Coal ash in Israel

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Keywords: fly ash, bottom ash, coal ash utilization

Abstract

The “coal era” was inaugurated in Israel in 1982 when the first coal-fired power generation unit, with a capacity of 350 MW, began to operate at the Orot Rabin power station on Israel’s Mediterranean coast near Hadera, halfway between Haifa and Tel Aviv. Since then, nine more coal-fired units have been constructed and activated, at Orot Rabin and at Rutenberg, the latter located in the southern part of the coast. These two power stations have an overall capacity of 4,840 MW, which constitute one-half of the national electricity production capacity.

The power-output breakdown according to kind of fuel in 2004 was as follows: 78% from coal, 10% from heavy fuel oil, 9% from natural gas and 3% from diesel oil. Conversion of the heavy fuel oil and diesel oil burning units to natural gas is in progress. Additional coal-fired units with a capacity of 1200 MW are planned for the current decade.

Two of the units in operation at Rutenberg have flue gas desulfurization systems (FGD) and low-NO_X burners. In the future, FGD will be added to existing coal burning units at Orot Rabin.

In 2005 1,170 thousand tons of coal ash were produced in Israel from 12 million tons of coal, of which 1,050 thousand tons were fly ash and 120 thousand tons bottom ash. The entire ash output was used up and demand by the ready-mix industry actually exceeds the available supply. 550 thousand tons were utilized by the cement industry for intergrinding (fly ash only) or as raw material for clinker production (fly and bottom ash); 500 thousand tons fly ash (unclassified) by the ready-mix concrete industry as partial replacement for dune sand and cement; 260 thousand tons (both types, part of it from old stock) in road construction and land reclamation, and 20 thousand tons (bottom ash only) for agricultural uses (substrates for plant growth and cowshed bedding). Utilization of fly ash in Israel took a while and most of it is related to the cement and the concrete industry and has much to do, of course, with the local conditions, technical and regulatory aspects and economics.

Introduction

Coal-based electricity power plant was initiated in Israel in 1982 when the first coal-fired generation unit, with a capacity of 350 MW, began to operate at the Orot Rabin power station on Israel's Mediterranean coast near Hadera, halfway between Haifa and Tel Aviv. Since then, nine more coal-fired units have been constructed and operated, at Orot Rabin and at Rutenberg, the latter located in the southern part of the coast. These two power stations have an overall capacity of 4,840 MW, which constitutes one-half of the national electricity production system. Conversion of heavy fuel oil and diesel oil burning units to natural gas is in progress. Additional coal-fired units with capacity of 1200 MW are planned for the current decade.

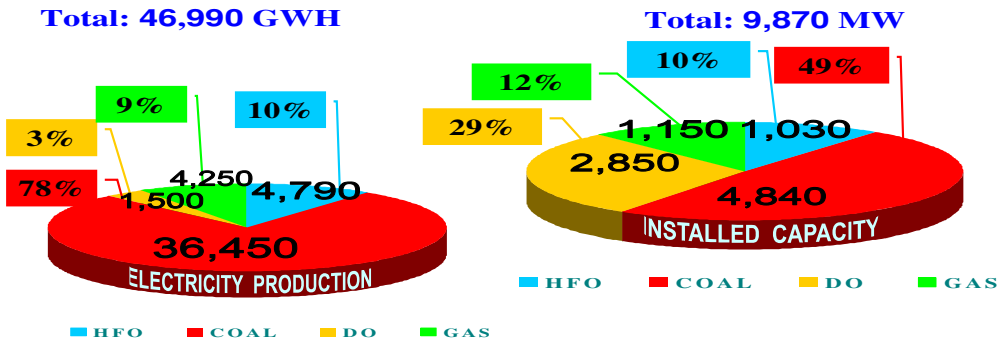


Fig. 1 – Installed Capacity and Production 2004

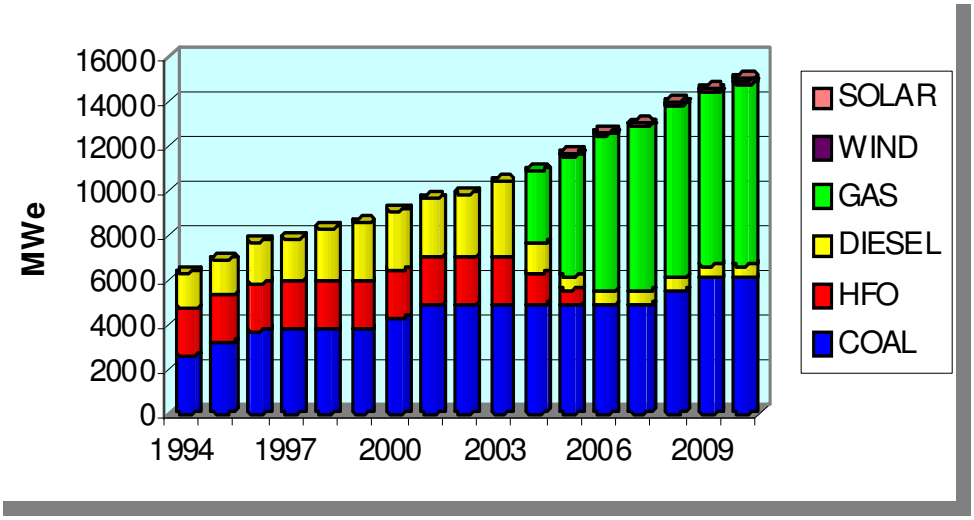


Fig. 2 – Generation Expansion Plan

In 2005 13,300 thousand tons of coals were purchased, Fig. 3, and 12 million tons were used. For economic and operational reasons, the Israel Electric Corporation recently replaced part of the South African coal by Colombian and Indonesian coals. This caused a significant reduction, (10% - more than 100 thousand tons a year) in the annual ash output as South African coal has an average of 14% ash, while the Colombian and Indonesian coals have 5-6 percent only.

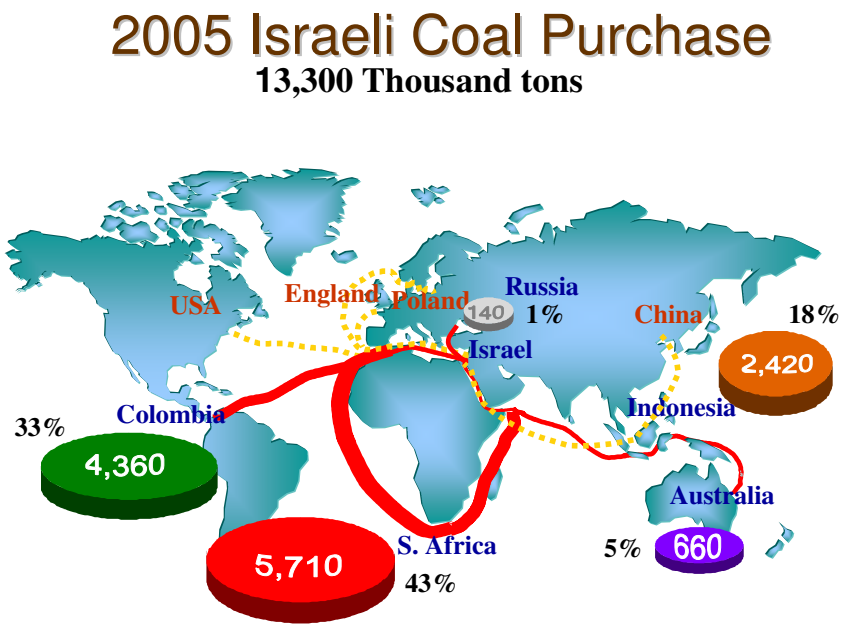


Fig. 3 - Israel's 2005 Coal Sources, Thousand Tons

In 2005 1,170 thousand tons of coal ash were produced from 12 million tons of coal of which 1,050 thousand tons were fly ash and 120 thousand tons bottom ash, Fig. 4. The entire fly ash output was used up, and demand by the ready-mix industry actually exceeds the available supply. 550 thousand tons were utilized by the cement industry for intergrinding (fly ash only) or as raw material for clinker production (fly and bottom ash); 500 thousand tons fly ash (unclassified) by the ready-mix concrete industry as partial replacement for dune sand and cement; 260 thousand tons (both types, part of it from old stock) in road construction and land reclamation, and 20 thousand tons (bottom ash only) for agricultural uses (substrates for plant growth and cowshed bedding). Utilization of fly ash in Israel took a while and most of it has much to do, of course, with the local conditions, technical and regulatory aspects and economics.

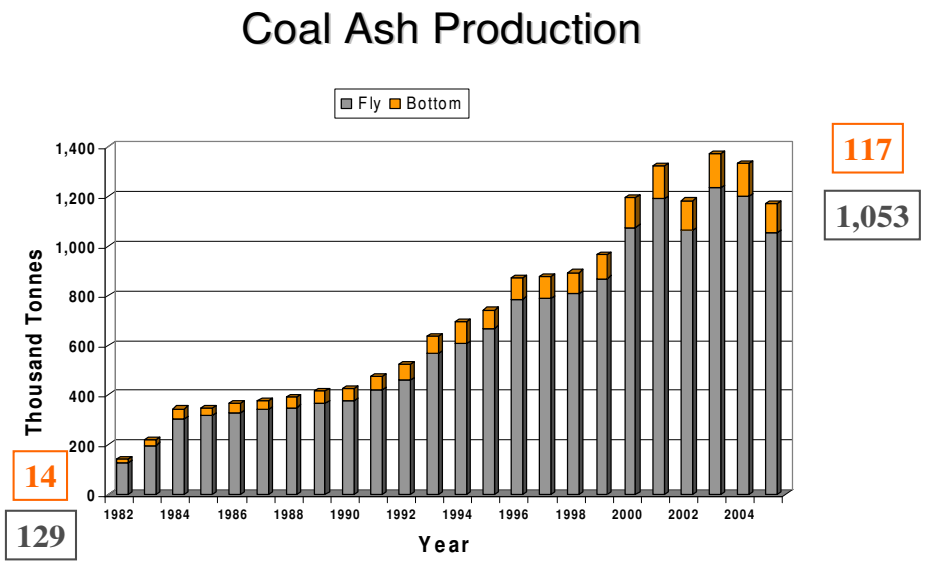


Fig. 4 – Coal Ash Production

In each country utilization of fly ash depends on the local condition and has much to do with the fact that fly ash is multifunctional material and can be used for various purposes. In the building industry fly ash can be used in different ways for different products. In concrete fly ash can be used as partially replacement of cement and/or sand to enhance workability of fresh concrete, to reduce heat of hydration and to improve concrete impermeability and resistance to sulfate attack.

The properties of fly ash are varying depending on the coal kind and origin and on the power plant mode of operation. In certain uses some kind of beneficiation is required, either to improve its properties for the specific use or to achieve homogeneity. In concrete, fly ash can actually be used also "as is" when its properties fall within certain limits, but classification by particle size and/or control of the unburned coal greatly enhance the beneficial effects of the fly ash and of course its commercial value.

Fly ash for use in concrete must conform to the requirements of the relevant standard. However, requirement, like that of the British Standard BS 3892 Part 1:1997, necessitate beneficiation and excluded utilization of fly ash which is inferior to some extent but still suitable for making good concrete.
In the past, Israeli standards were based on the American Standards, ASTM, but in the present the revised and new standards are based on the European EN standards.
The revised Israeli standard "fly ash for concrete" SII 1209:2006 is based on EN 450 with modifications in some major requirements, LOI and Fineness.

Israeli Standard SII 1209:2006 "Fly ash for concrete"

Chemical requirements:
Loss on ignition
Category A: Not greater than 3.0 % by mass
Category B: Not greater than 7.0 % by mass

Physical requirements:
Fineness: The fineness shall not exceed 30 % by mass
Activity Index: The activity index at 28 and at 90 days shall not be less than 75% and 85%, respectively

Israel imports coal from South Africa, Colombia, Indonesia and Australia. The actual properties of the fly ash in Israel are given in Figs 5, 6 and 7.

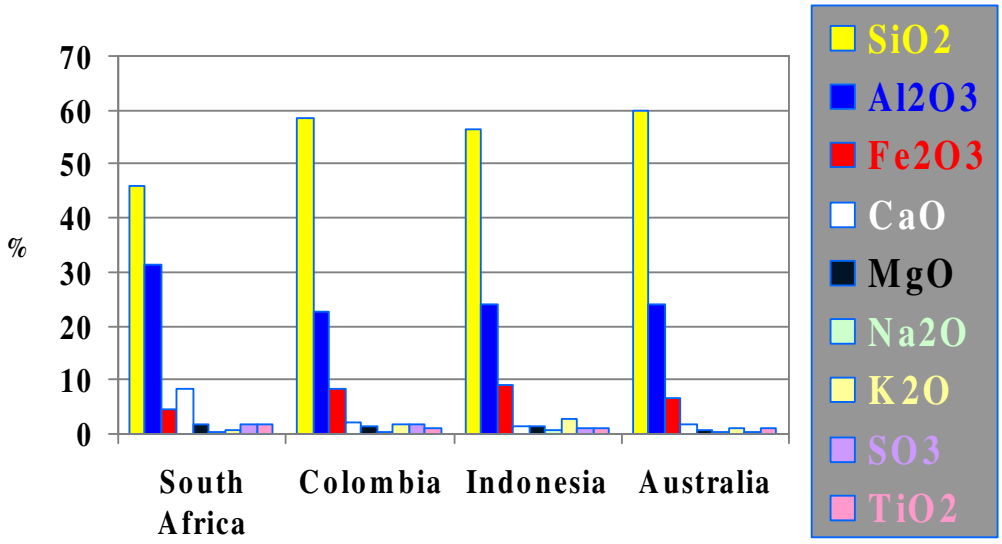


Fig. 5- Major Elements Concentration

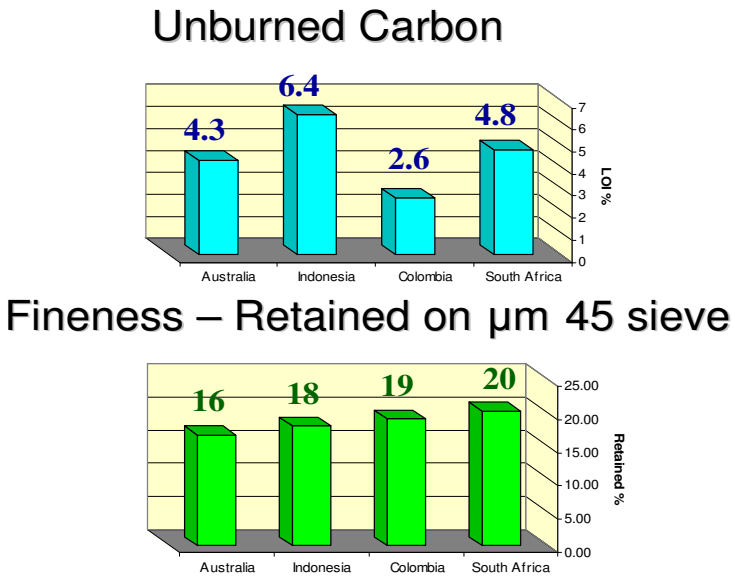


Fig. 6 – Unburned Carbon and Fineness

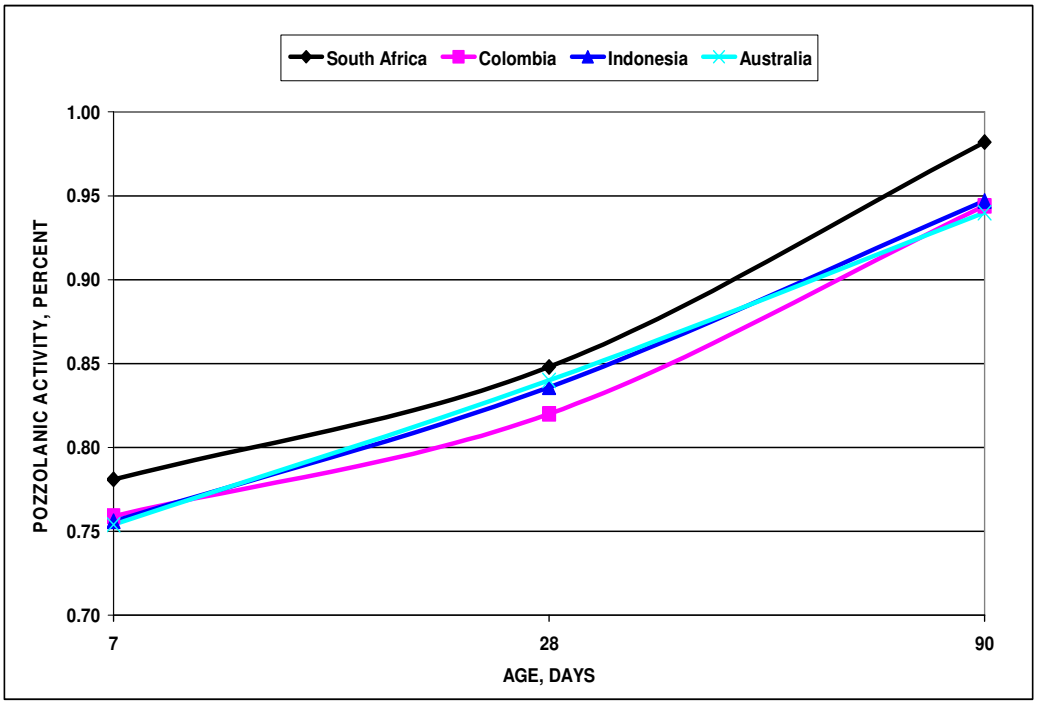


Fig. 7 – Pozzolanic Activity

Fly ash utilization

Initially, local fly ash was of irregular quality, some of it with high LOI. It was used by the cement industry mainly as an additive to the ground clinker. The high LOI ash had been utilized as a structural fill for embankments around the power station and irregularly as a raw material for the kiln. Later, when the quality of the fly ash was improved and with the increased demand for cement, due to the construction boom, most of the fly ash was consumed by the cement industry for intergrinding and as a raw material. But with the decline in the cement demand and with the restriction to use fly ash for road construction, due to environmental aspects, the unused fly ash, caused also by introduction of new power plants, was dumped into the sea. However, from 1997, when the price of dune sand went up significantly, the "conservative" concrete industry decided to start using fly ash with the necessary investment in the required additional facilities, Fig. 8. Moreover, the Electric Corporation provided free fly ash, up to ten thousands tons, to the ready-mix companies for "experiments" with technical consultancy given by the NCAB. At the beginning fly ash was used only as sand replacement, with economical saving, but after getting some experience also some replacement of cement was done and fly ash was used for its technical merits. At first, only one major ready-mix concrete company used fly ash but later, most of the concrete producers followed.

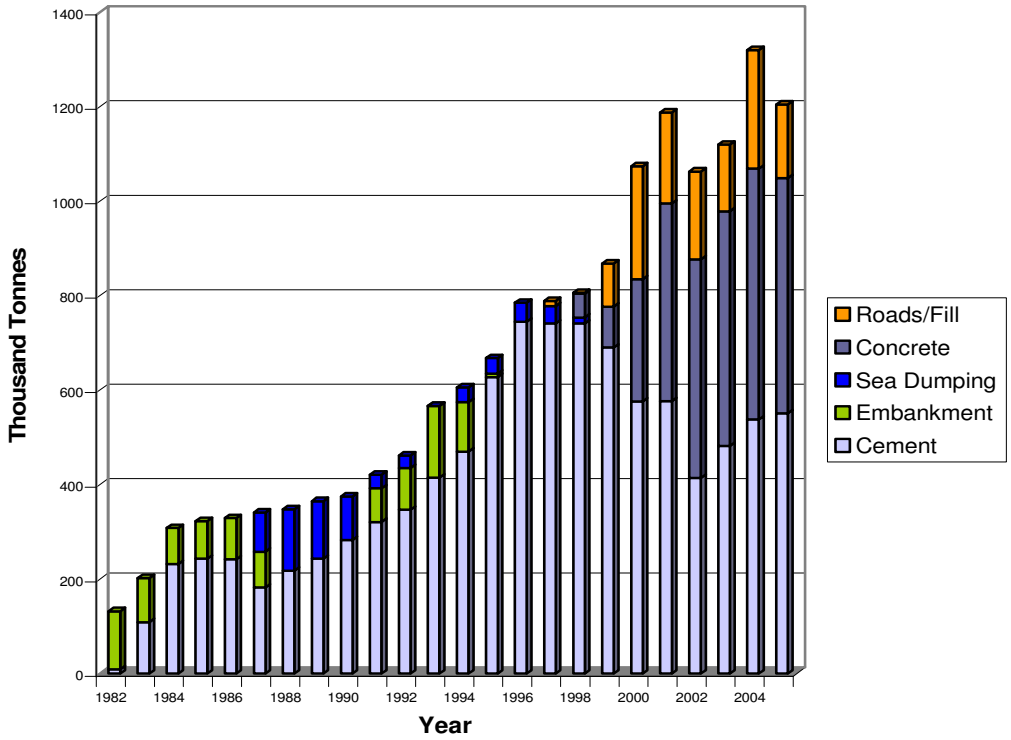


Fig. 8 – Fly Ash Destination

Cement

In Israel, the former Cement Standard allowed the addition of up to 10% pozzolanic material and still regards this cement as "Portland Cement". Moreover, the cement industry found that with this amount they can use the fly ash "as is" without any beneficiation except for a limit on the maximum LOI. The cement industry can also use high LOI fly ash but as part of the raw material that goes to the kiln.

Concrete

Concrete is the main structural material in Israel; steel and wood are used on very small scale. Most of the concretes are produced in ready-mix concrete plants and the most common concrete is B-30. Production is the year-round as the winter in Israel is mild, hence there is no need for extensive storage facilities. Use of fly ash by ready-mix plant is subjected to permission from the government environmental authority, and is sometimes precluded due to some other environmental problems of the concrete plant.

A unique situation exists in Israel regarding fly ash as a sand replacement. On the one hand there is a shortage of sand in close proximity to the center and particularly to the northern region while on the other, the use of crushed sand (quarry sand), that was allowed just recently, impaired the workability of the fresh concrete.

The natural sands from the dunes along the coastline were the main supply source until recently. However, this source was depleted due to the intensive building activity. Hence, as the electrical power stations are located in the center of Israel utilization of fly ash as sand replacement, with some cement reduction is economical.

The use of crushed sand instead of natural dune sand presents some disadvantages on the workability of fresh concrete. In general, the particle shape of crushed sand is more angular with a rougher surface texture, and usually flakier and more elongated than that of natural sand. By contrast, the fly ash particle has a spherical shape and a smooth surface. Thus, a combination of fly ash and crushed sand yield a far superior concrete mix than crushed sand alone and obviates the disadvantage of partial or total replacement of the natural sand with crushed sand. Moreover, as sand replacement, the utilization of fly ash can be done without beneficiation, but with limits on LOI.

Bottom ash utilization

Bottom ash utilization was delayed due to environmental restriction. It's utilization in road construction, land reclamation and agricultural were done only recently, Fig. 9.

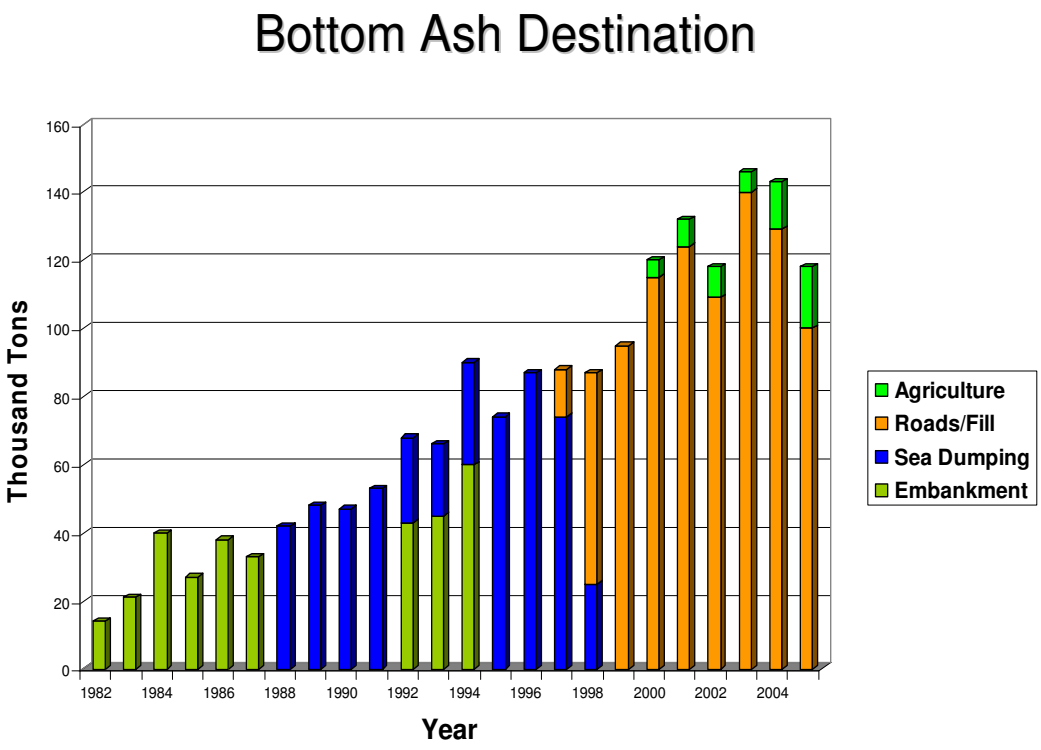


Fig. 9 – Bottom Ash Destination

Road construction

Bottom ash and fly ash, 260 thousand tons, were used in road construction and land reclamation through 2005. Most of it for the construction of Cross Israel Road (highway no. 6) which was suffered from lack of structural material sources. In view of the increased synchronization between fly ash production and concrete demand, we do not anticipate significant surpluses of fly ash in the near future, so that less will be available for road construction.

Agriculture

Bottom ash is used in small amount, 20 thousand tons, for agricultural applications.
Its coarse fraction, ≥ 2 mm, serves as substrates for plant growth - a substitute for tuff in detached beds, Figs. 10-11, and the fine fraction, ≤ 2 mm, for cowshed bedding and in poultry breeding, Figs. 12-13, as a secretion absorbent.

Fig. 10 – Gerbera Growing on Coarse Bottom Ash Detached Bed

Fig. 11–Well Developed Gerbera Root System in Coarse Bottom Ash Bed

Fig. 12 – Cows on Fine Bottom Ash Pad

Fig. 13 – Fine Bottom Ash Bedding for Fattened Poultry

Outlook for the future

Even though all the ash at present in Israel is economically utilized, proper planning is called for to provide answers to the following two scenarios: (a) unexpected drop in demand in the construction sector due to economic changes, (b). activation of a planned new power station.
With this in mind, NCAB invests in R&D with a view to high value utilization possibilities in industry (raw material for ceramics; filler for plastic, asphalt, bitumen fabric products etc.) and to massive applications in agriculture (amending of poor soils; stabilization of sewage for agricultural uses).

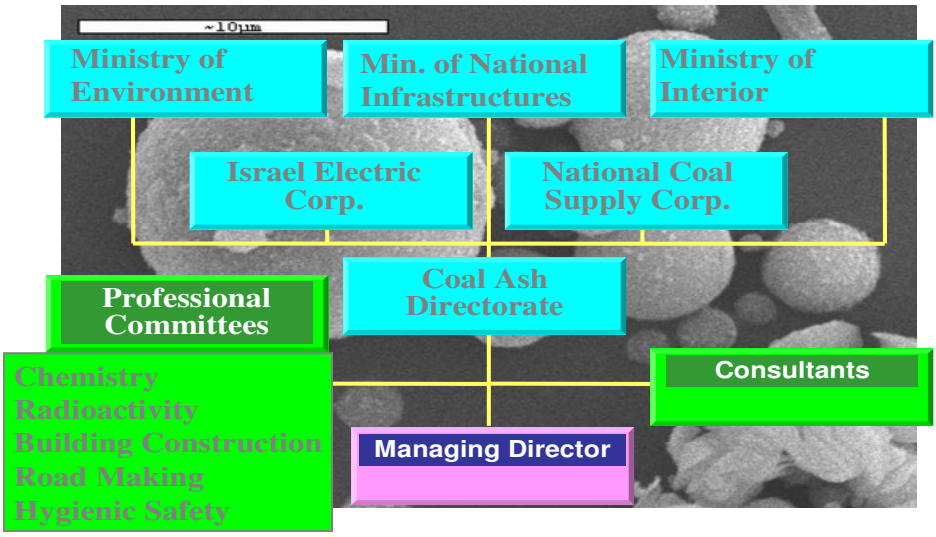
Summary

Actually, all the fly ash in Israel is used at present most of it in the concrete and cement industry. Local circumstances like shortage of natural sand, use of quarry sand and the fact that concrete is the main building material contributes to the demand for fly ash. However, technical support and close monitoring were found to be essential for the success of fly ash utilization. R&D with a view to alternative utilization possibilities would provide insurance in case of coal ash surplus situation in the future.

State Policy of the Israeli Government

* **Defining coal ash as a recyclable material requiring environmental control.**
* **Giving priority to economic uses to prevent disposal of ash as a waste.**
* **Setting up facilities for the temporary storage of large amounts of ash for future use.**
* **Preparing land site for disposal of ash remaining with no foreseeable use in the long run.**
* **Directing budgeted public bodies to cooperate in the recycling of ash.**

National Coal Ash Board (NCAB)



NCAB's Main Activities

- **Definition of environmental conditions for coal ash uses.**
- **Writing engineering standards and establishing quality control systems.**
- **Handling of trial projects for the demonstration of coal ash applications.**
- **Advancement of economic coal ash uses.**