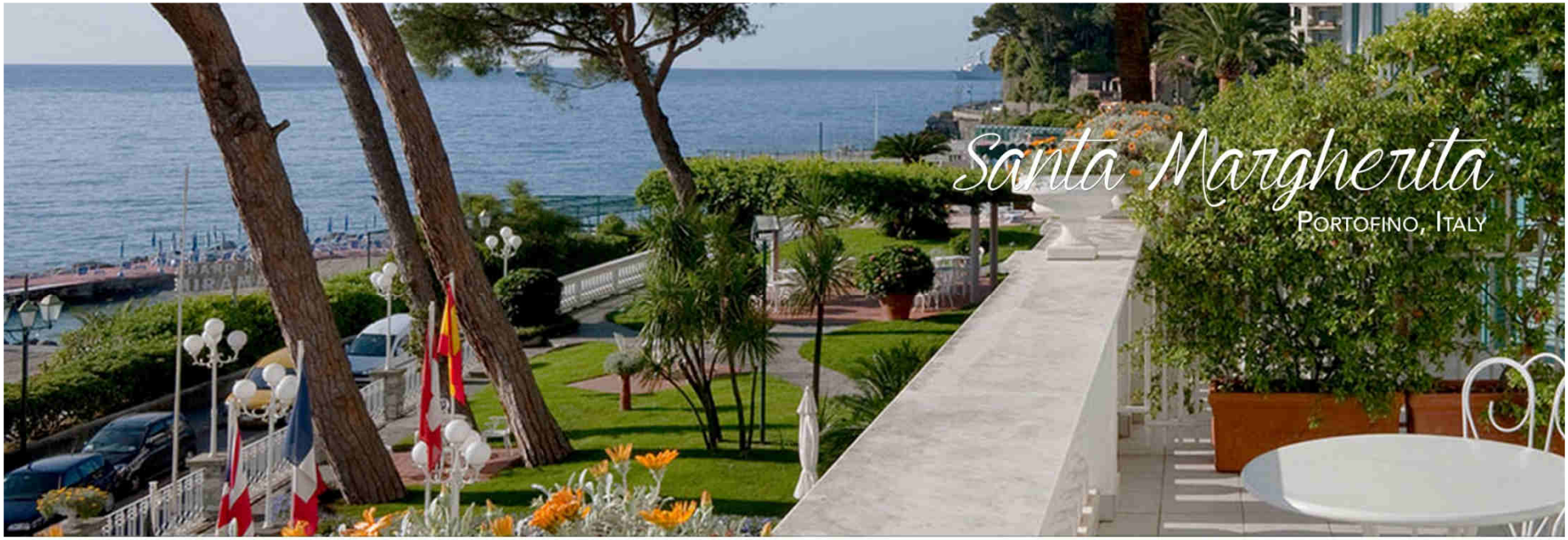


New Horizons for Desalination

MED-ADT: A NEW DESALINATION TECHNOLOGY FOR GEOTHERMAL ENERGY EXPLOITATION

Marco Garzoglio - Fisia Italimpianti

Renewable energy: a challenge for the future

how to face it?

- increasing equipment efficiency
  - same production with lower energy consumption -

- reducing carbon foot print
  - use of green power source -

Typical renewable energy sources:

Wind

Solar

Geothermal

Geothermal energy

What is it?

It is the thermal energy contained in the rocks and fluids that fill the fractures and pores within the rocks, in the Earth's crust.

Where does it come from?

It is the thermal energy generated and stored in the Earth.

The geothermal energy of the Earth's crust originates from the original formation of the planet (20%) and from radioactive decay of materials (80%).

How much?

The Earth's geothermal resources are theoretically more than adequate to supply humanity's energy needs

Geothermal energy

How to exploit it?

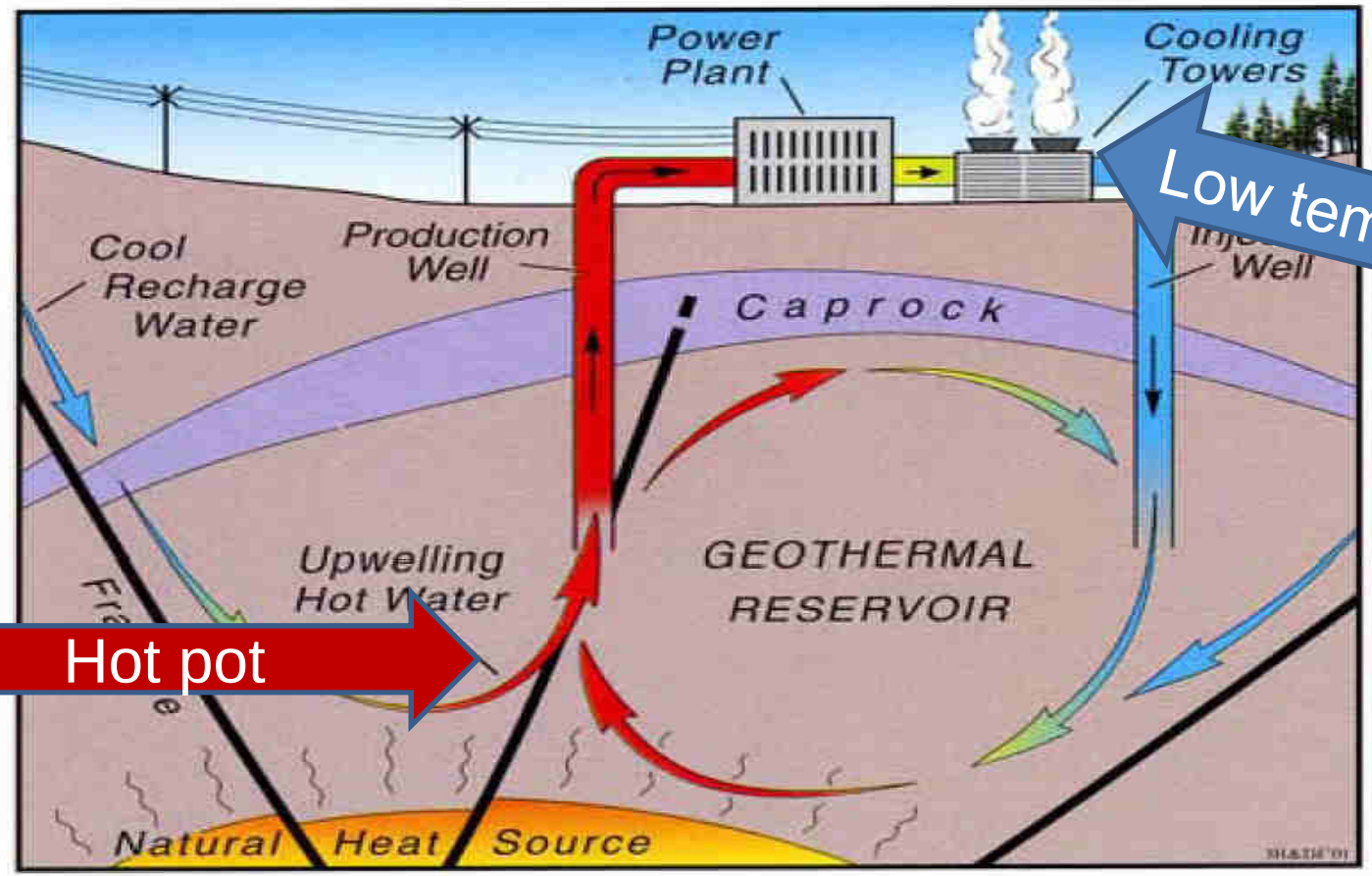
It is necessary to have two sources:

- an energy source, at high temperature (hot source or hot pot)
- a low temperature pot

The temperature difference between the two sources works as

driving force

Geothermal energy as renewable energy:



Available Geothermal Energy

There are 2 types of geothermal energy sources

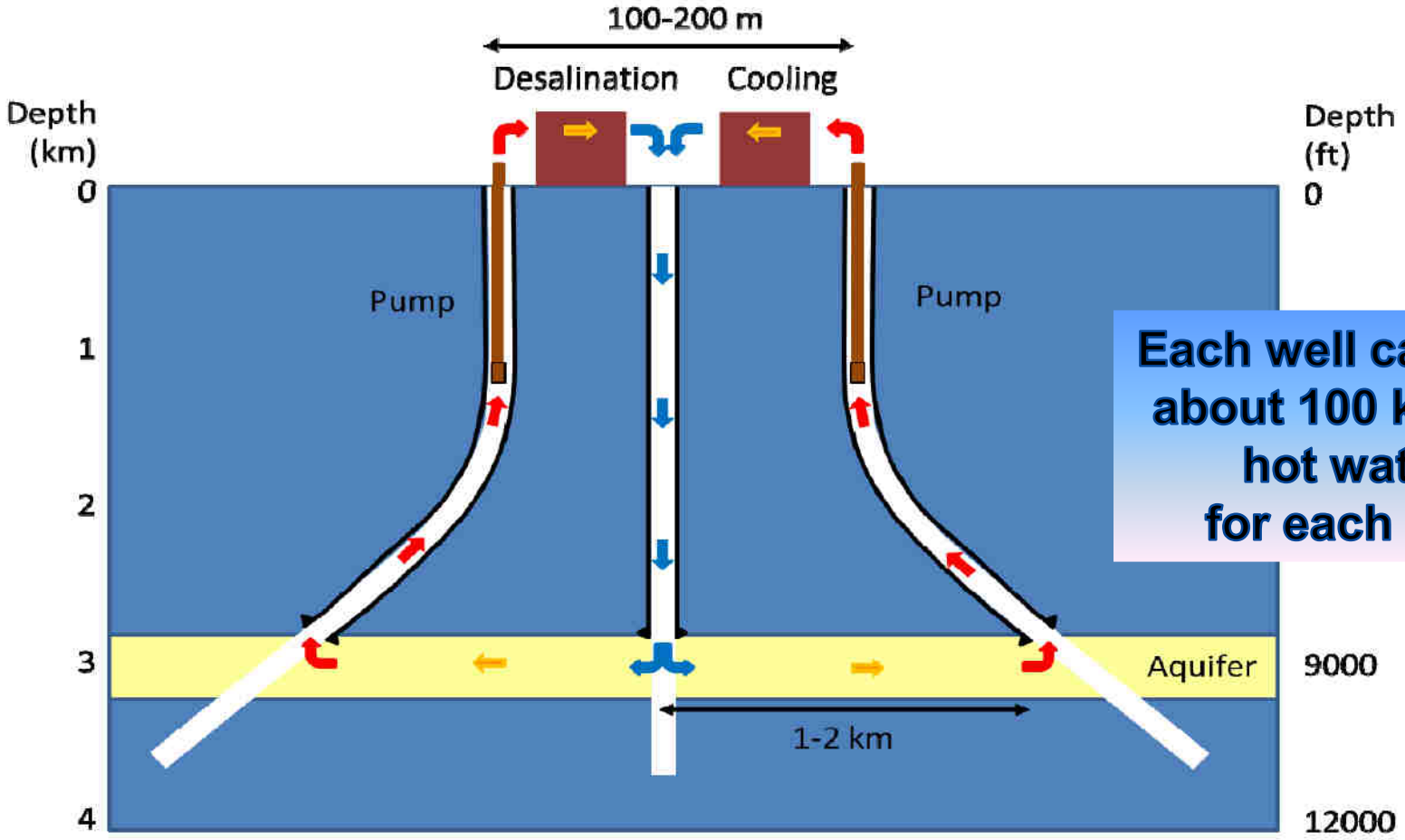
1. **Medium / High Enthalpy**

- 150 to 300°C
- low availability (only in volcanic areas)
- ideal for electric power conversion

2. **Low Enthalpy**

- 100 to 150 °C
- good availability
- ideal for thermal desalination

Geothermal wells for desalination



Each well can give about 100 kg/s of hot water for each km²

Geothermal Wells

Depth:

the required geothermal wells depth is in the range

1500 - 3000 m

Diameter:

the diameter has to be the required one to supply the proper amount of hot water, the expected diameter is about

250 – 300 mm

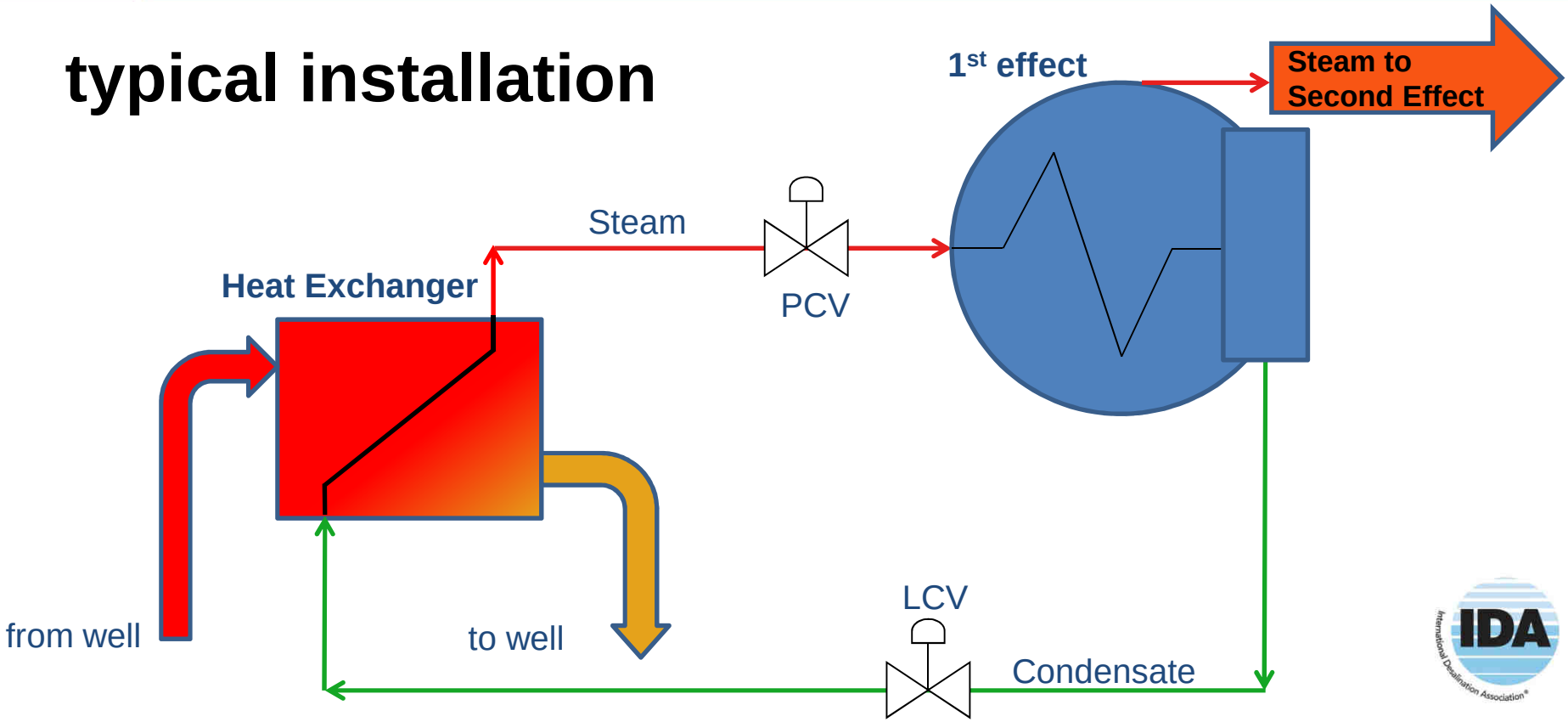
Current typical installation

The hot water coming from geothermal well is sent to a heat exchanger where it releases its energy, the condensate coming from the first effect absorbs the energy and turns to steam

The steam flows to the first effect as energy input for the MED unit

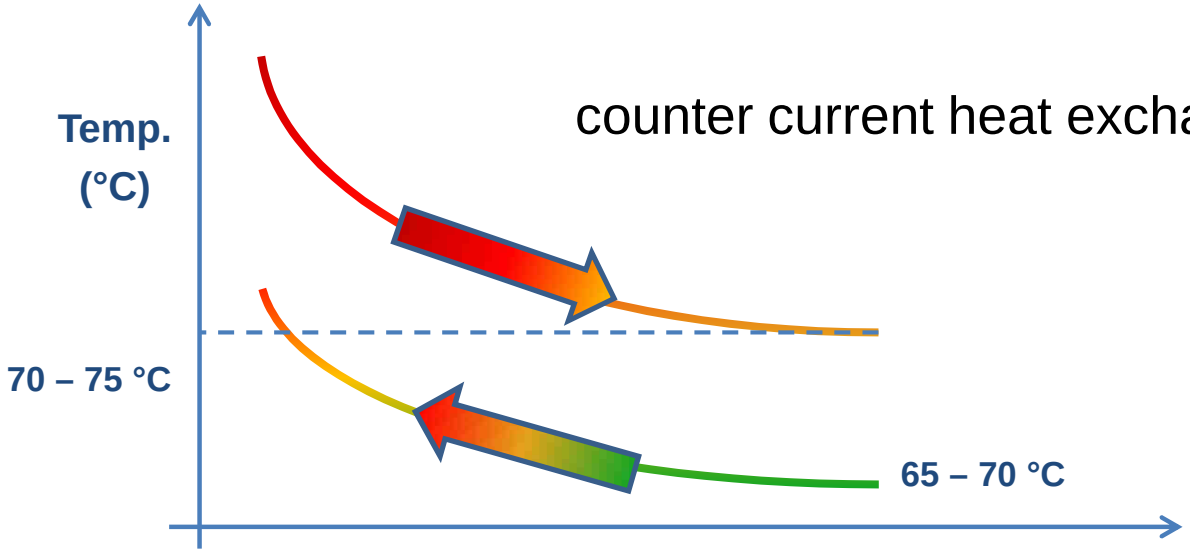
Nowadays geothermal energy to desalination

typical installation



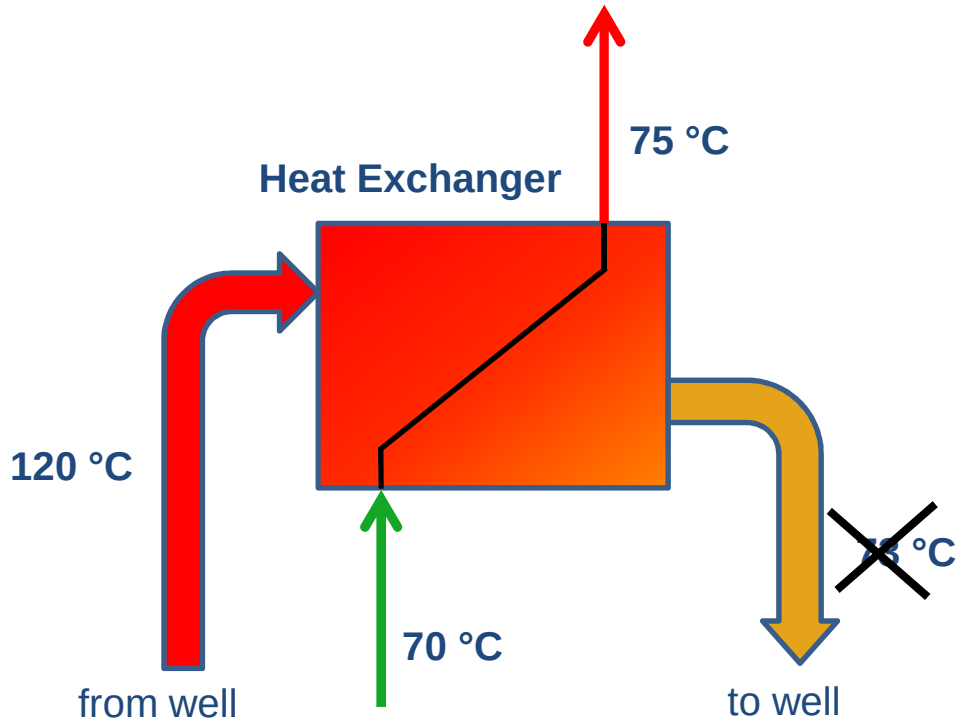
Current typical installation

It is nowadays possible to have a minimum geothermal water temperature of about 70 – 75 °C at the heat exchanger outlet, since the minimum temperature of the cold fluid, condensate coming from first effect, is about 65 – 70 °C:



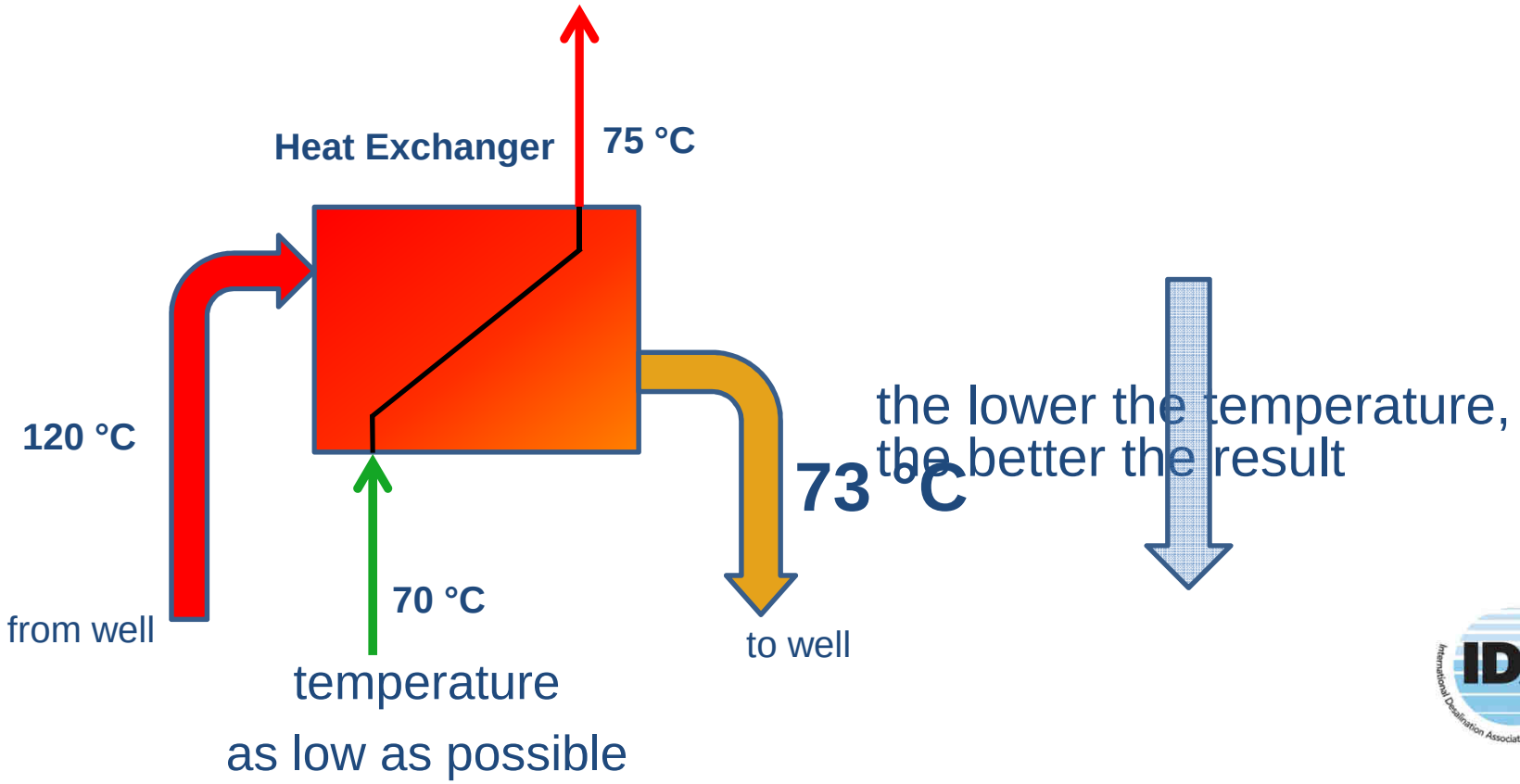
counter current heat exchange type

from/to well (in figures)



In this case,
the more the better
isn't true

Geothermal energy is free of charge



Efficiency improving

It is necessary to reduce as much as possible the temperature of the water to be re-injected in the ground in order to maximize the exploitation of the geothermal energy

The only way is:

to reduce the temperature of the cold stream fed to the heat exchanger

The question is:

how to achieve it?

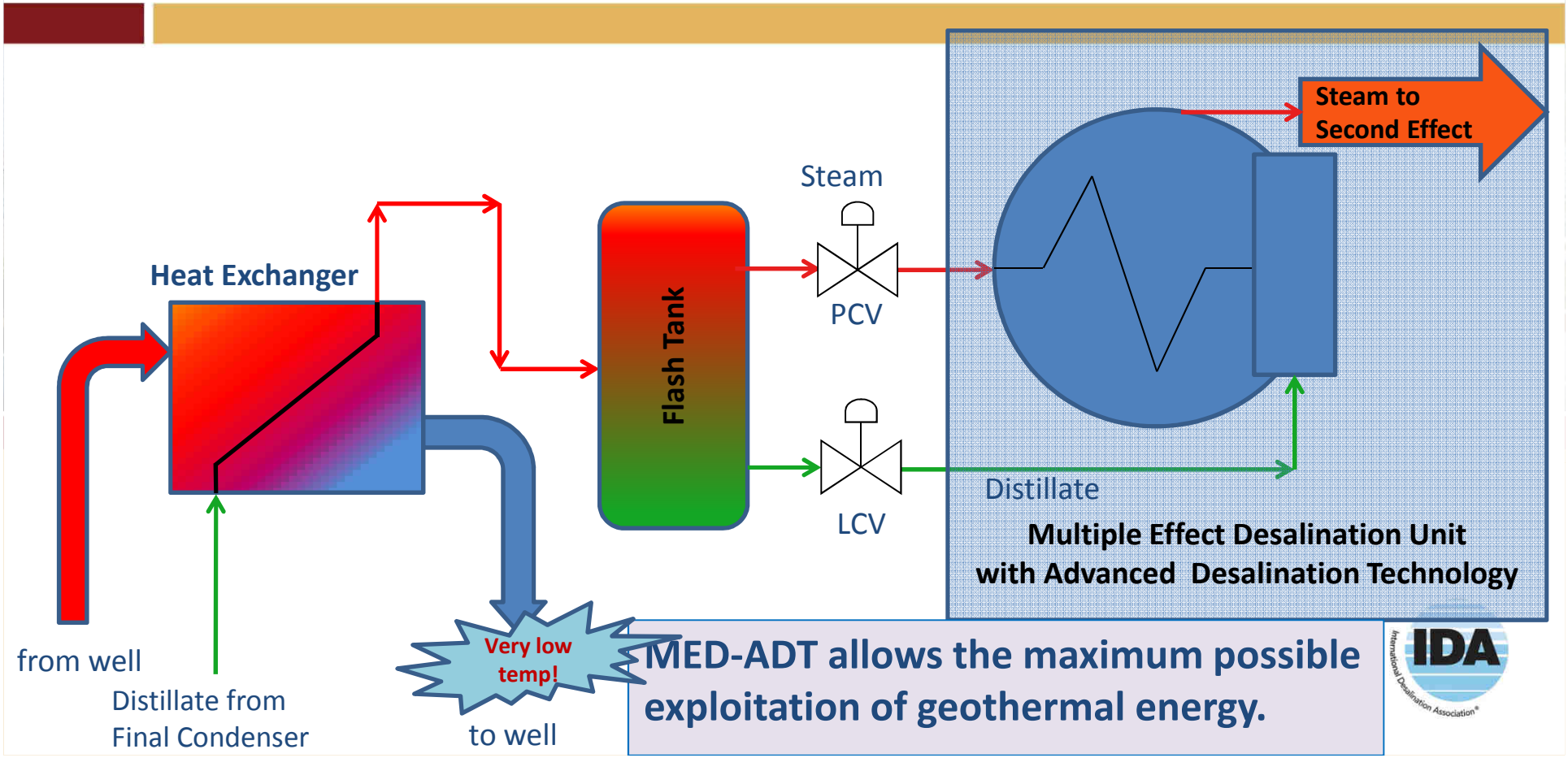
MED – Advanced Desalination Technology

- A portion of the produced distillate from the Final Condenser, and thus at minimum possible temperature, is sent to the heat exchanger and then to a flash tank
- Both steam and hot distillate, from flash tank, feed the first effect

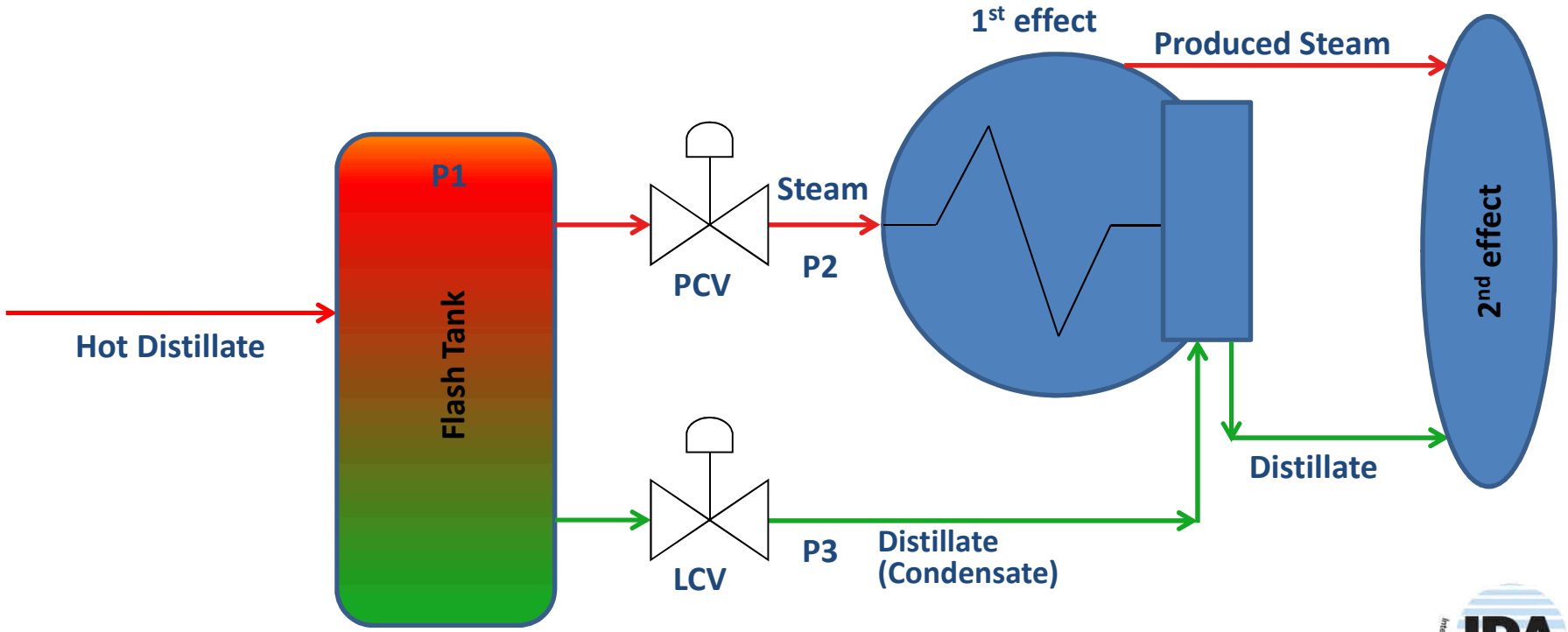
In the first effect:

- Steam releases its own latent enthalpy and condenses
- Distillate reduces its temperature reaching the equilibrium temperature for the effect and releasing a further portion of steam
- Both steam and distillate from the first effect outlet are the heat input for the second effect
- The above is repeated up to the last effect

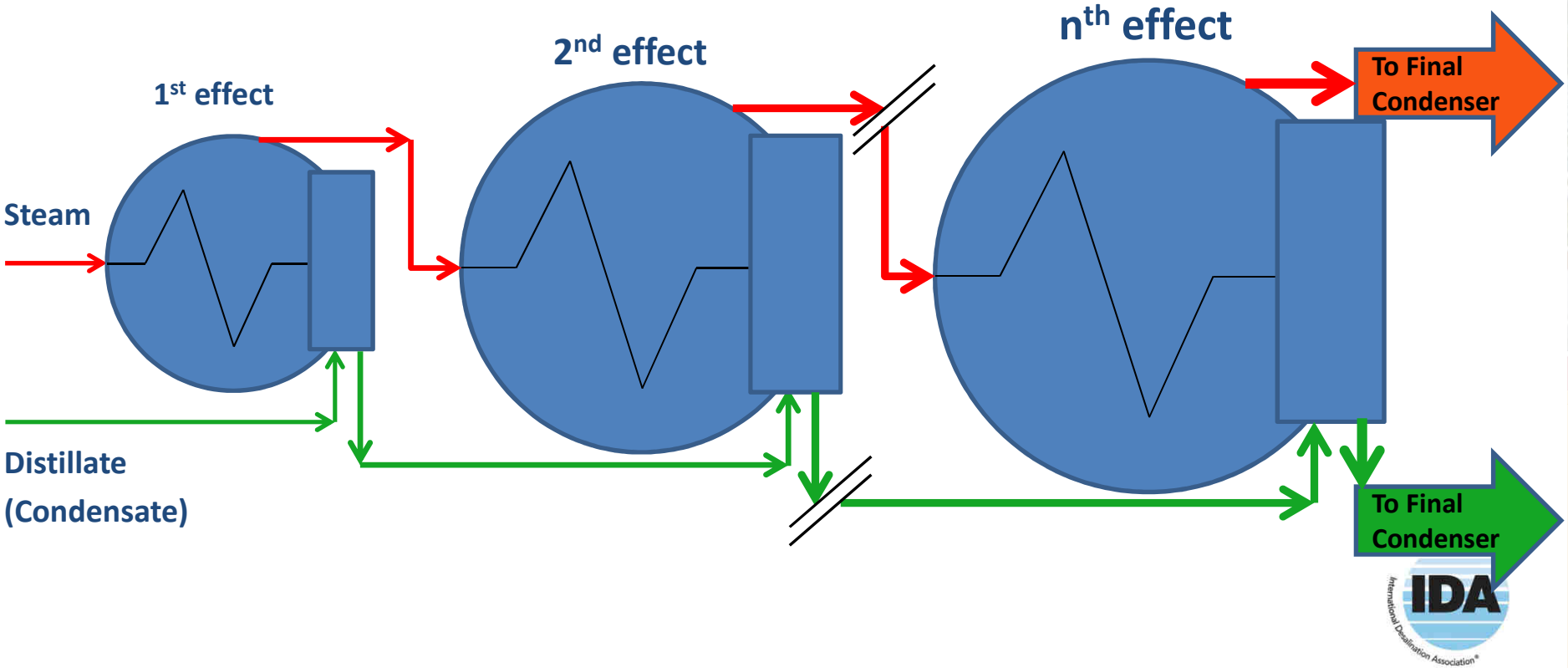
A relevant plant flow diagram



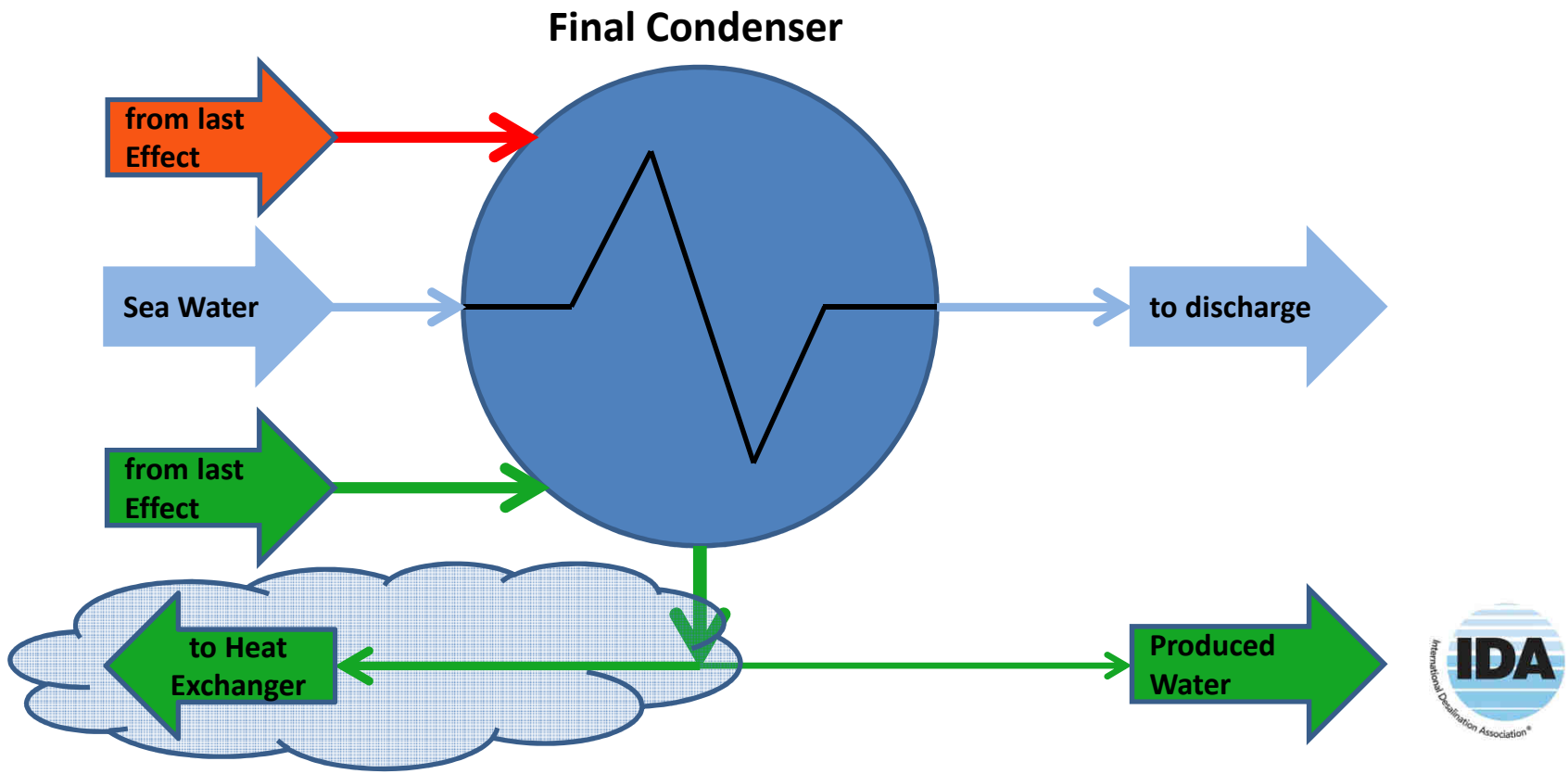
MED – ADT 1st effect



MED – ADT Unit


1st effect
2nd effect
nth effect
Steam
Distillate
(Condensate)
To Final
Condenser
To Final
Condenser
IDA
International Desalination Association

from Last Effect to Final Condenser



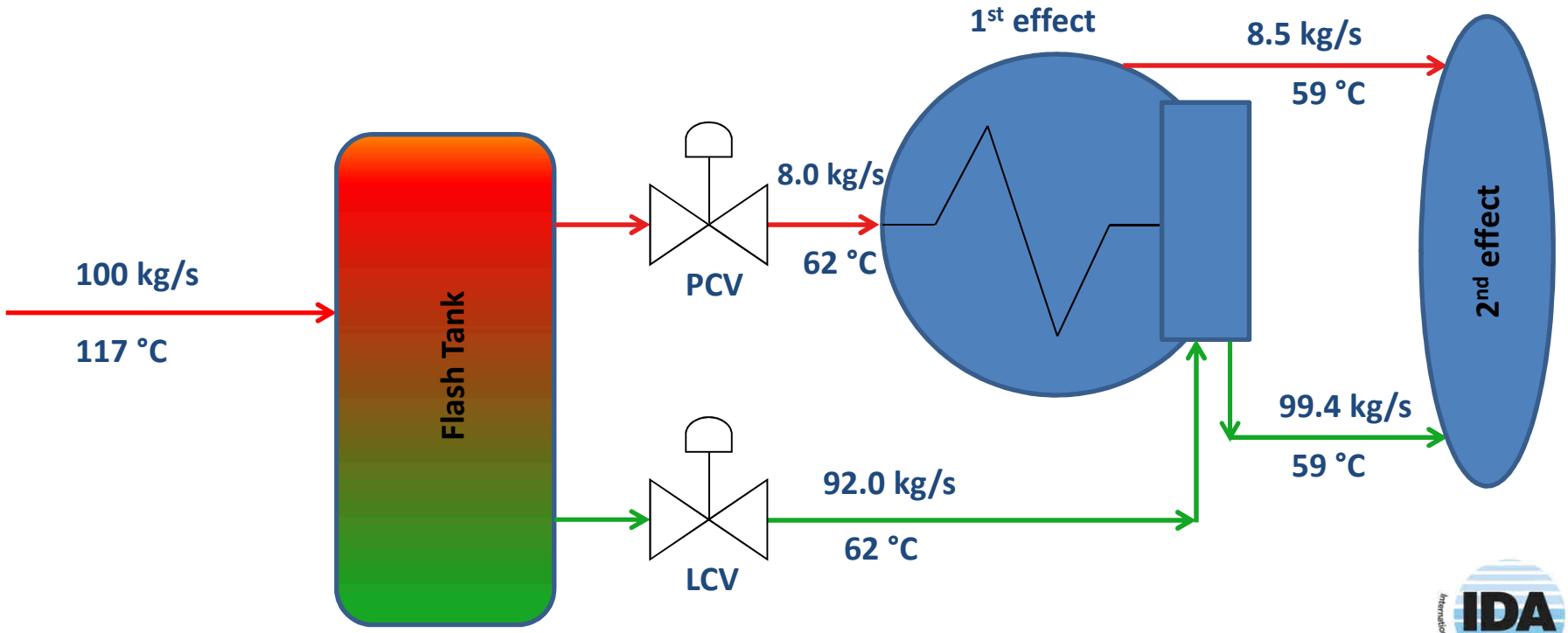
Fluid at minimum temperature

- **The temperature of the produced distillate in the Final Condenser is the minimum one being directly related to the sea water actual condition**

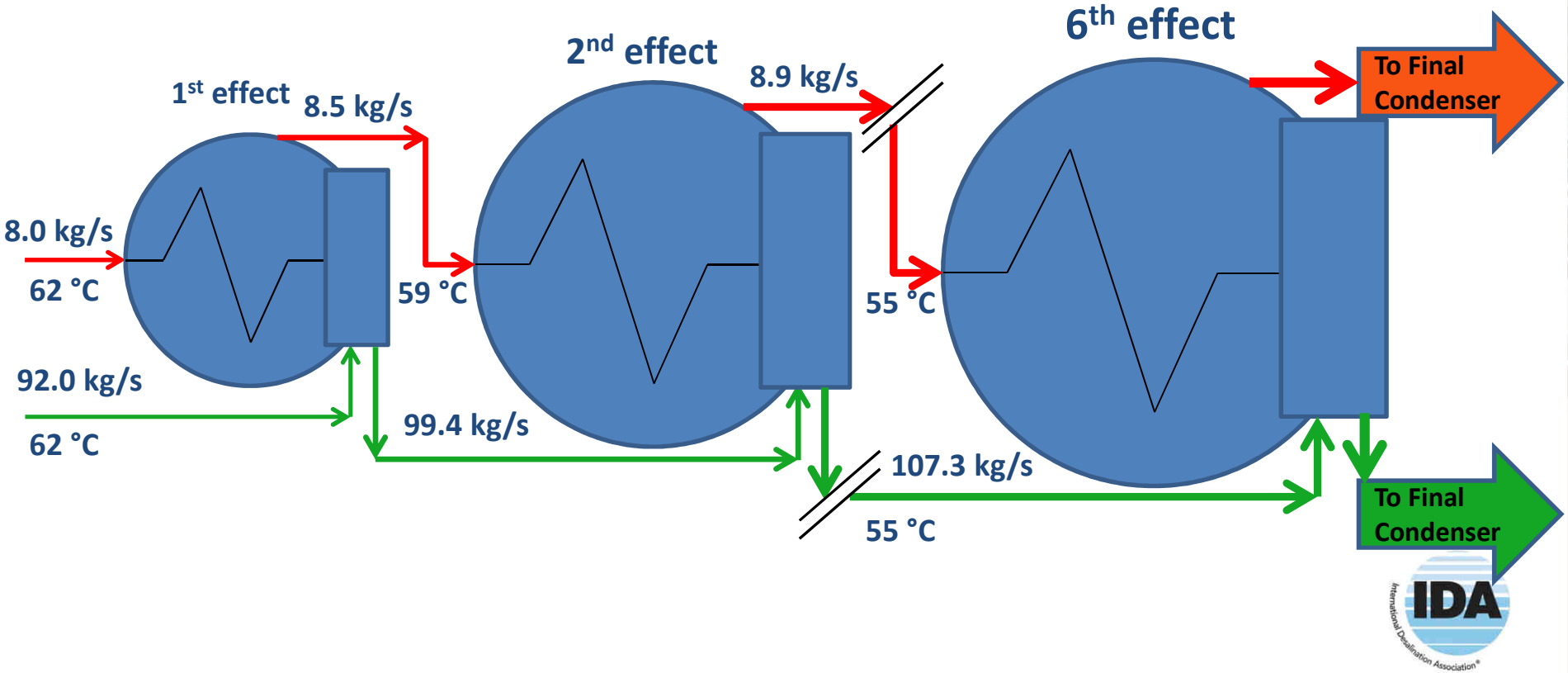
- **Feeding the cold side of the heat exchanger geothermal water/distillate with a stream at minimum possible temperature allows to reduce as much as possible the temperature of the geothermal water to be re-injected in the ground**

- **It leads to the maximum geothermal energy exploitation**

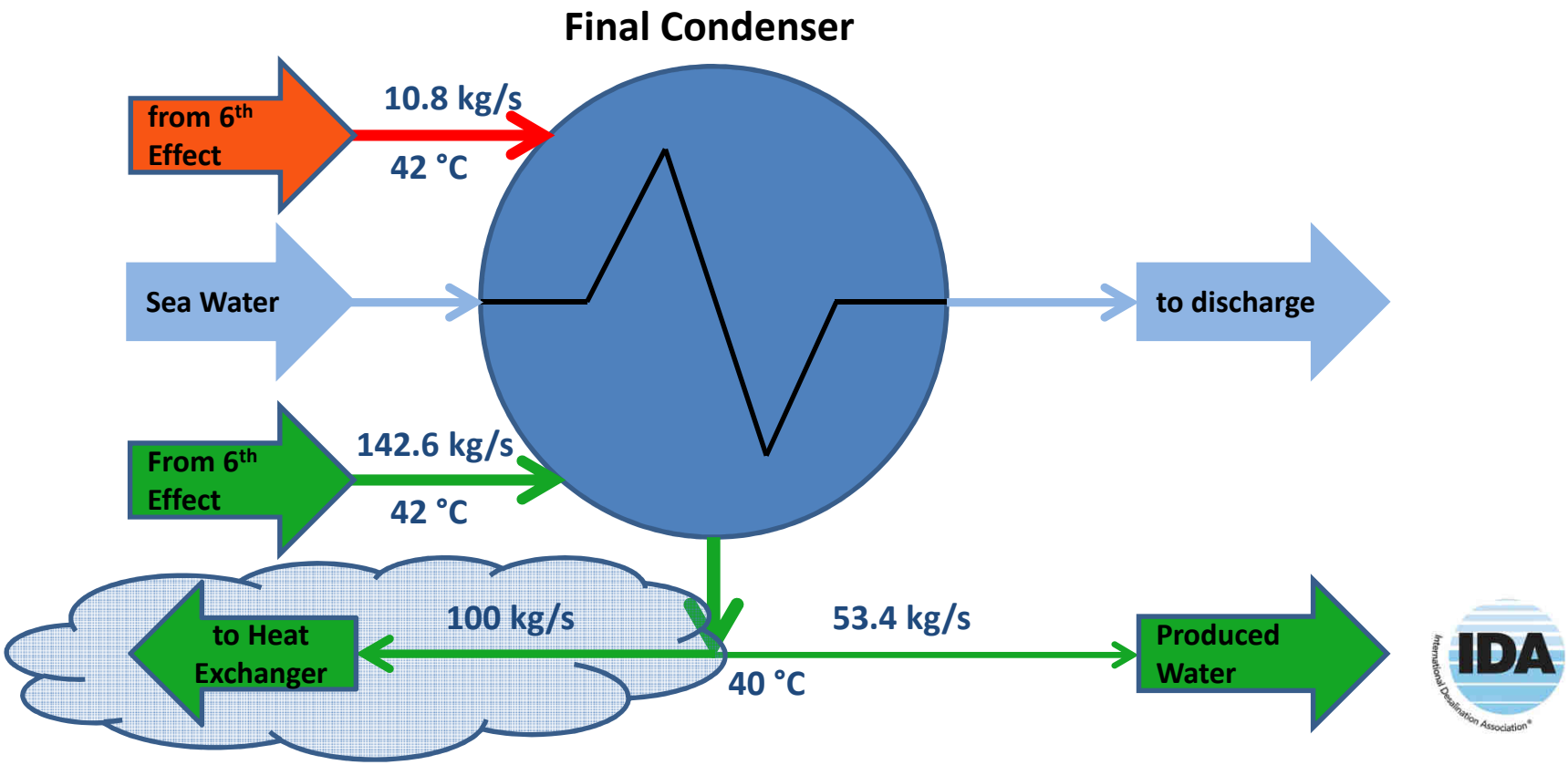
MED – ADT 1st effect (in figures)



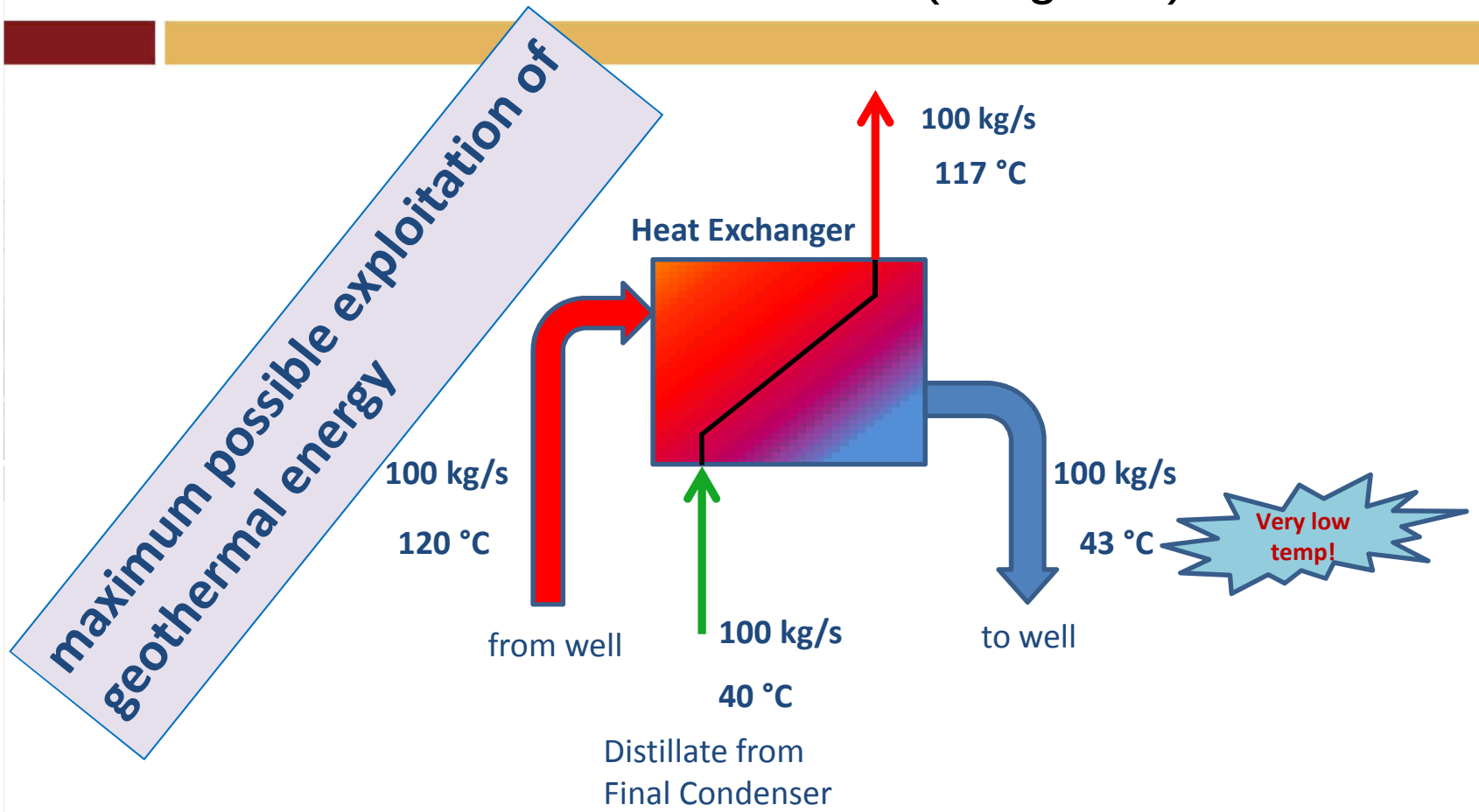
MED – ADT Unit (in figures)



from 6th Effect to Final Condenser (in figures)



from/to well (in figures)



Plant operating parameters (based on 1 km^2 area)

PARAMETER	M.U.	VALUE
Hot water from geothermal well (@ 120°C)	kg/s	100
Sea water flow (@ 32 °C)	kg/s	870
Distillate water flow	kg/s	53.4
Product water daily capacity	t/d	4,614
Plant GOR	kg_D/kg_V	6.7
Auxiliary power consumption for desalination	kW	410
Auxiliary power consumption for geothermal	kW	250

The Plant OPEX:

a comparison with MED / TVCs fuel based

PLANT DESCRIPTION	Production (t/y)	GOR (kg/kg)	Heat Cons. (MJ/s)	Heat Cost ($/GJ)	Aux power Cons. (kW)	Aux Power cost (c$/kWh)	Energy cost (M$/y)	Other OPEX (M$/y)	Overall OPEX (M$/y)
MED / TVC LOW P.R. (fuel based)	1.684.022	5,5	23,3	4,0	430	3	3,0	0,3	3,3
MED / TVC AVERAGE P.R. (fuel based)	1.684.022	8,0	16,0	4,0	430	3	2,1	0,3	2,4
MED / TVC HIGH P.R. (fuel based)	1.684.022	10,2	12,6	4,0	430	3	1,6	0,3	1,9
MED-ADT (geothermal based)	1.684.022	6,7	19,1	0,0	693	3	0,2	0,4	0,6

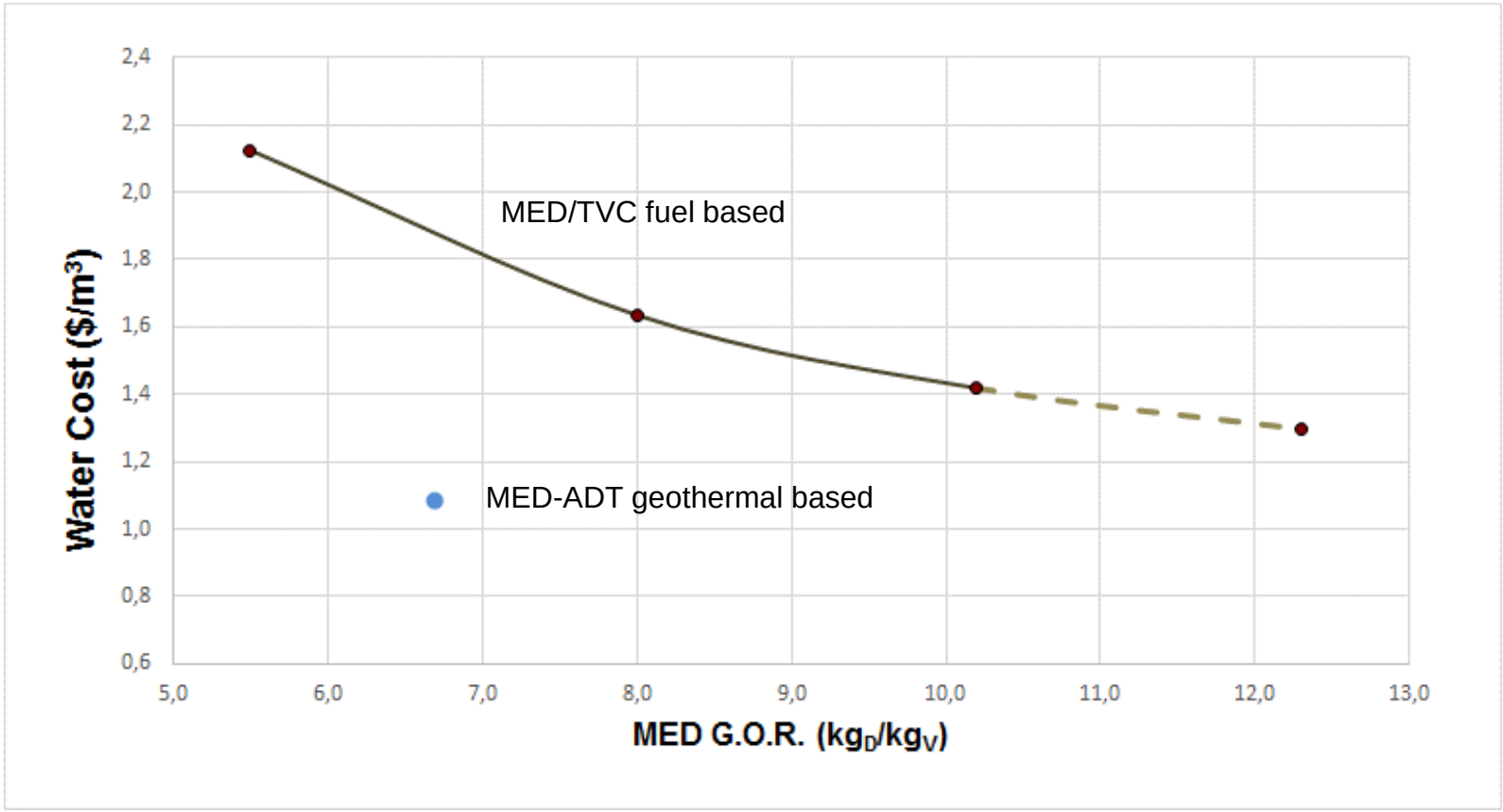
The Water Cost:

a comparison with MED / TVCs fuel based

PLANT DESCRIPTION	Production (t/y)	GOR (kg/kg)	CAPEX cost (M$)	Mortage period (y)	Annual interest rate (%)	Net Present Value Factor	OPEX cost (M$/y)	Water cost calculation formula	Water cost ($/m3)
MED / TVC LOW P.R. (fuel based)	1.684.022	5,5	3,6	25	7%	11,7	3,3		2,1
MED / TVC AVERAGE P.R. (fuel based)	1.684.022	8,0	4,3	25	7%	11,7	2,4		1,6
MED / TVC HIGH P.R. (fuel based)	1.684.022	10,2	5,0	25	7%	11,7	1,9	$\frac{(CAPEX + OPEX * NPVF)}{(Production * NPVF)}$	1,4
MED-ADT (geothermal based)	1.684.022	6,7	14,3 (*)	25	7%	11,7	0,6		1,1

(*) including geothermal plant

Water Cost vs. MED Performance



MED - Advanced Desalination Technology

The presented idea,
about how to exploit fully
the available geothermal energy
coming from underground water,
has been patented by Fisia Italimpianti
in January 2015

Other MED - ADT possible applications

to recover energy from low enthalpy industrial discharges like:

* Low pressure steam

  (humid and below atmospheric pressure)

* Low temperature exhaust gases

* Low enthalpy waste water or waste heat from chemical processes

MED – ADT BREAKTHROUGHS

O&M cost reduced by more than 60%

Water cost reduced by more than 20%

Maximum exploitation of geothermal energy

Tens of thousands oil barrels saved every year: the Earth thanks.

In other words:
a good idea to contribute to a greenhouse effect reduction

for our offsprings' benefit

THANK YOU !