fuel supply and an oxidizing agent, for example oxygen in the air. Fuel cells can be operated on fuel such as natural gas or hydrogen. Fuel cells can operate continuously as long as the necessary reactant and oxidant flows are maintained.

A fuel cell will be able to replace diesel generators, but will not be able to replace a backup battery system in combination with a UPS. The reason being that the fuel cell will not operate before fuel is added and thus has a certain start-up time.<sup>36</sup>

A super capacitor is an advanced capacitor that stores energy in a static state. The super capacitor resembles a regular capacitor with the exception that it offers very high capacitance in a small package. Super capacitors are expensive in terms of cost per watt.

Advantages:

- Near unlimited cycle life
- Low impedance
- Rapid charging
- Simple charge
- No danger of overcharge.

Limitations:

- Linear discharge voltage
- Low energy density compared to electrochemical cells
- Low voltages
- High self-discharge

More information on super capacitors can be found at [batteryuniversity.com](http://batteryuniversity.com).<sup>37</sup>

There is no doubt that the future market will come to include increasingly advanced batteries that also may be very useful for back up use and emergency use. New, non proven battery systems, should however not be used for such purposes as reliability is of higher importance than advanced technical parameters.

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<sup>36</sup> More information on fuel cells can be found at [http://en.wikipedia.org/wiki/Fuel\\_cell](http://en.wikipedia.org/wiki/Fuel_cell)

<sup>37</sup> [http://batteryuniversity.com/learn/article/whats\\_the\\_role\\_of\\_the\\_supercapacitor](http://batteryuniversity.com/learn/article/whats_the_role_of_the_supercapacitor)

## 7. Studies and Information sources

Information on air- and water cooled generators:

<http://www.idieselgenerators.com/difference-between-air-cooled-water-cooled-diesel-generators/>

Emission control for diesel generators:

<http://www.dieselforum.org/uses/power-generation/news-center/pdfs/F-1464-CleanDieselGensets-Cummins.pdf>

The battery university

<http://batteryuniversity.com/parttwo-54.htm>

Batteries in the future:

<http://www.icis.com/Articles/2008/07/14/9139058/what-does-the-future-hold-for-battery-technology.html>

Supercapacitors:

[http://batteryuniversity.com/learn/article/whats\\_the\\_role\\_of\\_the\\_supercapacitor](http://batteryuniversity.com/learn/article/whats_the_role_of_the_supercapacitor)

The modern Li-ion battery:

[http://batteryuniversity.com/learn/article/the\\_high\\_power\\_lithium\\_ion](http://batteryuniversity.com/learn/article/the_high_power_lithium_ion)

## **Annex 1. Description of rechargeable batteries**

There are a number of different batteries on the market today. Batteries can be produced based on different electrochemical systems. Within each of these systems batteries can be constructed for different purposes.

Batteries for use in large power backup systems are normally based on two different electrochemical systems:

Lead-acid battery

NiCd battery

The Lead-acid battery is the oldest technology and is based on a system with two lead electrodes and an electrolyte with sulphuric acid. The batteries can be constructed as open system or as gel-systems where the electrolyte is dissolved in a gel. In the open system water will evaporate and hydrogen and oxygen will be emitted from the battery. Open lead-acid batteries require regular service and maintenance. The higher the temperature is, the more often it will be necessary to refill the batteries.

Lead-acid batteries can also be made with controlled valve systems that only open up to reduce internal high pressure. Such systems cannot be refilled. Service will not be necessary/possible but lifetime will be less than for well serviced open systems. Good ventilation is mandatory to prevent accidents for open battery systems due to release of hydrogen.

The gel based system has the same advantage and disadvantage as the valve controlled systems. One benefit with the gel systems is that they will not leak if damaged.

NiCd batteries are based on the two metals Ni and Cd and an alkaline electrolyte. NiCd batteries have very long life time but cannot be discharged and recharged as many times as Lead-acid batteries and are sensitive and loose capacity if not discharged properly before recharging.

NiCd batteries are best used for purposes where they never or seldom are to be used for backup.

If batteries are to be used for numerous discharging and recharging cycles the best solution is a so called traction battery, a battery designed for multiple numbers of cycling's, for example for use in trucks. Such batteries are normally constructed as Pb-acid or as Pb-gel batteries.

Gel batteries cannot deliver the same current as standard Pb-acid batteries, but do not require the same amount of service.

There are other kinds of batteries on the market, for example Ni-metal and Li-ion types. However, there is no long period experience with such batteries for large power backup purposes.

Within recent years a new version of the traditional Lead-acid battery has come on to the market, this battery is constructed with a venting system that together with a catalyst recombines hydrogen and oxygen to water and leads it back to the battery. This system reduces the required service element for traditional lead-acid battery and may be an attractive solution for systems that can benefit from the performance of the traditional Lead-acid battery. The Pb-gel battery can also be constructed with a recombination system.

AGM (Absorbed glass mat) batteries are Pb-acid based batteries with a special internal construction in the electrode system to enhance high current performance. AGM batteries do not leak if damaged. AGM batteries are expensive compared to traditional Pb-acid batteries

and have a lower lifetime.

Table 7.3.1 gives an overview of the different battery types used for large power backup systems.

**Table 7.3.1 Typical performance parameters for different types of batteries**

Parameter	Pb-acid open	Pb-acid valve	Pb-acid Recomb.	Pb-gel	NiCd	AGM
Cell voltage	2	2	2	2	1,2	2
Number of recycles in lifetime	1000	1000	1000	100	500	500
Deep discharge capability	Yes	Yes	Yes	No	Yes	No
Maximum temperature, °C	40 (1)	40	40	25	40	40
Minimum temperature °C	-20	-20	-20	-10	-10	-10
Service required (water refilling)	Yes	No (2)	No	No (2)	Yes	No
High dry out risk	No	No	No	Yes	No	No
Reliability	High	High	High	Medium	Good	High
Leakage of chemical if damaged	Yes	Yes	Yes	No	Yes	No
Requires ventilated room	Yes	Yes	No	(Yes)	No	No
High current output	Yes	Yes	Yes	No	Yes	Yes
Lifetime, years (maximum) (3)	<12	<12	<12	<12	>12	<10

(1): High temperature will require regular service and water refilling

(2): Not possible

(3): Depends on construction and use

# GENERATORS AND BATTERIES

The following table provides a description of batteries for use in emergency backup systems or as power supply for remote location operations.

<b>Lead-acid battery</b>	
<b>Cell voltage</b>	2 Volts.
<b>Construction</b>	Lead-acid batteries are composed of a Lead-dioxide cathode, a sponge metallic Lead anode and a Sulphuric acid solution electrolyte.
<b>Applications</b>	<ul style="list-style-type: none"> <li>• Automotive and traction applications</li> <li>• Standby/Back-up/Emergency power for electrical installations</li> <li>• Submarines</li> <li>• UPS (Uninterruptible Power Supplies)</li> <li>• Lighting</li> <li>• High current drain applications</li> <li>• Sealed battery types available for use in portable equipment</li> </ul>
<b>Advantage</b>	<ul style="list-style-type: none"> <li>• Low cost</li> <li>• Reliable and robust</li> <li>• Tolerant to overcharging</li> <li>• Low internal impedance, high current</li> <li>• Wide range of sizes and capacities available</li> <li>• Many suppliers world wide</li> <li>• The world's most recycled product</li> </ul>
<b>Shortcoming</b>	<ul style="list-style-type: none"> <li>• Heavy and bulky</li> <li>• Can typically only be charged to 70% of theoretical capacity</li> <li>• Danger of overheating during charging. Not suitable for fast charging</li> <li>• Typical cycle life 300 to 500 cycles</li> <li>• Release of hydrogen and oxygen during charging from open constructions – can cause an explosive atmospheres</li> <li>• Sulphation during long storage if not used, which makes the battery useless.</li> <li>• Release of toxic materials (Lead and sulphuric acid) by improper shredding</li> </ul>
<b>Environment</b>	Batteries can leak acid if not handled correct. If not disposed and recycled correctly there is a risk that free lead may pollute the environment. Prolonged exposure to lead is a health risk for workers that handle battery components.
<b>Variations</b>	<p><b>VRLA (Valve Regulated Lead Acid) batteries</b>            The VRLA battery is also called a sealed Lead Acid (SLA) battery. This construction is designed to prevent electrolyte loss through evaporation, spillage and gassing and this in turn prolongs the life of the battery and eases maintenance. Instead of simple vent caps on the cells to let gas escape, VRLA have pressure valves that open only under extreme conditions. Valve-regulated batteries also need an electrolyte design that reduces gassing by impeding the release to the atmosphere of the oxygen and hydrogen generated by the galvanic action of the battery during charging. This usually involves a catalyst that causes the hydrogen and oxygen to recombine into water and is called a recombinant system. Because spillage of the acid electrolyte is eliminated the batteries are also safer.</p> <p><b>AGM Absorbed Glass Mat Battery</b>            The AGM battery is also known as Absorptive Glass Micro-Fibre. Boron Silicate fibreglass mat acts as the separator between the electrodes and absorbs the free electrolyte. Its purpose is to promote recombination of the hydrogen and oxygen given off during the charging process. The electrolyte is more readily available to the plates allowing faster reactions and higher charge/discharge rates. The construction is very robust and the cells will not leak if the case is cracked. Nearly all AGM batteries are sealed valve regulated "VRLA". AGM's have a very low self-discharge rate.</p> <p><b>Gel Cell</b>            This is an alternative recombinant technology used in VRLA batteries to promote</p>

recombination of the gases produced during charging. It also reduces the possibility of spillage of the electrolyte. Prone to damage if gassing is allowed to occur, hence charging rates may be limited. They must be charged at a slower rate to prevent excess gas from damaging the cells. They cannot be fast charged on a conventional automotive charger or they may be permanently damaged. Used for UPS applications.

**SLI Batteries (Starting Lighting and Ignition)**

This is the typical automotive battery application. Automotive batteries are designed to be fully charged. These batteries are not designed to be discharged below 50% and discharging below these levels can damage the plates and shorten battery life.

**Deep Cycle Batteries**

Marine applications, golf buggies, fork lift trucks and electric vehicles use deep cycle batteries which are designed to be completely discharged before recharging. Because charging causes excessive heat which can warp the plates, thicker and stronger or solid plate grids are used for deep cycling applications. Normal automotive batteries are not designed for repeated deep cycling.

<b>NiCd battery</b>	
<b>Cell voltage</b>	1,2 Volt
<b>Construction</b>	NiCd batteries are composed of Nickel hydroxide Ni(OH) <sub>2</sub> for the positive electrode (cathode) and cadmium (Cd) for the negative electrode (anode). The electrolyte is potassium hydroxide (KOH). Small size and high rate discharge capacity make them good for portable tools and other consumer applications. The cells are sealed and utilise a recombinant system to prevent electrolyte loss and extend the useful life.
<b>Applications</b>	<p>The NiCd battery has for many years been used for:</p> <ul style="list-style-type: none"> <li>• Motorised equipment.</li> <li>• Power tools</li> <li>• Two way radios</li> <li>• Electric razors</li> <li>• Commercial and industrial portable products</li> <li>• Medical instrumentation</li> <li>• Emergency lighting</li> <li>• Toys</li> </ul> <p>Nowadays the NiCd battery is losing its market position to Li-type batteries.</p>
<b>Advantage</b>	<ul style="list-style-type: none"> <li>• Relative low cost, but 3-5 times as expensive as Lead-acid for the same capacity.</li> <li>• Low internal resistance</li> <li>• High rate charge and discharge rates possible</li> <li>• Tolerates deep discharges - can be deep cycled</li> <li>• Wide temperature range (Up to 70°C)</li> <li>• Typical cycle life is over 500 cycles</li> <li>• Can be stored in the charged or discharged state without damage</li> <li>• Can be restored for service by recharging several charge/discharge cycles</li> <li>• Available in a large variety of sizes and capacities</li> </ul>
<b>Shortcoming</b>	<ul style="list-style-type: none"> <li>• Capacity can be lost by improper discharging and charging, the so called memory effect</li> <li>• Can be damaged by overcharging</li> <li>• The use of Cadmium is problematic for environmental reasons</li> </ul> <p>NiCd batteries are gradually replaced in many types of equipment by Nickel metal hydride and Lithium based batteries, both for environmental reasons but also because the new batteries have technological advantages</p>
<b>Environment</b>	Batteries can leak alkaline electrolyte if not handled correct. If not disposed and recycled correctly there is a risk that free nickel and cadmium may pollute the environment. Exposure to nickel and cadmium is a health risk for workers that handle battery components.
<b>Variations</b>	<p><b>Sealed batteries</b> Traditional NiCd batteries are of the sealed type which means that charge gas is normally recombined. Batteries used for consumer applications are all sealed batteries.</p> <p><b>Vented batteries</b> Vented cells have a vent or low pressure release valve that releases generated oxygen and hydrogen gases when overcharged or discharged rapidly. Vented cells can be constructed with higher current performance than sealed gel based batteries. They are used in aviation, rail and mass transit, backup power for telecoms, engine starting for backup turbines etc.</p>

<b>NiMH battery</b>	
<b>Cell voltage</b>	1.2 Volts
<b>Construction</b>	The NiMH batteries include a cathode of Nickel-hydroxide, an anode of Hydrogen absorbing alloys (usually alloys of Lanthanum and rare earths elements). Like NiCd batteries, Nickel-metal Hydride batteries are susceptible to a "memory effect" although to a lesser extent. They are more expensive than Lead-acid and NiCd batteries, but do not contain environmentally unfriendly materials as Lead or Cadmium.
<b>Applications</b>	<ul style="list-style-type: none"> <li>• Low cost consumer applications</li> <li>• Electric razors</li> <li>• Toothbrushes</li> <li>• Cameras</li> <li>• Camcorders</li> <li>• Mobile phones</li> <li>• Pagers</li> <li>• Medical instruments and equipment</li> <li>• Automotive batteries</li> </ul> <p>Nowadays the NiMH battery is losing its market position to Li-type batteries.</p>
<b>Advantage</b>	<ul style="list-style-type: none"> <li>• High energy density, about 50 % higher than NiCd.</li> <li>• Low internal resistance though not as low as NiCd</li> <li>• Typical life cycle is 500 cycles (less than NiCd).</li> <li>• Can be deep cycled.</li> <li>• Robust. Can also tolerate over charge and deep discharge</li> <li>• Flat discharge characteristic</li> <li>• Wide operating temperature range</li> <li>• Rapid charge possible in 1 hour</li> <li>• Reconditioning is possible</li> <li>• Environmentally friendly</li> </ul>
<b>Shortcoming</b>	<ul style="list-style-type: none"> <li>• Very high self discharge rate, nearly ten times worse than lead acid or Lithium batteries.</li> <li>• Suffers from memory effect though not as pronounced as with NiCad batteries</li> <li>• Battery deteriorates during long time storage.</li> <li>• High rate discharge but not as good as NiCd.</li> <li>• Less tolerant of overcharging than NiCd.</li> <li>• Must have safety vents to protect the cell in case of gas generation.</li> <li>• While the battery may have a high capacity it is not necessarily all available since it may only deliver full power down to 50% depending on the application.</li> <li>• Limited supplies of rare earth element Lanthanum.</li> </ul>
<b>Environment</b>	Batteries can leak alkaline electrolyte if not handled correct. If not disposed and recycled correctly there is a risk that free nickel may pollute the environment. Prolonged exposure to nickel is also a risk for workers that handle battery components. The use of rare earth elements will reduce the available resources of such elements for other possible and more needed applications.

# GENERATORS AND BATTERIES

<b>Li- batteries</b>	
<b>Cell voltage</b>	3,6 Volt
<b>Construction</b>	<p>The typical Lithium-ion cells use Carbon for its anode and Lithium Cobalt dioxide or a Lithium Manganese compound as the cathode. The electrolyte is usually based on a Lithium salt in an organic solvent. Lithium batteries have now taken their place as the rechargeable battery of choice for portable consumer electronics equipment. Wider applications may be seen in the future also for use in high power applications systems. (Modern Li batteries do not contain free Lithium and do not have the safety problems as previous systems).</p> <p>Lithium-ion technology uses a liquid or gel type electrolyte. This cell chemistry and construction permits very thin separators between the electrodes which can consequently be made with very high surface areas. This in turn enables the cells to handle very high current rates making them ideal for use in high power applications.</p>
<b>Applications</b>	<ul style="list-style-type: none"> <li>• Consumer products. Electrical hand-held tools, cameras, camcorders, electric razors, toothbrushes, calculators, medical equipment, communications equipment, instruments, portable radios and TVs, pagers and PDA's.</li> <li>• High power versions for use in traction applications in electric and hybrid vehicles as well as for standby power.</li> </ul>
<b>Advantage</b>	<ul style="list-style-type: none"> <li>• High cell voltage</li> <li>• No liquid electrolyte means they are immune from leaking.</li> <li>• Very high energy density (About 4 times better than Lead acid).</li> <li>• Low weight</li> <li>• High discharge rate</li> <li>• Fast charge possible.</li> <li>• Can be deep cycled.</li> <li>• The cell maintains a constant voltage for over 80% of its discharge curve.</li> <li>• Very low self discharge rate. Can retain charge for up to ten years.</li> <li>• Very high efficiency (Capacity discharged over Capacity charged) of almost 100%. Thus very little power is lost during the charge/discharge cycles.</li> <li>• No memory effect. No reconditioning needed.</li> <li>• Tolerates microcycles</li> <li>• Long cycle life. 1000 to 3000 deep cycles.</li> <li>• Does not need reconditioning as do nickel based batteries.</li> </ul>
<b>Shortcoming</b>	<ul style="list-style-type: none"> <li>• Internal impedance higher than equivalent NiCd</li> <li>• Higher price than traditional Lead Acid battery. But this may change in the future</li> <li>• Stability of the chemicals has been a concern in the past and has caused stricter regulations on shipping methods than for other batteries. This may also change in the future</li> <li>• Degrades at high temperatures</li> <li>• Capacity loss or thermal runaway when overcharged</li> <li>• Degradation when discharged below 2 Volts</li> <li>• Venting and possible thermal runaway when crushed</li> <li>• Can not tolerate overcharging. Need for protective circuitry</li> <li>• Measurement of the state of charge of the cell is more complex than for most common cell chemistries</li> </ul> <p>Although Lithium cell technology has been used in low power applications for some time now, there is still not a lot of field data available about long term performance in high power applications. Reliability predictions based on accelerated life testing however shows that the cycle life matches or exceeds that of the most common technologies currently in use.</p>
<b>Environment</b>	<p>Modern Li-batteries are environmentally friendly compared to other batteries. A number of Li batteries contain other metals as Cobalt. Cobalt is an element that occurs naturally in the environment as Li. Human intake of both lithium and cobalt may, as with other metals, cause diseases. Correct handling and disposal will be necessary as with other batteries.</p>

<b>Li- batteries</b>	
<b>Variants</b>	<p><b>Lithium-ion</b> Lithium-ion batteries were designed to overcome the safety problems associated with the highly reactive properties of Lithium metal. The essential feature of the Lithium ion battery is that at no stage in the charge-discharge cycle should there be any Lithium metal present.</p> <p><b>Lithium-ion Polymer</b> Lithium-ion polymer batteries use liquid Lithium-ion electrochemistry in a matrix of ion conductive polymers that eliminate free electrolyte within the cell. The electrolyte thus plasticises the polymer, producing a solid electrolyte that is safe and leak resistant. Lithium polymer cells are often called Solid State cells. Because there's no liquid, the solid polymer cell does not require the heavy protective cases of conventional batteries. The cells can be formed into flat sheets or prismatic (rectangular) packages or they can be made in odd shapes to fit whatever space is available. As a result, manufacturing is simplified and batteries can be packaged in a foil. This provides added cost and weight benefits and design flexibility. Additionally, the absence of free liquid makes Lithium-ion polymer batteries more stable and less vulnerable to problems caused by overcharge, damage or abuse. Solid electrolyte cells have long storage lives, but low discharge rates.</p> <p><b>Other Lithium Cathode Chemistry Variants</b> Numerous variants of the basic Lithium-ion cell chemistry have been developed. Lithium Cobalt and Lithium Manganese were the first to be produced in commercial quantities but Lithium Iron Phosphate is taking over for high power applications because of its improved safety performance. The rest are either at various stages of development or they are awaiting investment decisions to launch volume production. While the basic technology is well known, there is a lack of operating experience and hence system design data with some of the newer developments which also hampers their adoption.</p>

Source: Electropedia<sup>38</sup>

<sup>38</sup> [www.mpoweruk.com/battery\\_types.htm](http://www.mpoweruk.com/battery_types.htm)

## SUSTAINABLE UNITED NATIONS

Sustainable United Nations (SUN) is a UNEP initiative that provides support to UN and other organisations to reduce their greenhouse gas emissions and improve their sustainability overall.

SUN was established in response to the call from UN Secretary General Ban Ki-Moon at the World Environment Day 2007 (5 June), to all UN agencies, funds and programmes to reduce their carbon footprints and “go green”. This call was echoed in October 2007 in a decision of the UN Chief Executives Board (CEB/2007/2, annex II) to adopt the UN Climate Neutral Strategy, which commits all UN organisations to move towards climate neutrality. Within this context, SUN is working with the UN Environment Management Group – the UN body coordinating common environmental work within UN – to provide guidance, and develop tools and models for emission reduction within organisations.



**Sustainable**  
**United Nations**

### **About the author: Knud Erik Poulsen (MSc. Chem.)**

Knud Erik Poulsen has 25 years of experience as consultant within environmental matters for both enterprises and authorities. Professional country experience includes more than 15 countries within and outside Europe. Knud Erik Poulsen's experience include a number of different industry branches, among others chemical industry, energy producing plants, waste incineration, fertilizer industry, steel industry, battery technology, surface coating industry and transportation. Special expertise areas include air pollution, risk assessments, Environmental Impact Assessment (EIA), Life Cycle Assessment (LCA), Environmental Due Diligence (EDD) and Best Available Technique (BAT).



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**About the Sustainable Procurement Guidelines**

The UN operates to achieve the goals of peace, equality, sustainable development and respect for human rights. The way the UN manages its operations and procures products and services should reflect these goals.

Ensuring lowest environmental and most positive social impact of procurement does not only build on the international community commitments. It also manages the reputational risks associated with labour exploitation or environmental damage in the supply chain; it gives a strong signal to the market and encourages the innovative production of cleaner and more ethical products enhancing an economy based on social and environmental responsibility.

These guidelines are designed to assist UN procurers and requisitioners in their choice to include sustainability considerations in their procurement work. They are built on the recognition that market situations are different from one country to another and thus provide advice based on research made about availability of more sustainable products in world regions. Overall, the guidelines provide a comprehensive overview of the specific factors affecting the sustainability of a given product category and suggest a language and specific criteria to include sustainability in tenders.

Guidelines are specifically provided for the areas of:

- IT equipment
- Cleaning
- Furniture
- Stationary
- Vehicles
- Cafeterias, Food and Kitchen equipment.
- Freight Forwarding
- Generators and Batteries
- Carbon Credits

They are available at: [www.greeningtheblue.org](http://www.greeningtheblue.org) and [www.ungm.org](http://www.ungm.org)