H4

COMMISSION OF EUROPEAN COMMUNITIES
C.C.R. - ISPRA
Nuclear Studies Division

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WORKING PAPER

Prospects for the introduction of HTR's: economical and environmental aspects

- Calculation methods available at Ispra
- Programme for 1972

1 - The problem

The HTR is an effective competitor of all types of electric power station.
The economic incentives to its penetration into the market should be assessed for a variety of assumptions concerning economics as well as power requirements, fuel availability, industrial capability of plant construction, separative work, fabrication and reprocessing.
The data concerning pollution (thermal, SO_2 etc) due to various types of plant should be considered, as well as the cost of pollution abatement.
These problems have already been treated to some extent by various organizations, but usually with the aim to reach a prefixed conclusion about HTR's.
The activity of the JRC in this field is a part of a wider action of technical service to the Commission, aiming at providing the Commission with the information on all types of plant necessary to emit recommandations to the member countries and to properly evaluate the large amount of information which it receives from inside and outside the Community.
This action has been started with a very limited effort in 1971 and 1972. For the moment only three problems are treated:

- possible penetration of various types of plant into the electric energy market
- pollution due to electric power generation and economical effects of pollution abatement
- choice of the siting for a given power generation capacity in a defined region, with constraints due to maximum allowed concentration of pollutants.

2 - Available codes

INTAT It's a code developed by Interatom. It searches for the installation policy which leads to the minimum integrated cost of energy production over a given period.
It is based on the linear programming tecnique, and has therefore a number of limitations such as the inability to treat a continuous load diagram and to account for a feed-back of the chosen policy on the unit costs.
It searches for the minimum expenditure, which is only theoretically the optimum policy. But it is very useful because this policy is a starting point for a sensitivity analysis around the optimum and because its results allow to draw a good deal of deductions.

POPE This code performs the materials balance and the cost evaluation for a given strategy. Its typical use is to perform variations around the optimum found by INTAT, in order to assess whether simpler strategies should be preferred to the theoretical optimum.

SITE This code searches for the cheapest distribution of power stations, given :
- a grid A of points where electricity can be produced
- a grid B of points where electricity is consumed
- a grid C of points where pollution is measured
- the cost of energy transport from any of the A points to any of the B points, as a function of the transmission-line power
- the transfer function for air and water pollution from A to B
- the energy requirements at any B point and the load diagram
- the maximum pollutant concentration at any C point.

The code is based on the MPS linear programming routine and searches for the minimum cost of energy production and transport with given constraints on pollutant concentration.
The various types of station are caracterized by their costs as by their pollutants production.
The code is still in its debugging stage as far as the economical side is concerned.
The elaboration of its section dealing with pollutants transfer functions has not started yet.

3 - Programme for 1972

The programme of the Nuclear Studies Division which in some way concerns the HTR can be subdivided as follows :

1. Code POPE - Final improvements and automatization of input variations.
2. Code SITE - Debugging of the economical part, development and may-be completion of a first pollutant-transfer routine.
3. Possible HTR penetration into the electric energy market. Parametric survey of economical hipotheses. Effects on and feedback of requirements concerning separative work, fabrication and reprocessing facilities.
4. Pollution by SO_2. Advantages due to the introduction of reactors in general and HTR's in particular.
5. Evaluation of the advantages for the HTR's penetration due to the general use of cooling towers.
6. First studies with SITE to evaluate the advantages of the low thermal pollution by HTR's.

Few comments on the work concerning points 3 and 4 performed during the first quarter of 1972 are reported here just to give an idea of the work which is being carried out: we are far from reaching conclusions at the moment.

Figs 1 to 5 show the competition of HTR's with the fast breeders in the Community for two different hypotheses on the fast breeder performance :

	System Doubling Time at 80 % load (years)	fissile Pu inventory (Kg/MWe)
Reference breeder (oxide fuel)	10.1	4.6
Advanced breeder (carbide fuel)	6.8	2.8

In the figures the penetration (% of the installed power) of the various plant types is plotted.
The meaning of the symbols is as follows :

C = conventional
L = light water
LB = plutonium recycle in LWR's
F = fast breeder

The figures should be considered just as an indication, because they correspond to a theoretical matematical optimum.

Figs 1 and 2 show that the introduction of the low enrichment HTR is sufficient to eliminate the advantage of introducing the poor breeder. With a good breeder (figs 3,4,5) the competition of the low-enrichment HTR and even more of the Thorium fueled HTR is quite remarkable.

One should be careful before drawing conclusions, as a number of aspects of the problems must be considered : e.g. with the assumed growth rate the separative work required over 50 years increases by about 50% if the HTR's are introduced, due to the reduced number of fast breeders.

Conversely, an additional advantage of the HTR's penetration is the reduced pollution by SO_2 in the late years of the strategy, due to the better competition of the nuclear stations with conventional stations for part-load operation. This can be seen from fig. 6.

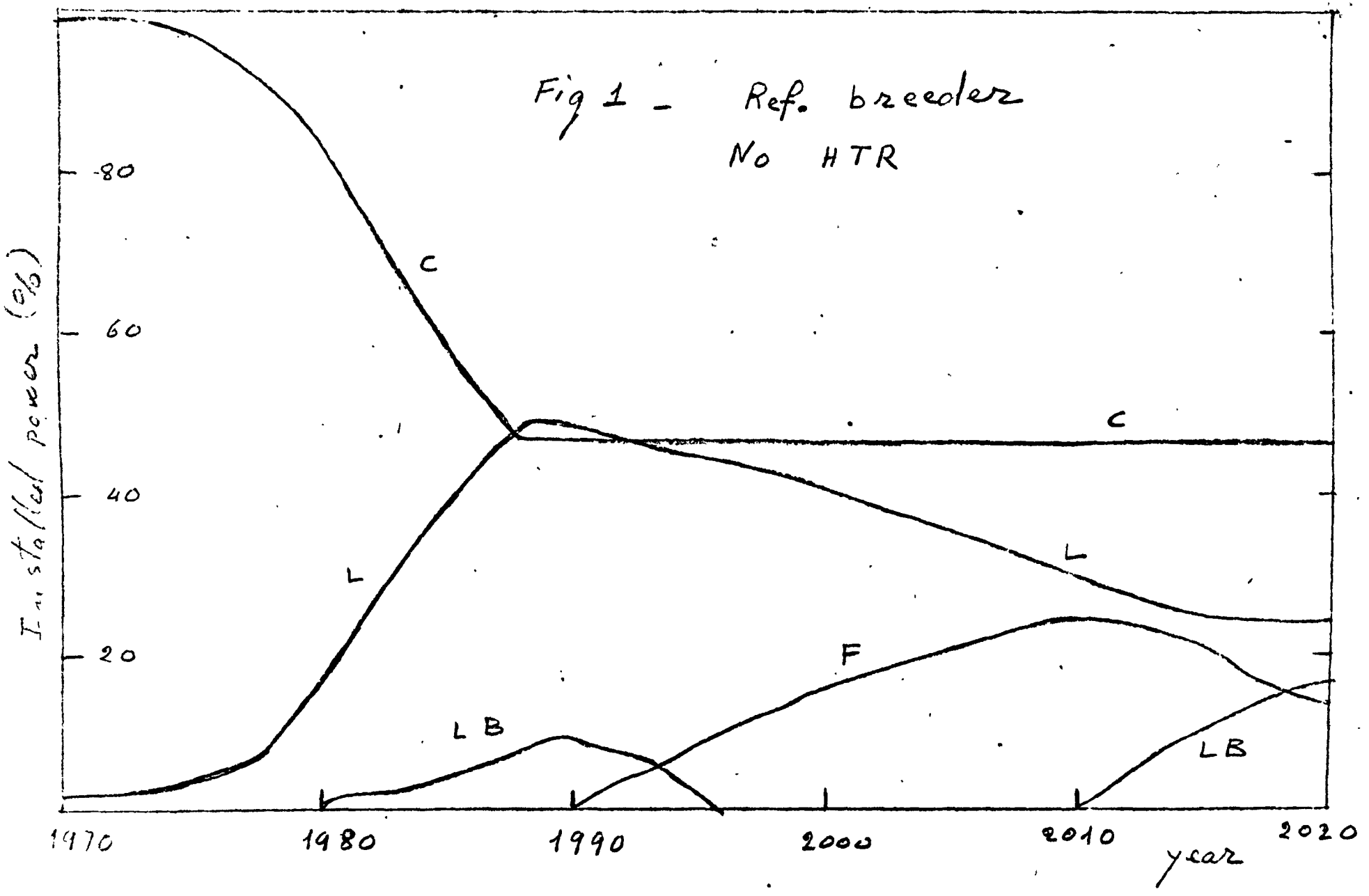
Fig 1 - Ref. breeder
No HTR
Installed power (%)
80
60
40
20
C
C
L
L
F
LB
LB
1970
1980
1990
2000
2010
2020
year

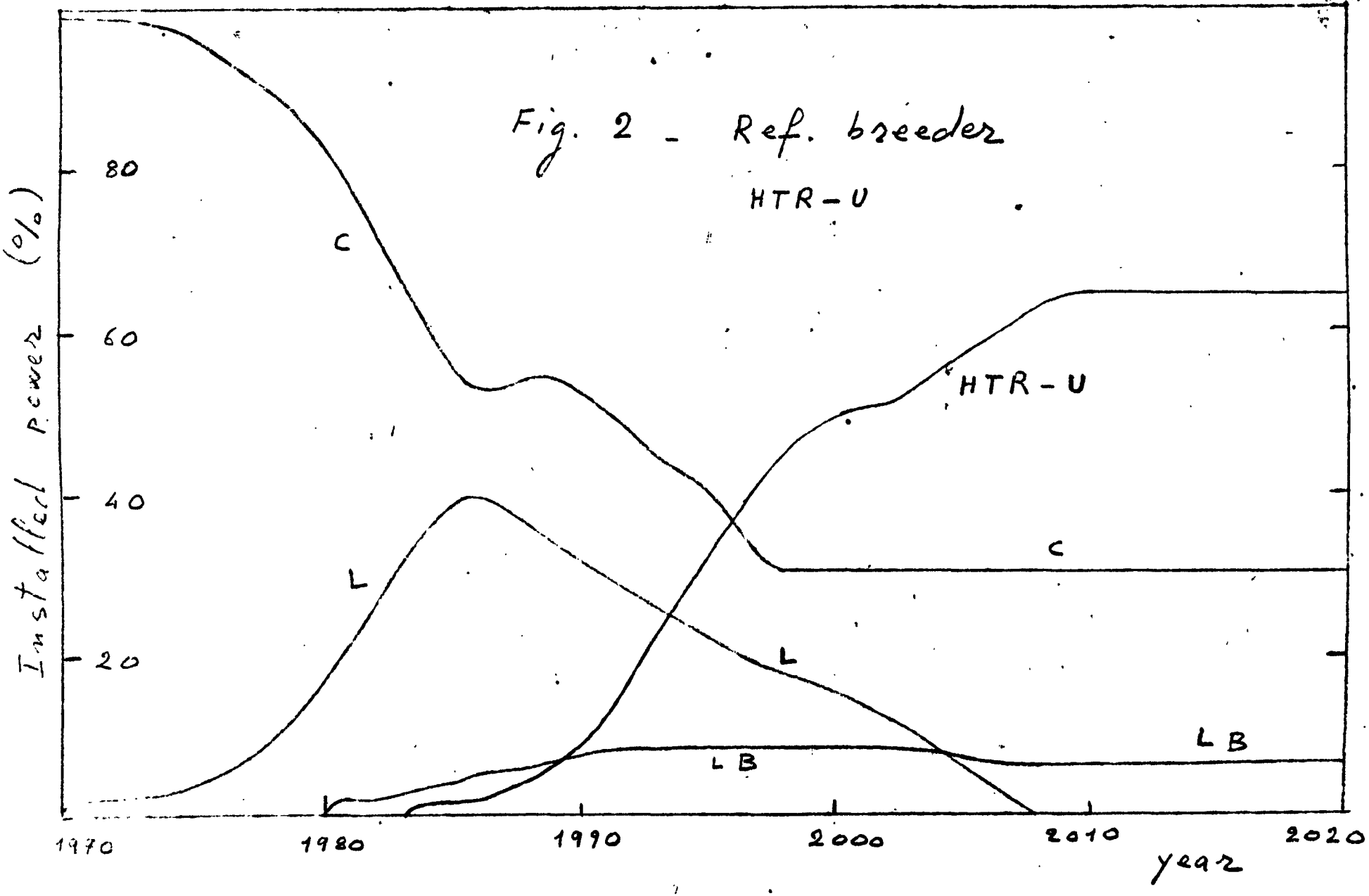
Fig. 2 - Ref. breeder
HTR-U
C
HTR-U
C
L
L
LB
LB
80
60
40
20
Installed power (%)
1970
1980
1990
2000
2010
2020
year

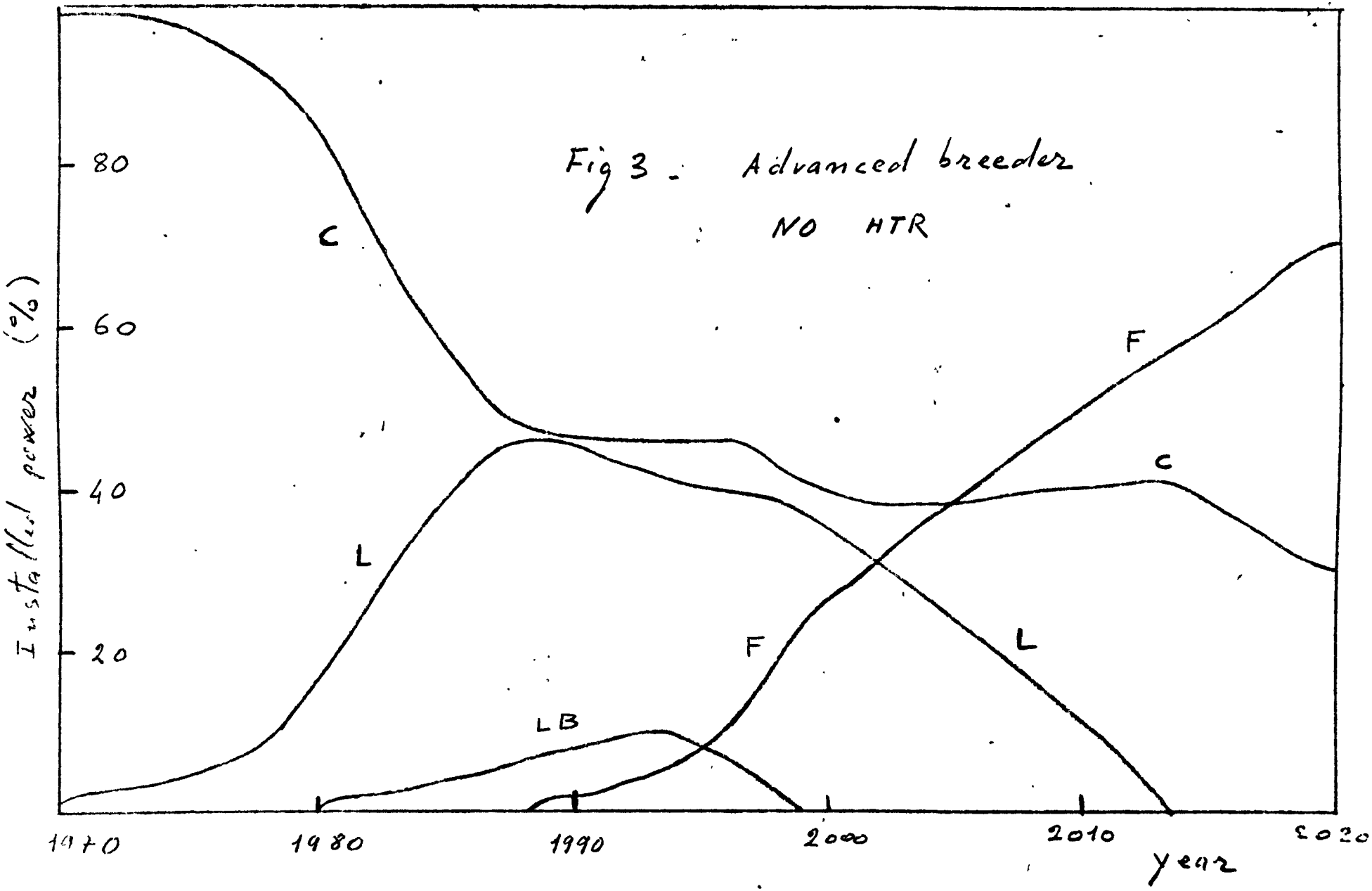
Fig 3 - Advanced breeder
NO HTR
Installed power (%)
80
60
40
20
C
L
LB
F
F
C
L
1970
1980
1990
2000
2010
2020
year

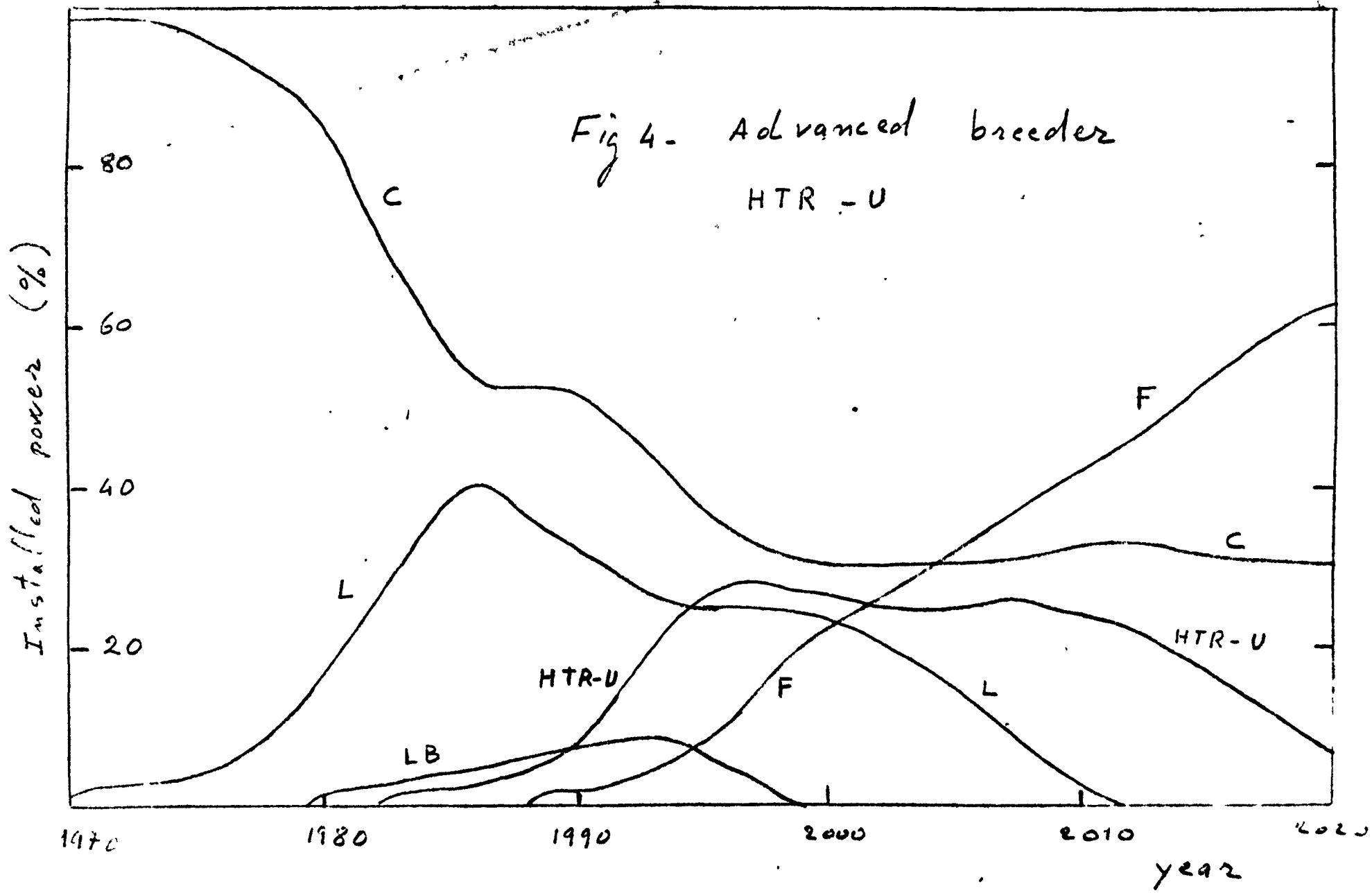
Fig 4- Advanced breeder
HTR - U
Installed power (%)
80
60
40
20
C
L
LB
HTR-U
F
HTR-U
F
L
C
1970
1980
1990
2000
2010
year

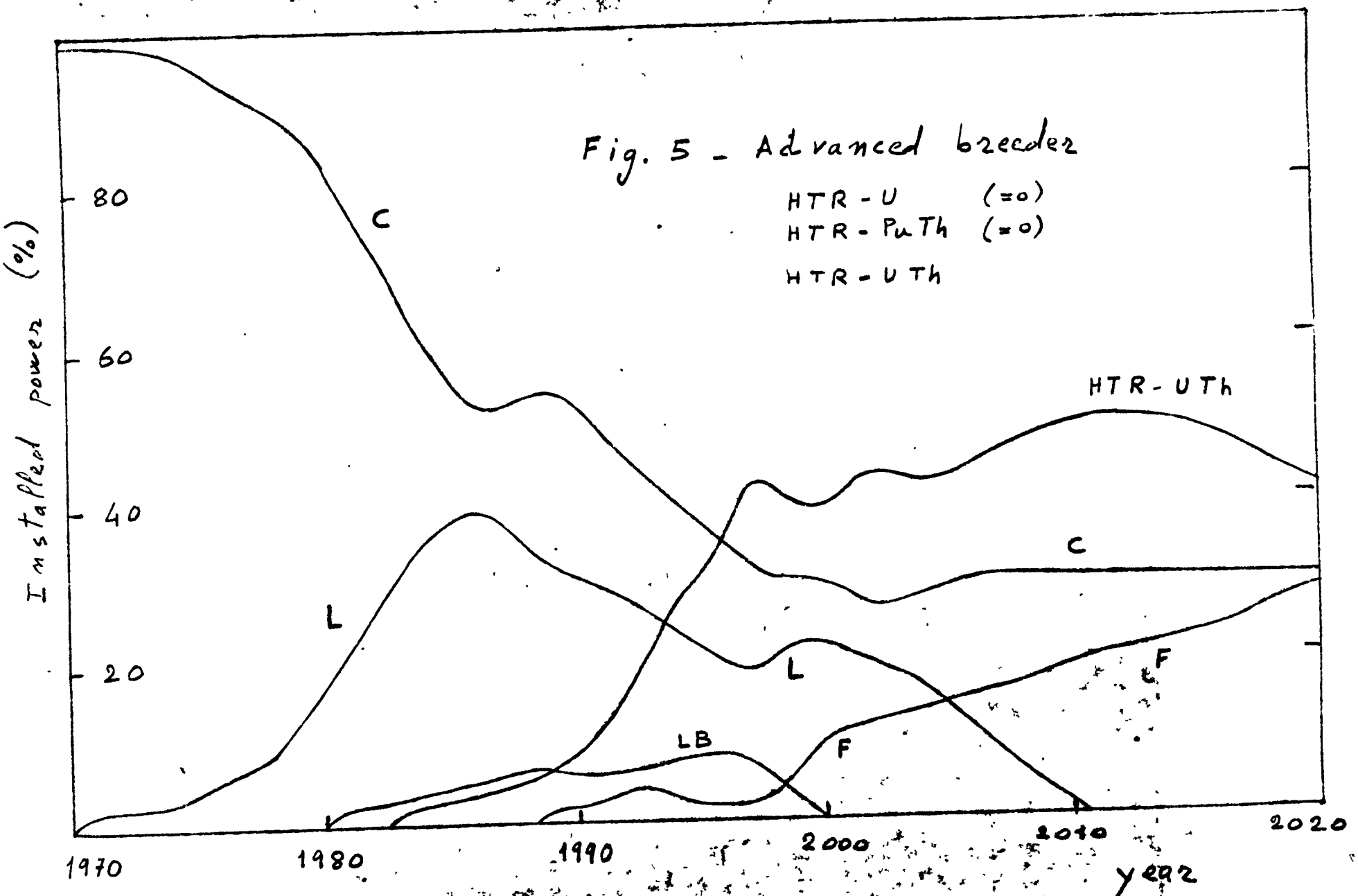
Fig. 5 - Advanced breeder
HTR - U (=0)
HTR - PuTh (=0)
HTR - UTh
Installed power (%)
80
60
40
20
C
L
LB
F
HTR - UTh
C
L
F
1970
1980
1990
2000
2010
2020
year

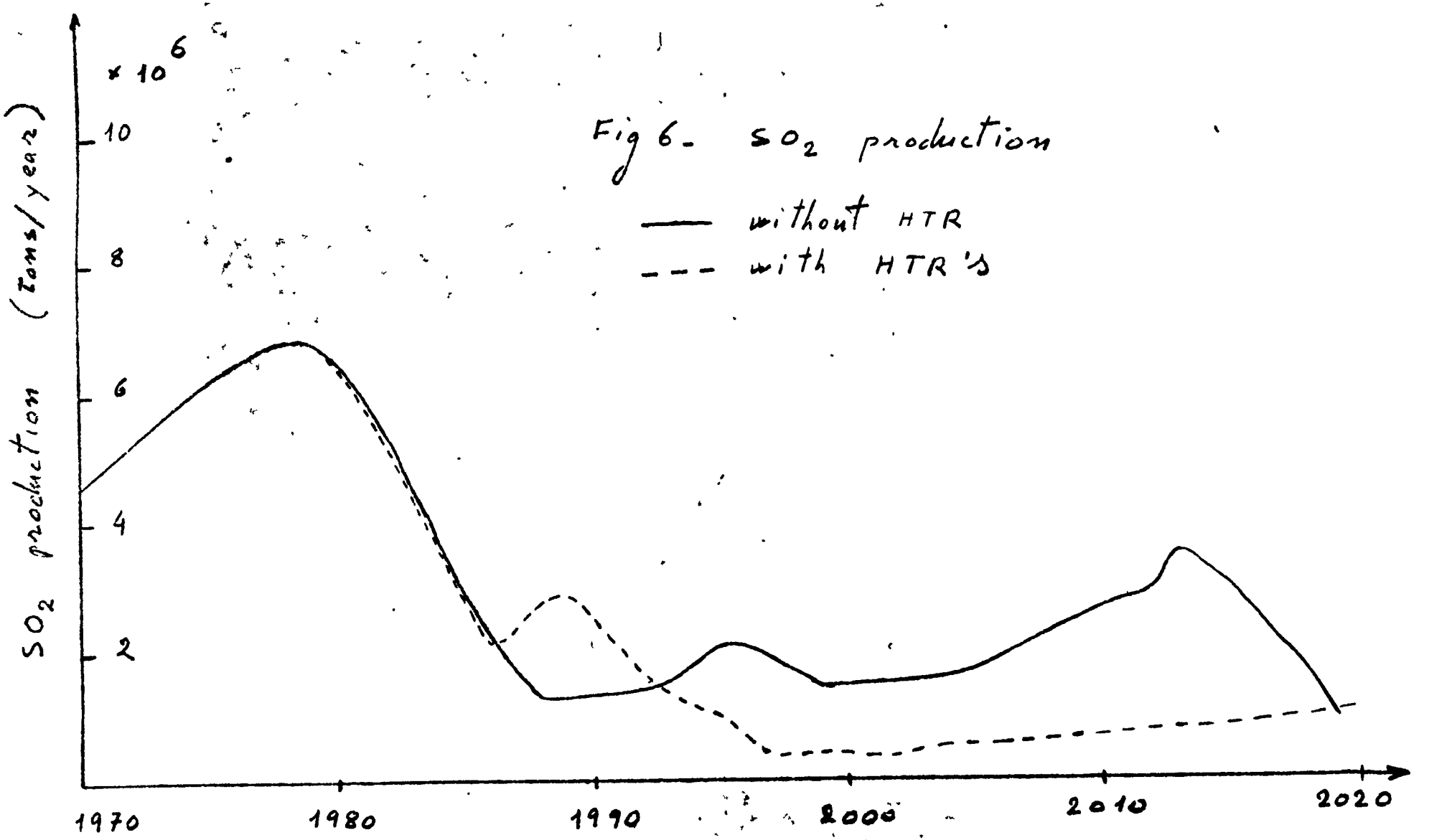
Fig 6- SO_2 production
without HTR
with HTR's
SO_2 production (tons/year)
$\times 10^6$
10
8
6
4
2
1970
1980
1990
2000
2010
2020