The Waste Management System of the Principality of Monaco

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The Principality of Monaco has a population of 36,371 and stretches over an area of 2.02 km² (0.78 square miles). Monaco is the second smallest and most densely populated country in the world. The warm Mediterranean climate attracts tourists both staying and visiting the principality from neighbouring coastal resorts. The Formula One Grand Prix, held annually, also adds to visitor numbers with consequent increases in waste production.

Because of this, it is vital to maintain a high standard of cleanliness, so waste management is a very important task in the Principality. The responsibility for waste management lies with the Societe Monegasque D’Assainissement (SMA), a private company with a history dating back to 1938 when it provided the first waste management systems in the Principality.

The SMA today provides the collection of municipal, commercial and industrial wastes as well as dry recyclables such as source separated paper, cardboard; plastics - Tetrapack, HDPE, PET, drinks cartons; aerosol cans, glass and packaging
wastes; the collection of waste electronic and electrical equipment (WEEE); and hazardous wastes – waste oil, batteries, gas canisters, paints and solvents.

In the heart of the Fontvieille district, the SMA operates an incineration plant with the capability of processing 80,000 tonnes of waste per annum with energy recovery. Initially, the plant was built with three identical furnace grates but the plant only treats a maximum of around 50,000 tonnes of waste per annum to reduce carbon dioxide (CO2) emissions thus complying with the KYOTO protocol. This is achieved by using two of the three furnace grates continuously and having the third as a standby furnace grate for when one of the other two are shut for annual maintenance.

![Incineration plant](image)

It is also the responsibility of the SMA to provide street and beach cleansing services which includes the cleaning of public channels and private alleys, galleries, public elevators, commercial and technical galleries, waterways, car parks as well as road tunnels and industrial areas.

**Waste Collection and Recycling**

SMA’s waste collection services in the Principality have various types of collection systems. For the hotels, casinos, restaurants etc. collection containers of 660 and 1100 litre capacities are provided, for large volumes of food waste and packaging wastes produced from these establishments due to the volume and density of the wastes. Communal collection points are also provided, housing containers from 240, 660 and 1100 litre capacities near to villas for the storage of wastes. In some
parts of the Principality, a door to door waste collection system is provided where residents place their waste on the pavement, in plastic bags, for collection.

The collection of municipal and commercial wastes is carried out using a fleet of Provence Bennes rear loading satellite refuse collection vehicles mounted onto Toyota Dyna two axle 7.5 tonne chassis and larger Geesinknorba GPM Mini, Grange Variopress and Farid T1SM rear loading refuse collection vehicles mounted onto Renault Midlum two axle 12 and 15 tonne chassis and Renault Premium and Iveco Eurocargo two axle 18 tonne chassis. The smaller Provence Bennes 7.5 tonne two axle satellite units and Geesinknorba GPM Mini refuse collection vehicles are used for areas of tight access such as side streets and beaches as well as for villas where large volumes of waste are not produced. The larger Faun Grange and Farid T1SM two axle waste collection vehicles are used to collect the larger volumes of municipal and commercial wastes produced from hotels, casinos, restaurants etc. Any excess waste produced and placed next to full waste containers is also collected to maintain hygiene and prevent odours produced from decomposing waste in the warm climate.

The SMA also provide a roll – on – off container service offering portable compactor containers for the collection of large volumes of municipal, commercial and industrial wastes produced by hotels or commerce. The containers can be housed in the basement of the building to be emptied daily or weekly dependent on the fluctuations of waste produced. They come with their own power pack so the producer can operate the compaction mechanism consisting of a block compactor inside the portable compactor container. They are totally sealed and
retain all leachates produced in the compaction process which is 6:1. These containers are collected and emptied by SMA’S Iveco Eurocargo two axle 18 tonne roll – on – off hook lift container truck which discharges at the incineration plant at Fontvieille.

A further development is the use of the pneumatic waste collection system for the Fontvieille district. The waste from the pneumatic collection system is transported through the pipework system directly into the waste storage bunker of the incineration plant at Fontvieille. This reduces the need for additional waste storage infrastructure to accommodate the wastes from the pneumatic collection system.

Underground container collection systems are also used for the collection of dry recyclables such as paper and cardboard collected together, while plastics - TETRAPACK, HDPE and PET, drinks cartons, steel and aluminium cans and aerosol cans are collected commingled. The underground containers are emptied by an Iveco Stralis three axle rear steer 26 tonne roll – on – off hook lift container truck with truck mounted crane which has been fitted on the truck chassis behind the vehicle’s cab which facilitates the emptying of the containers. They are discharged into an open top roll – on – off container carried on the roll – on – off vehicle. Once the container is full, or the vehicle has finished its collection route the container is sheeted by the driver for transport either to SMA’S facilities or for delivery directly to reprocessors.

Smaller satellite Provence Bennes satellite waste collection vehicles mounted on Toyota Dyna 7.5 tonne two axle chassis collect waste plastics - TETRAPACK, HDPE, and PET as well as drinks cartons, steel and aluminium cans and aerosol cans
commingled using 660 litre containers from communal points in areas where underground containers cannot be placed for the storage of the recyclables.

A larger Renault Midlum 15 tonne two axle Grange Variopress rear loading waste collection vehicle collects paper and cardboard from 240 litre containers in the Principality where there is insufficient space for the placement of underground waste collection containers.

**The Waste Collection Service**

The waste collection service has a workforce of forty staff who collect the waste generated seven days a week. Two thirds of the waste is collected during the day with the other third collected at night. The SMA provides the resources - the staff and vehicles - to provide waste collection services for the State of Monaco and the commune of La Turbie.

A varied mix of collection vehicles are used on both collection shifts, the smaller satellite collection trucks being manned by a driver and one or two crew members, the larger collection vehicles manned with a driver and two loaders. The roll – on – off with truck mounted crane collecting underground containers containing recyclables and the conventional roll – on – off truck for emptying portable compactors are manned only with a driver.

**Incineration plant / energy recovery facility**

The history of waste incineration in the Principality stems back to 1898 when the first incineration plant was constructed at Fontvieille. This facility had a batch
treatment process and was successfully operated until it was replaced in 1938 with a new incinerator on the same site. This new incinerator, also of batch process type opened in 1938 and was successfully operated in the Principality until it closed in 1980.

In 1980, the third waste incineration plant for the Principality was constructed on the same location at Fontvieille. The plant occupies an area of 1500 m2 which justifies its vertically orientated design. The plant is a continuous operation incinerating municipal, commercial and industrial wastes 24 hours, seven days a week, 365 days a year. It is very efficient, reducing the waste by 90% of its volume and 75% by weight. When the plant was constructed, it was made earthquake resistant and the chimney of the facility has been incorporated into the building so it is invisible to the human eye. This was important since it is located in the heart of the Fontvieille district and close to the harbour. The white water vapour plume, traditionally produced by incineration / energy from waste plants across Europe, is heated so it is totally eliminated. The waste incineration plant was upgraded in 1994 to comply with the EC Directive on Air Pollution. The upgrade incorporated a wet scrubbing system to treat the emissions produced by the incineration process prior to discharge from the chimney. In 2006, the incineration process was upgraded again, incorporating the use of the CNIM Lab Selective Catalytic Reduction (SCR) technology to further reduce emissions.

The incineration plant treats around 50,000 tonnes per annum of municipal, commercial and industrial wastes and produces energy which is recovered, utilised either as electricity, heat, or cooled for use in air conditioning systems. The
electricity provides power to the incineration plant so that it is self sufficient while the remainder is exported to the Societe Monegasque de I Electricite et du Gaz, the local electricity company for the Principality. The remaining electricity supplies the annual public lighting requirements for the whole Principality.

Steam produced by the incineration process is supplied to a neighbouring heat production and chilled water plant where the heat is recovered in the form of hot and chilled fluids. The hot and chilled water are distributed through two networks, one to supply hot water at 95oC and the cold water at 5oC for the use in air conditioning for public sector offices and public facilities in Fontvieille.

On arrival at the incineration plant, the incoming waste is weighed on a thirty tonne weighbridge of 8 metres in length. The vehicles are weighed both entering and leaving the plant. This obtains the vehicle’s gross vehicle weight when incoming loaded and its tare weight when empty and leaving the facility. The incineration plant disposes of all wastes produced by the Principality as well as from neighbouring communes such as Communaute d’ Agglomeration de la Riviera Francaise which includes the cities of Beausoleil, Roquebrune Cap Martin and La Turbie. Approximately 70% of the waste entering the incineration plant is municipal waste while 23% is assorted waste from packaging, non – hazardous industrial wastes as well as wastes from parks and open spaces. The facility also receives sewage sludge from the Monaco sewage treatment plant.

Once the collection vehicles have been weighed, they enter the enclosed sound proofed building which eliminates internal operational noise from the plant for the surrounding area. The vehicles discharge their loads simultaneously into a 1200m3 waste storage bunker with a capacity to store two – four days waste. Waste from the pneumatic waste collection system is transported to the incineration plant and discharged directly into the waste storage bunker. A shredder has been installed in the tipping hall to shred incoming green and bulky wastes to a suitable size to be incinerated. Once shredded, these are discharged into the waste storage bunker. The tipping hall is under negative pressure to eliminate foul odours produced by the delivery of fresh waste as well as waste stored in the waste storage bunker. The waste is mixed by two overhead travelling cranes fitted with cactus grabs. They mix the waste and place it into the two furnace feed hoppers. Sewage sludge delivered to the plant is pumped directly into the furnace grate using an IC 850 where it is destroyed at 850o degrees.
The waste moves down the furnace feed hoppers by gravity and is pushed by a hydraulic ram from the furnace feed tables onto the Martin Reverse Acting Stoker Grates, one of two identical furnace streams inclined at an angle of 270 degrees giving an hourly throughput of 4.5 tonnes of waste per hour. The grates have a surface area of 15.3m2 and handles wastes made up of a net calorific value of 2400Kcal/Kg. The calorific composition of the waste comes from the Mediterranean diet and the large volumes of food waste produced by hotels, casinos, restaurants as well as the community in the Principality. The Martin Reverse Acting Stoker grates bar moves in both a forward and reverse action and fresh waste entering the furnace grate is ignited instantly when contacting the red hot mass of waste in the combustion chamber. This is achieved by the forward and reverse motion of the furnace grates which agitates the waste, ensuring complete burnout of the waste. The incineration plant complies fully with the Integrated Pollution Prevention and Control Directive (IPPC) (96/61/EC), the Waste Incineration Directive (2000/76/EC) and the Industrial Emissions Directive (2010/75/EU) and burns to a temperature of 850o degrees. Auxiliary burners which run on fuel oil are also used inside the grate to maintain the temperature in case the temperature falls below 850o.

Energy from the combustion process is recovered in the CNIM boilers at 13.3 tonnes per hour of steam which is then superheated to 300o degrees and 28.5 bar. The steam is cooled on contact with the screens and the various tube assemblies so that, the temperature is reduced to 230o degrees at the outlet of the economiser. The heat exchangers are cleaned regularly using steam operated rotary and harrow type soot removers. The energy recovered is in three forms: electricity, heat and
refrigeration. The electricity is produced through a 2.6 megawatt back-pressure turbine driven alternator which supplies the facility directly with its own electrical requirements.

The incinerator bottom ash (IBA) a by-product produced from the incineration process constitutes to 250kg per tonne of municipal, commercial or industrial wastes incinerated at the Fontvieille plant. It is processed through a drum and then cooled and extinguished through an extractor unit. The ash is transported by conveyor where the remaining ferrous and non ferrous metals are removed by magnet for export to a metal processor. The remaining bottom ash is transported to a pit of 170m³. The incinerator bottom ash is collected by a tipper vehicle. It is loaded into the vehicles by an overhead travelling crane with clamshell bucket which lifts the bottom ash out of the 170m³ storage pit. The bottom ash is taken to be processed for use in the construction industry, for use in the construction of roads and buildings thus reducing the use of virgin aggregates.

Dust removal is carried out using two field electrostatic filters. These enable dust levels of 30 mg/Nm³ to be achieved at the outlet before final treatment. The ash recovered from this process, known as Air Pollution Control Residues (APCR), is the second type of residue produced in an incineration plant equating to 25 kg per tonne of waste. To comply with stringent environmental controls (EC Directive on Air Pollution), an additional dust treatment stage comprising wet scrubbing was introduced in 1994 and then further optimised introducing the CNIM Lab Selective Catalytic Reduction (SCR) technology in 2006. The purpose of these upgrades is to ensure the levels of chlorine, sulphur, and heavy metals (dioxins) are drastically
reduced and that there is improved filtration of dust at the electrostatic filter outlet. The system incorporates a wet scrubbing process which involves scrubbing the dioxins in two reactors and a filter agglomeration module used to absorb acidic gases while pollutants are transferred to a milk of lime and soda solution. The solution is purified in a small effluent treatment plant on site.

The treatment plant separates the pollutant materials using precipitation, flocculation and settling. The remaining water is removed using a filter press. The residue left once the water has been extracted is known as filter cake, which is a third by-product of incineration. The extracted water is filtered by being passed through a sand filter and an activated charcoal filter before being discharged off site.

The CNIM Lab Selective Catalytic Reduction (SCR) technology further reduces emissions after the wet scrubbing cleaning process by heating the gases to 250o degrees by burners operated by natural gas. The gases are mixed with ammonia gas, used as a reagent agent. The Catalytic reaction converts the dioxins into nitrogen and water vapour.

The Air Pollution Control Residues, the second constituent of incineration captured by the bag house filter, are driven by endless screws and stored in a silo before being filled into large sealed bags. Due to the hazardous nature of this waste, it is taken to a hazardous landfill site where it is stabilised and solidified to encapsulate its toxic constituents before burial.

The filter cake, the third constituent of incineration extracted from the supplementary Air Pollution Control Residue cleaning process, is also sent to hazardous landfill because its constituents contain chlorine and heavy metals. The filter cake too is stabilised and solidified to encapsulate its toxic constituents on arrival at the landfill site before burial.

After the gases have been cleaned, they are discharged using a horizontal silencer into the atmosphere through the plant’s chimney where sampling probes are fitted, connected to an analyser. This provides a continuous measurement of the contaminants discharged into the atmosphere. If the level of contaminants exceeds the specified limits, the command and control system immediately alters the regulation settings so that the operation regains its standard and stable state.
In conclusion, the SMA provide a highly efficient waste management system for the Principality of Monaco, incorporating modern waste collection systems as well as an energy from waste incineration plant boasting all of the latest emission cleaning equipment. The Principality will be self sufficient in its current waste management system for many years to come.