

RENEWABLE ENERGY IN DEVELOPING COUNTRIES

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THE ISRAELI WIND ENERGY PROGRAM

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PROGRAM SUMMARY

ESTIMATED POTENTIAL:

- * National annual electrical energy saving 2 - 3 billion KWh
- * National equivalent fuel oil saving 500,000-750,000 ton
- * Total Investment Up to 1 billion USD
- * Research projects cost Up to 20 million USD

AIMS:

* Long Term -

- Erection of wind farms in potential sites in range of 1,000 MWe.
- Time period: 30 % up to year 2,000
100 % up to year 2,020

* Short term -

- Erection of single wind turbines as demonstration projects in the total range of 5 MWe.
- Erection of few wind farms in various geographical areas in the range of 100 MWe.
- Time period: Up to year 1995

ACTIVITIES:

- * Siting of potential areas for wind farms.
- * Siting of potential sites for demonstration turbines, erection and performance research.
- * technologies development.
- * Integration of, public. private and regional entrepreneurs with the wind energy program.
- * Collection and providing information.

BACKGROUND

Preliminary activities in the field of wind energy in Israel were performed by a researcher from the Israeli Institute of Technology (The Technion), Professor Frenkel. He performed measurements in different areas in Israel.

In the 60's and 70's, further research was done by professors in the Technion, and the subject was brought to greater recognition in academic circles.

Towards the end of the 70's, computerized wind simulation models were developed and wind potential studies carried out by academic institutes, by the Meteorological and Nuclear Institutes, by the Israeli Electric Company and by the Ministry of Energy.

A preliminary large scale survey was initiated and sponsored by the Ministry of Energy and prepared by the Meteorological Institute at the end of the 70's.

The results of this survey indicated that the potential of wind energy is approximately 24,000 MW.

Preliminary estimations have indicated that due to land use for other purposes and due to other limitations, the usable wind energy is down to 1,000 MW installed.

Based on the above, a national wind energy program was established in order to site and develop the proper areas for wind turbines and wind farms.

BASIC PROGRAM

In 1981, the Wind Energy Utilization Program was defined and a Steering Committee was formed by the Ministry of Energy & Infrastructure. A goal was set for turbine application on a 1,000 mega watt scale by the beginning of the 2000's.

An intermediate goal was to erect small and medium sized demonstration models, of tens and hundreds KWe output, for customers - settlements, Local Councils and the like. This serves to gain firsthand experience in the subject and to determine the profitability of erecting wind farms.

Towards achieving the above goals, the following tasks were defined:

1. Finding candidate customers and sites for demonstration turbines;
2. Securing favorable sites for wind farms;
3. Siting surveys for demonstration turbines;

4. Erecting demonstration turbines and follow up;
5. Siting surveys for wind farms;
6. Planning and erecting wind farms;
7. Research in wind simulation models (numerical models and wind tunnels models);
8. Interconnection to the Electric Grid - resolving technical and financial aspects;
9. Developing Israeli wind turbine technologies;
10. Carrying out a nationwide information, campaign, developing government policies and more.

The following main activities according to the basic program mentioned above from 1981 to 1985 were done:

LITERATURE STUDIES:

Literature studies in the fields of wind surveys for single turbines and for wind farms and technologies. The studies were defined by the wind energy committee and were fully supported by the Ministry. Various research institutes were involved in this studies: the National Meteorological Services, Tel Aviv University, Bar-Ilan University, Hebrew University, Biological Institute.

SURVEYS IN PRIVATE OWNERS SITES:

Surveys in various settlements industrial facilities sites in various geographical regions in order to define the potential for demonstration turbines. The surveys were defined by the potential owners and the wind energy committee. The National Meteorological Services performed the surveys with 100% support of the Ministry (approximately \$ 10,000 per each site).

As a result of these surveys some areas were defined as areas with high potential for demonstration turbines. Those are:

Site	Geographic Region	Annually Average Wind Speed (meter/sec.)
Alonei Habashan	Golan Heights (North)	7.5
Mavo Chama	Golan Heights (North)	6.9
Geshor	Golan Heights (North)	6.7
Maale Gilboa	Galilee (North)	7.5

During this period of time the policy was to enable potential turbines owners, such as settlements or industries to produce electricity to their use only for purpose of saving. According to

this policy these types of owners could sell excess electricity only to the national electricity grid served by the Israeli Electric Corporation (IEC).

PRELIMINARY WIND FARMS SURVEY IN GALILEE:

Preliminary surveys at 12 Galilee in order to define potential sites for wind farms. The surveys were defined by the Wind Energy Committee and were performed by IEC with partially support (50%) by the Ministry. The total cost was around \$ 90,000 (including simulation of a specific site in wind tunnel).

PRELIMINARY WIND FARMS SURVEY IN THE NEGEV:

Preliminary surveys at the Negev (Southern of Israel) in order to define potential wind farms sites. The surveys are defined by the Wind-Energy-Committee. The first stage (land survey and existing wind data studies) was performed by Bar-Ilan University. The second stage (wind measurements at 6 selected sites at 10 m heights continuously and up to few hundreds meters during two day/month) was performed by the Biological Institute. The total cost of the surveys was above \$ 120,000. As a results some sites were selected later on for advanced survey.

PRELIMINARY LAND AVAILABILITY SURVEY:

Preliminary land availability survey in most regions. The survey was defined by the Wind-Energy-Committee and by the Ministry of Interior and was performed by the Ministry of Interior with the supported (100%) of the Ministry of Energy.

COMPUTERIZED WIND SIMULATION MODELS:

Basic computerized models development for wind simulation and prediction. The projects were performed by the Hebrew University and by the Biological Institute with the Support (100%) of the Ministry.

DEMONSTRATION TURBINE:

Erecting of the first demonstration turbine (45 KW) in Iskar industrial facility site at Maalot (Galilee). The project (total cost of \$ 70,000) was supported partially by the Ministry (30%). The main purpose of the project was for study.

ISRAELI TECHNOLOGY DEVELOPMENT:

Development of an Israeli wind turbine first prototype (10 KW), lightweight with potential low cost (10 KW) as the first stage of a multi-year development program hundreds kilowatts machines.

MODIFIED PROGRAM

The program was modified first during 1984 as a result of the requirement to accelerate the development of the utilization of wind energy in Israel. According to this modification the Ministry of Energy involved entrepreneurs (in addition to IEC) in order to perform the projects from the first stage to the last stage (i.e.: from preliminary wind energy field study and performing of preliminary wind surveys, through performing of advanced wind surveys towards erecting of demonstration turbines and wind farms).

As a result of implementation the modified program the following activities were performed:

SURVEYS:

Many additional siting surveys have been performed during the last 4 years in the Golan Heights and the Galilee, in Judea and Samaria and in the Negev mountains. In the last 2 years advanced surveys were performed which mapped candidate areas for wind farms. For example, advanced mapping was done by the Israeli Electric Company, with partial support of the Ministry of Energy. A wind farm of several megawatts is to be erected in the Yudfat Mountain Range. Advanced mapping is also being done in the Golan Heights by Mei Golan, the local waterworks utility, and in the Gilboa Mountains by Kibbutz Ma'ale Gilboa.

Some results of the surveys are indicated below:

Region	Site	Entrepreneur	Wind Speed (m/sec)	Potential Capacity (MWe)
Golan Heights	Various	Mei Golan	7.0 - 9.2	40
Galilee	Yudfat	IEC	7.0 - 7.5	20
Galilee	Gilboa	Maale Gilboa	7.0 - 7.5	40
Judea & Samaria	Various	Develop. Co.	7.0 - 7.5	
Yatir	Yatir	Beit Yatir	7.0 - 8.0	20
Negev	Various	Magal Co.		50

and more.

According to the modified-program-policy the Ministry supplies the required equipment for the surveys to be used by the entrepreneurs (data aquisition systems, wind instruments, measurement towers, lighting at top of towers including photovoltaic cells or small turbines and batteries, microcomputers for data analysis), supplies instructions and training, and support partially the expenses of meteorological consultant (75%). The entrepreneurs perform the survey and supply the man power and all other expenses.

DEMONSTRATION TURBINES:

In addition, several demonstration turbines have been erected:

Region	Site	Entrepreneur	Turbine Size (KW)	Date
Golan Heights	Various	Mei Golan	55	7.85
Galilee	Yudfat	IEC	225	3.86
Galilee	Gilboa	Maale Gilboa	200	7.86
Yatir	Yatir	Beit Yatir	200	8.87

The Ministry has partially supported the private entrepreneurs projects (30%):

Region	Site	Entrepreneur	Project Cost (\$)	Minis. Supp. (\$)
Golan Heights	Various	Mei Golan	90,000	27,000
Galilee	Gilboa	Maale Gilboa	210,000	63,000
Yatir	Yatir	Beit Yatir	220,000	66,000

The Ministry supports also follow-up of the demonstration turbines owned by the local private entrepreneurs (equipment, meteorologists, data analysis).

ISRAELI TECHNOLOGY DEVELOPMENT:

The prototype for the lightweight, low cost turbine of 10 KWe output has been completed and a 200 KWe model is being developed and tested.

SALE OF ELECTRICITY:

Infrastructure has been formed for connecting renewable energy sources to the electric grid and for selling the electricity fed to the grid.

FINANCIAL SUPPORT FOR WIND FARMS:

A policy of financial support was authorized which is similar to that for support of industries in development areas.

PROTOTYPE SPECIFIC LAND SURVEY:

Land surveys for specific 2 regions were performed according to the initiation of the Ministry in order to study the land problems due to authorities limitations (Army, Natural Reserve authority, Building Authorities, agricultural use, etc.). The surveys reports are prototypes.

LOOKING TOWARDS THE FUTURE

SURVEYS:

The goal is to broaden the activities, with the participation of local developers and with the Electric Company and to obtain detailed results as to the energetic and economic potential in all available sites.

In the coming year, surveys will be widened in the Golan Heights, Ma'ale Gilboa, the Galilee, Judea and Samaria and the South. This includes 8 sites in the Golan, 5 in the Galilee, between 20 and 40 in Samaria, 4 in the Hebron Mountains and at least 6 in the Negev. If all proves profitable, wind farms can produce some 100 megawatt within 7 years.

DEMONSTRATION TURBINES:

A wind turbine as a demonstration model will be erected at each potential wind farm site. The models will have outputs of 200-500 KWe.

WIND FARMS:

A pioneer wind farm in the Golan Heights of 2.5 megawatts is being planned, dependant on results of the follow-up survey on the present demonstration model.

Additional wind farms are planned to be erected in the following years in the Golan heights, Galilee, Gilboa, Samaria and Judea, South Hebron Mountains, Negev. Installed capacity schedules are indicated above.

ISRAELI TECHNOLOGY DEVELOPMENT

A 200 KWe model will soon be ready for testing, and a commercial model will be developed.

ILLUSTRATIVE INFORMATION

The following figures describe schematically and by diagrams some features in the Israeli Wind Energy Program:

Figure No.	Description
1	Wind energy programs goal and main tasks
2	Hierarchic organization of the wind energy program
3	Estimated planning budget flow for 100 MWe program
4	Activities flow in surveys by entrepreneurs
5	Measured and analyzed wind data flow
6	Planned wind energy development flow in a region
7	Relative budget flow a regional plan
8	Israel wind energy map (turbines & potential areas)
9	Typical demonstration turbine plant
10	Turbines performance follow-up results

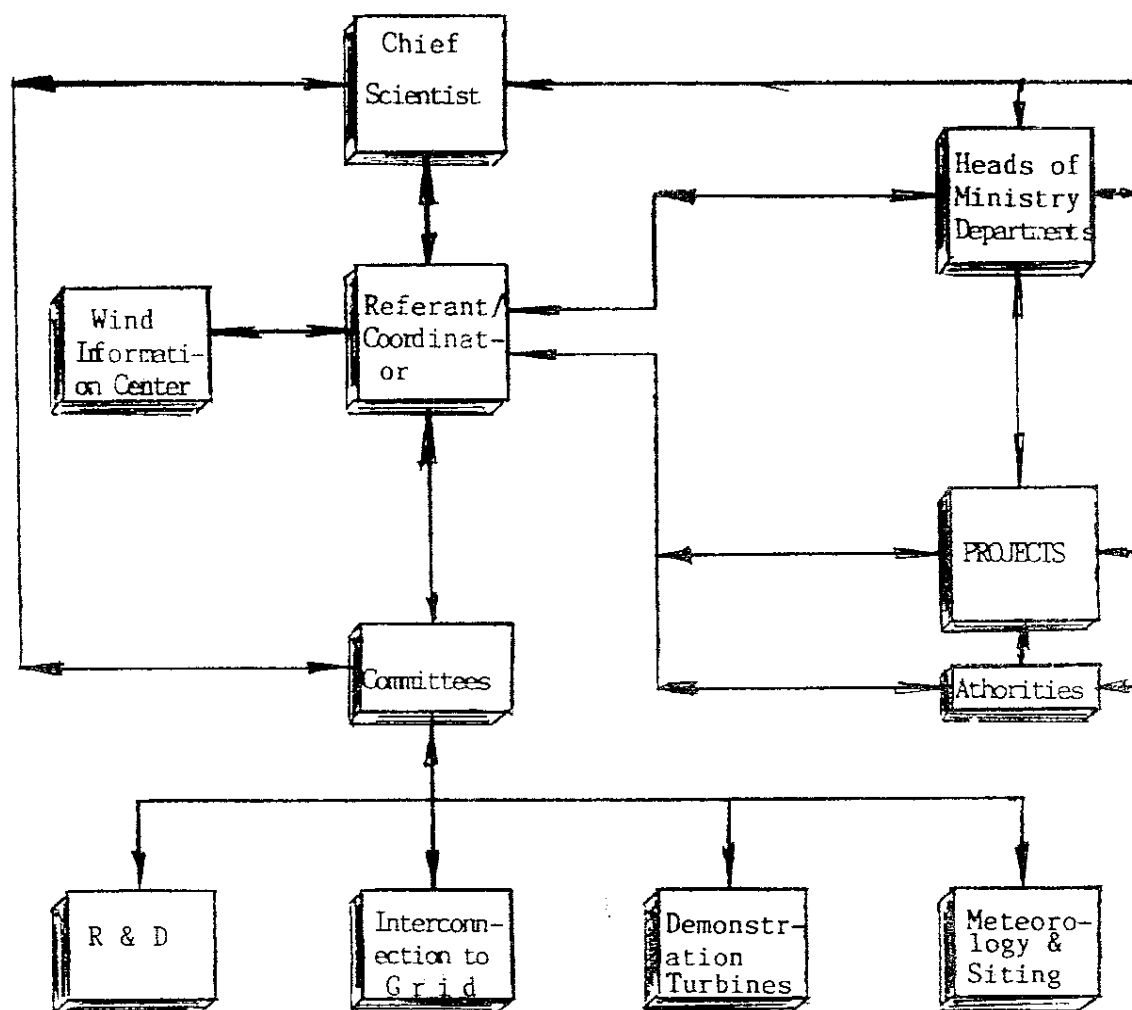


Figure 2: Hierarchic organization of the wind energy program

Total Budget (K\$)

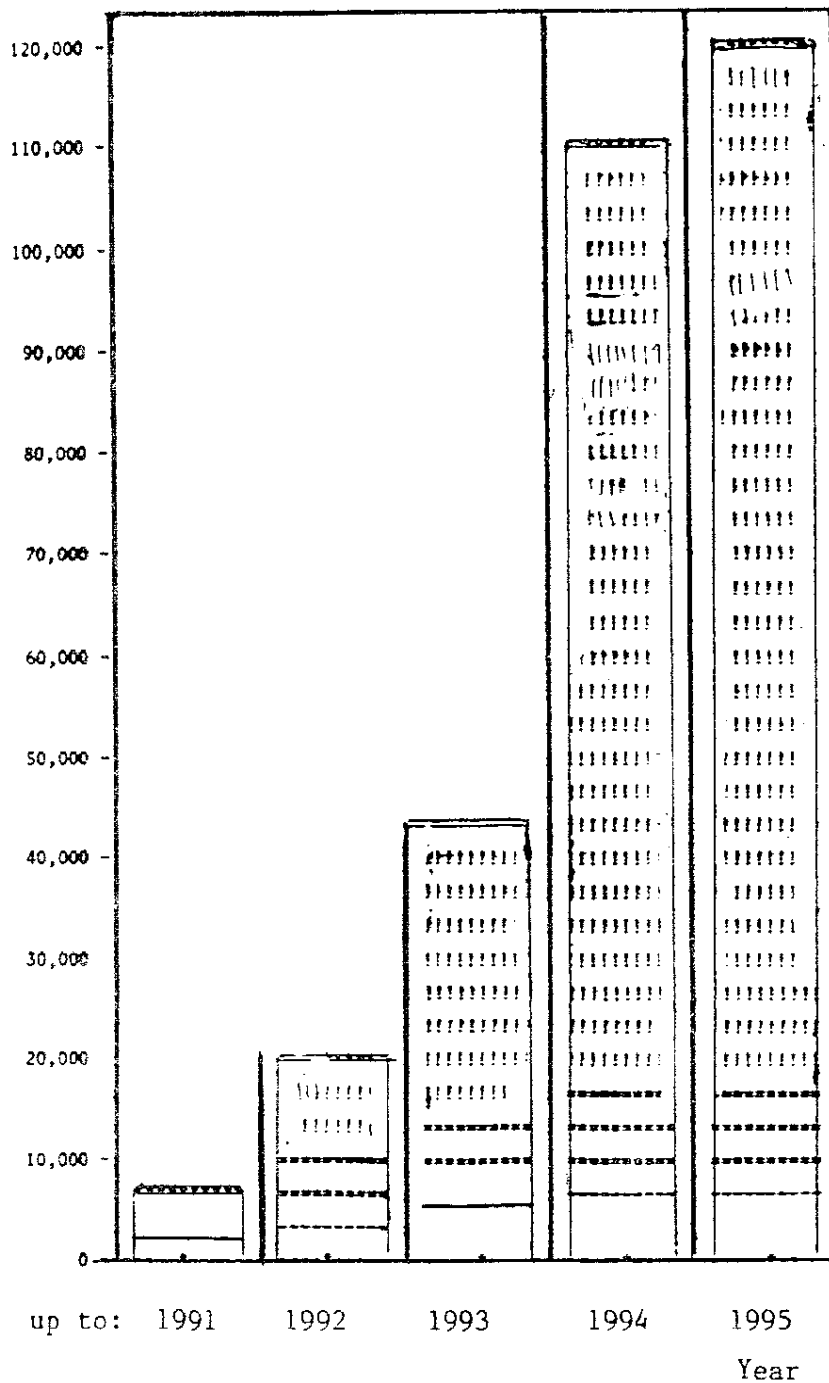


Figure 3: Estimated total budget flow for 100 MWe program
(turbines/farms owners will invest the most)

- 1 - Towers authorization
- 2 - Towers siting
- 3 - Lighting supply
- 4 - Instrumentation supply
- 5 - Instrumentation study
- 6 - Instrumentation calibration
- 7 - Installation
- 8 - Instrumentation run-up
- 9 - Calibration report
- 10 - Cassetts supply
- 11 - Cassetts replacement
- 12 - Software training
- 13 - Software application
- 14 - Preliminary data analysis
- 15 - Periodical reports
- 16 - Data quality assurance
- 17 - Maintenance
- 18 - Final report

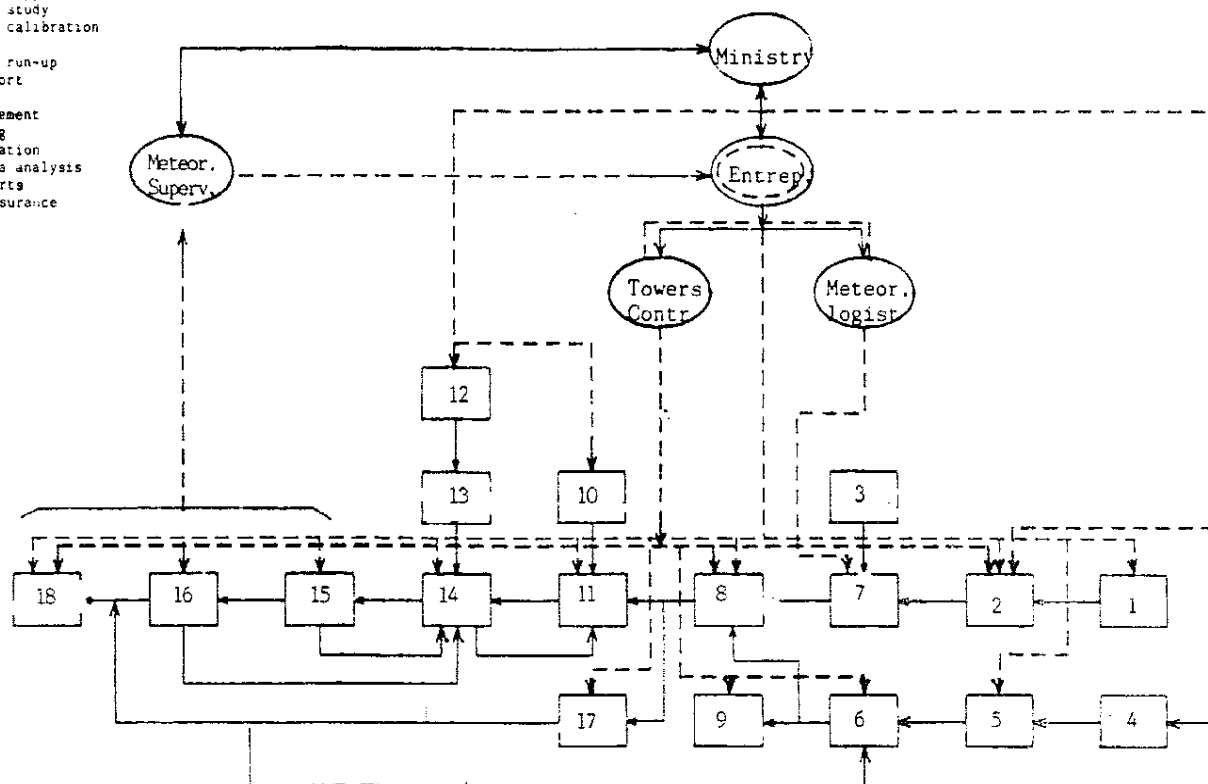


Figure 4: Activities flow in surveys by entrepreneurs

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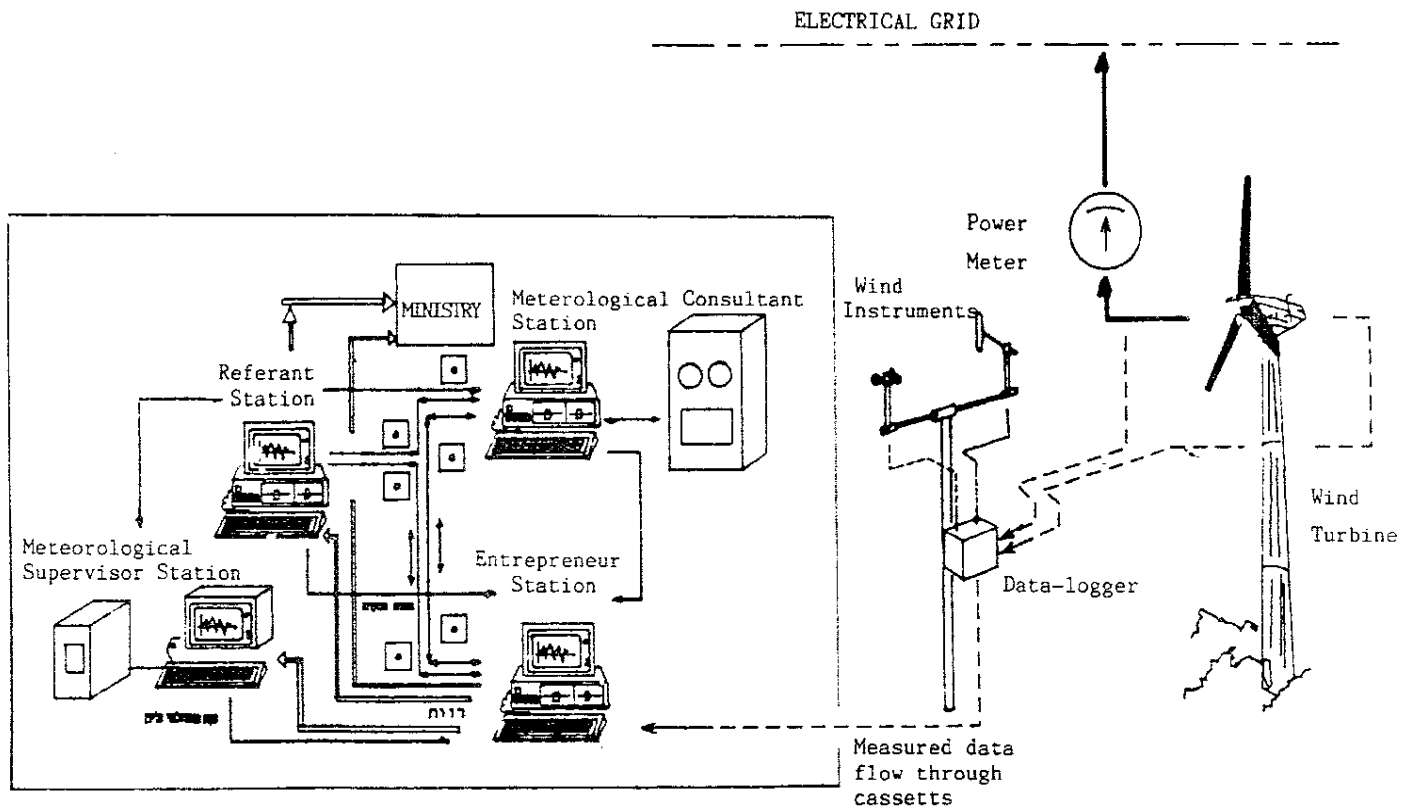


Figure 5: Measured and analyzed wind data flow diagram

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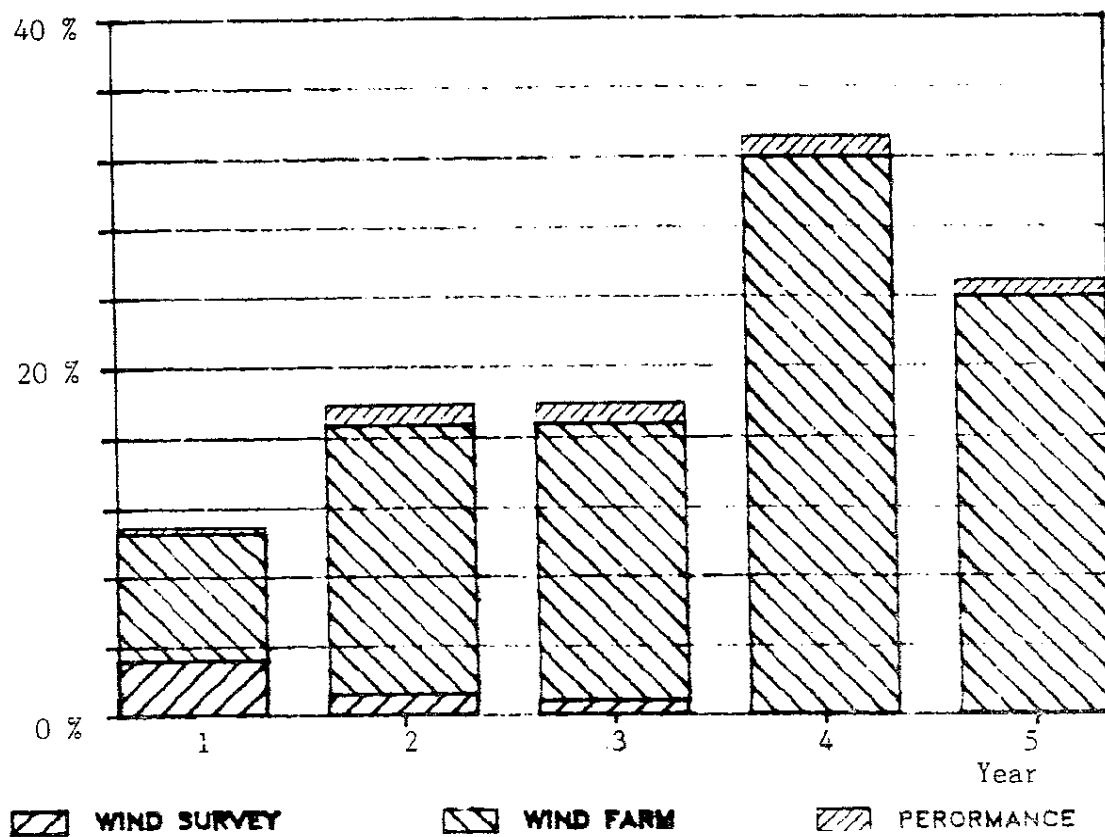


Figure 7: Relative Budget Flow in a Regional Plan

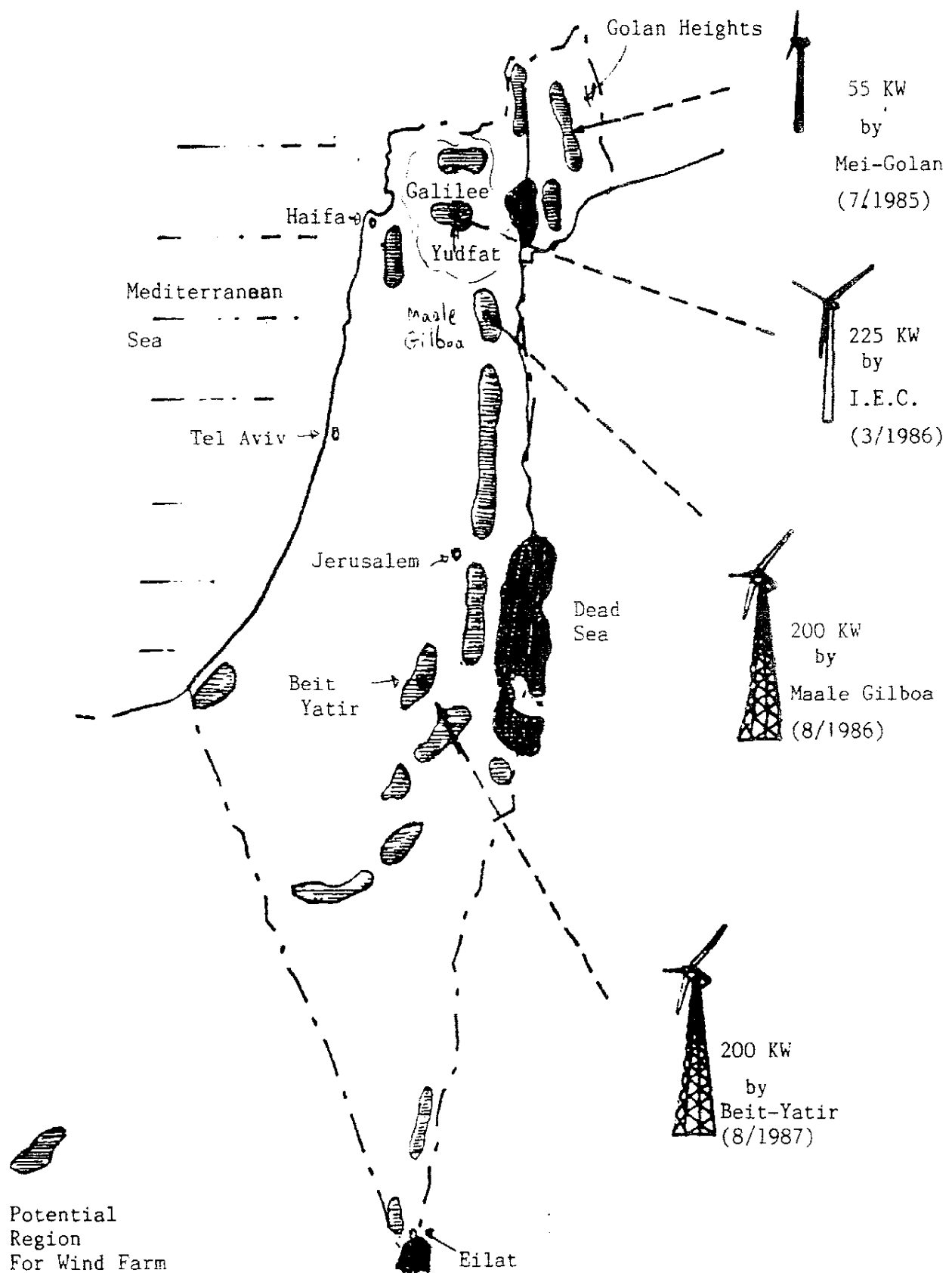


Figure 8: Israel Wind Energy Map (turbines & Potential Sites)

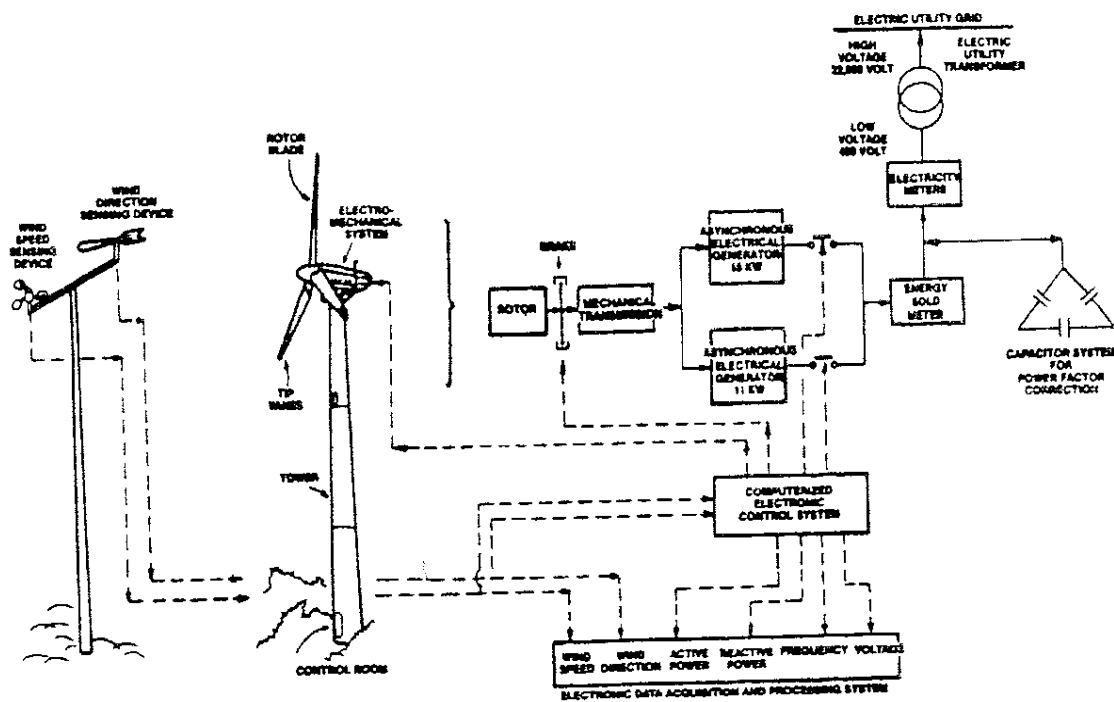


Figure 9: Typical Demonstration Turbine Plant (Golan Height 55 KW Turbine)

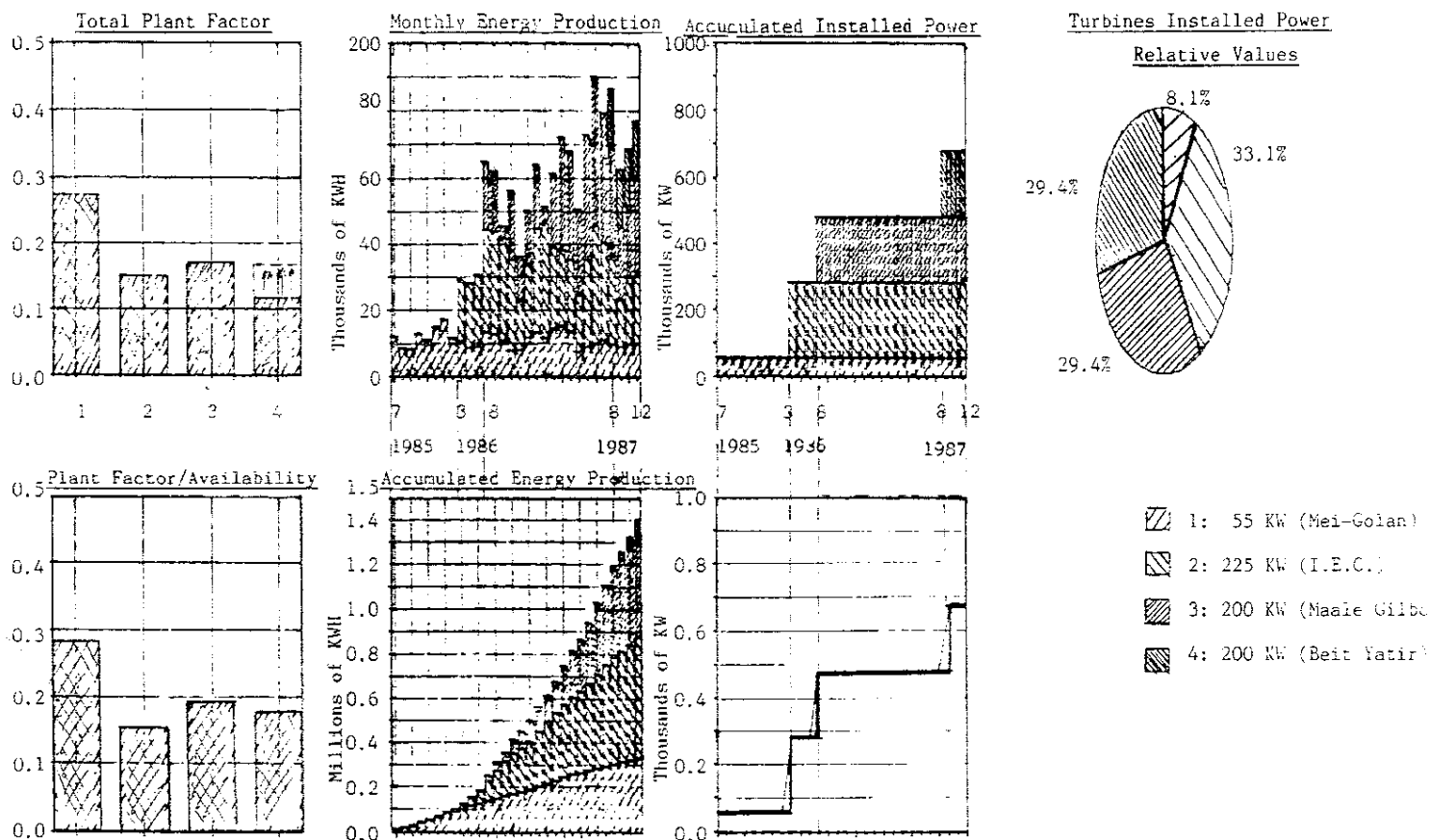


Figure 10: Turbines performance follow/up results

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