

TRANSFERÊNCIA DE CALOR e MASSA I

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- Luis.moura@ufpr.br

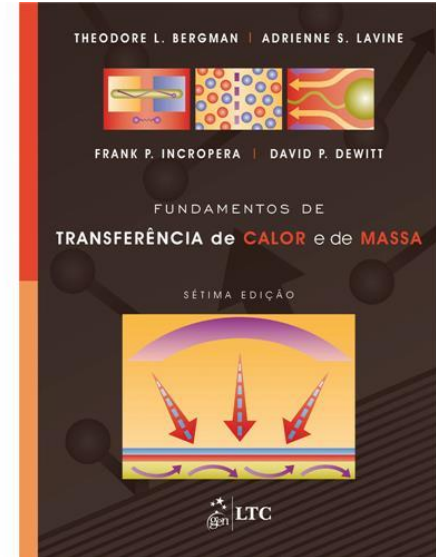
EMENTA

- Mecanismos básicos de transferência de calor. Lei de Fourier e o vetor fluxo de calor. A equação geral da condução e condições de contorno. Condução unidimensional em regime permanente, resistência térmica, geração de calor e aletas. Condução bidimensional em regime permanente. Condução transiente: método da capacitância global. Métodos numéricos e simulação computacional aplicada à condução de calor. Conceitos fundamentais da radiação: feixe, onda, partícula, repartição espectral, fontes, sensores e propagação. Radiação de um corpo negro. Lei de Kirchoff. Lei de Wien. Troca de calor entre as superfícies. Introdução: Mecanismos Básicos de Transferência de Calor.

Data	nº de aulas	Total	Programa
16/02	2	2	Aula Introdutoria - apresentação da metodologia - Exemplos e aplicações. Cap. 1 - Introdução à Transferência de Calor: Condução, Convecção e Radiação.
18/02	2	4	Reunião ABCM
23/02	2	6	Cap. 1 - Introdução à Transferência de Calor: Condução, Convecção e Radiação. Conservação da Energia.
25/02	2	8	Cap. 1 - Conservação da Energia - Ex. 1.3, 1.4 e 1.5.
01/03	2	10	Cap. 2 - Introdução à Condução - Eq. Da Difusão e Condições de contorno.
03/03	2	12	Cap. 3 - Condução em Regime Permanente: Analogia Elétrica - Circuito Térmico Equivalente. Condução em Regime Permanente: Parede Composta.
08/03	2	14	Cap. 3 - Resistência de Contato. Sistemas Radiais - Espessura Crítica. Sistemas Esféricos - Problemas com geração de Energia.
10/03	2	16	Cap. 3 - Introdução à Aletas - Formulação Geral - Dedução, Condições de contorno, Desempenho e efetividade de aletas.
15/03	2	18	Cap. 3 - Aletas - Eficiência Global - Ex. Projeto de Aletas.
17/03	2	20	Cap. 4 - Condução Bidimensional - Solução Analítica.
22/03	2	22	PROVA 1
24/03	2	24	Cap. 4 - Condução Bidimensional - Solução por Método Numérico.
29/03	2	26	Cap. 5 - Condução Transiente - Método Capacitivo.
31/03	2	28	Cap. 5 - Condução Transiente.
05/04	2	30	Cap. 12 - Introd. a Radiação.
07/04	2	32	Cap. 12 - Introd. a Radiação: Radiação de Corpo Negro.
12/04	2	34	Cap. 12 - Prop. de Superfícies. Cap. 13 - Fator de Forma.
14/04	2	36	Reunião ABCM
19/04	2	38	PROVA 2
21/04	0	38	FERIADO
23/04	0	40	Encerramento do semestre letivo e entrega de notas
26/04	2	40	PROVA FINAL
28/04			Prova de 2ª Chamada: Prova 1 e Prova 2
01/05			Prazo para entrega das cadernetas

BIBLIOGRAFIA

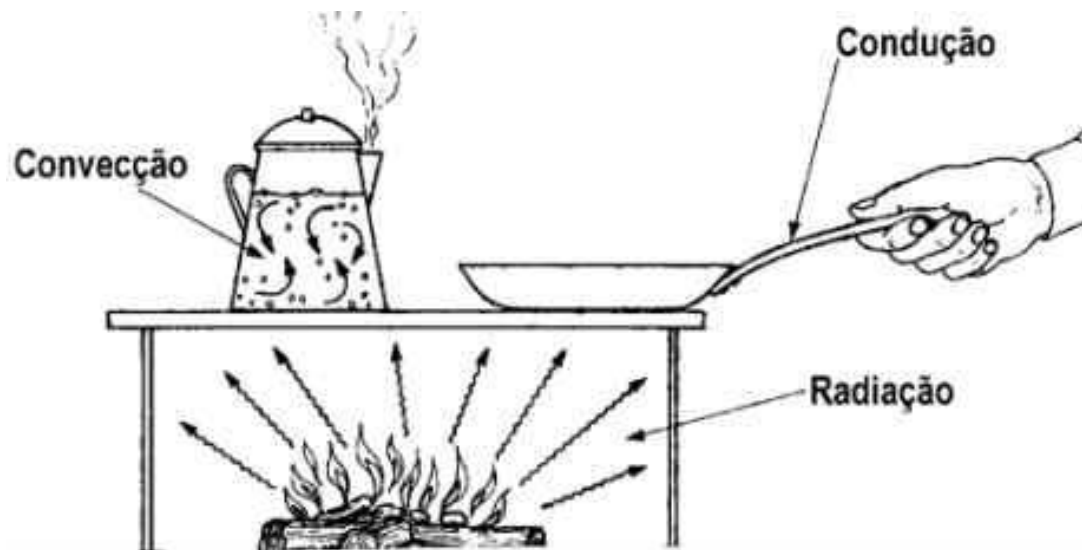
- **Básica:**
- **INCROPERA, F.P. e DE WITT D.P. Fundamentos de Transferência de Calor e Massa, Guanabara Koogan 7ª Edição, 2014.**
- **Complementar:**
- KREITH, F., BOHN, M., Princípios de Transferência de Calor, Editora: PIONEIRA, 1ª Edição 2003.
- ÖZISIK, M.N., Transferência de Calor: Um texto Básico, Editora Guanabara, 1990.
- HOLMAN, J.P. Transferência de calor. Ed. McGraw-Hil, 1997.



PROCEDIMENTOS DE AVALIAÇÃO

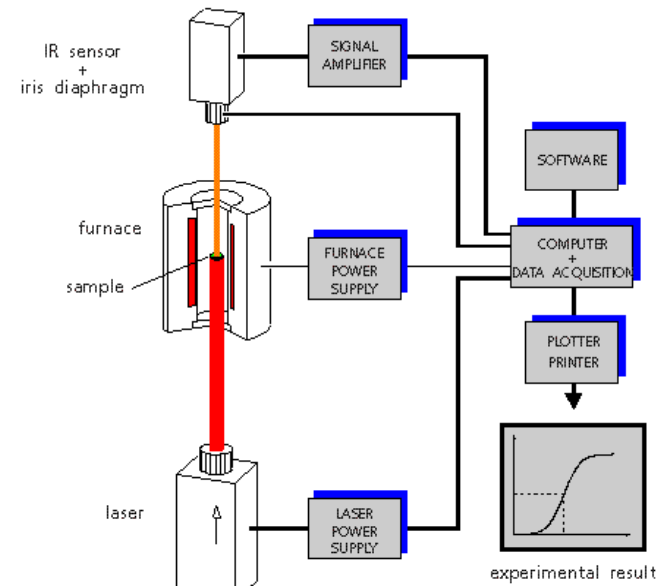
- Duas provas realizadas durante o bimestre (peso 80%), trabalhos (20%). Exame final.
- Não é permitido calculadoras com tela de alta definição em provas.

Transferência de Calor

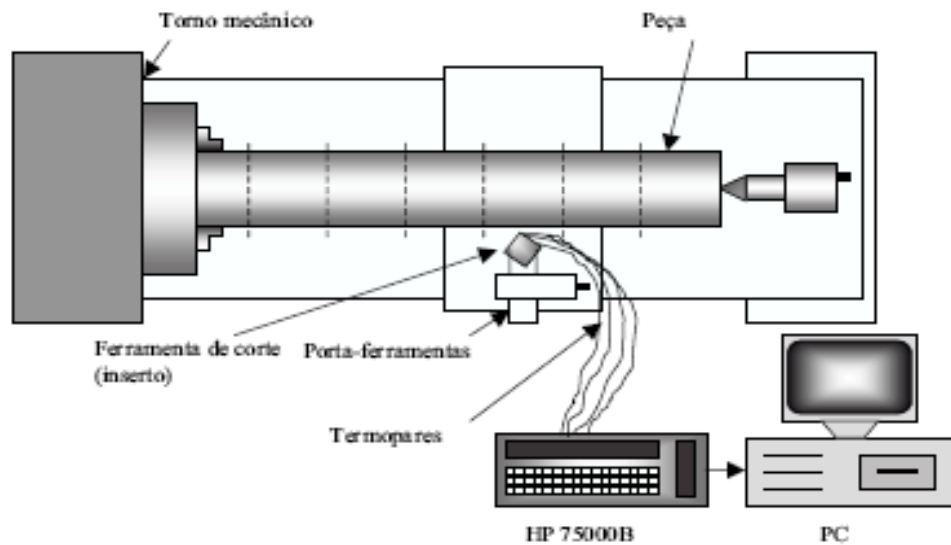


fisica.ufpr.br/grimm/aposmeteo/cap2/cap2-9.html

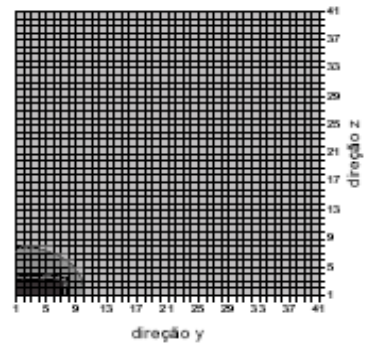
Condução



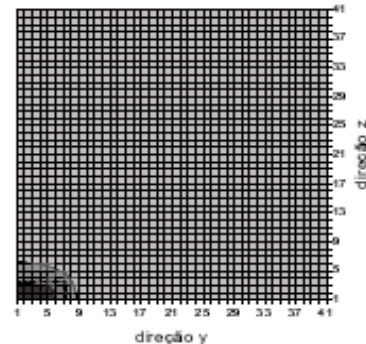
Laser Flash Apparatus
LFA 427

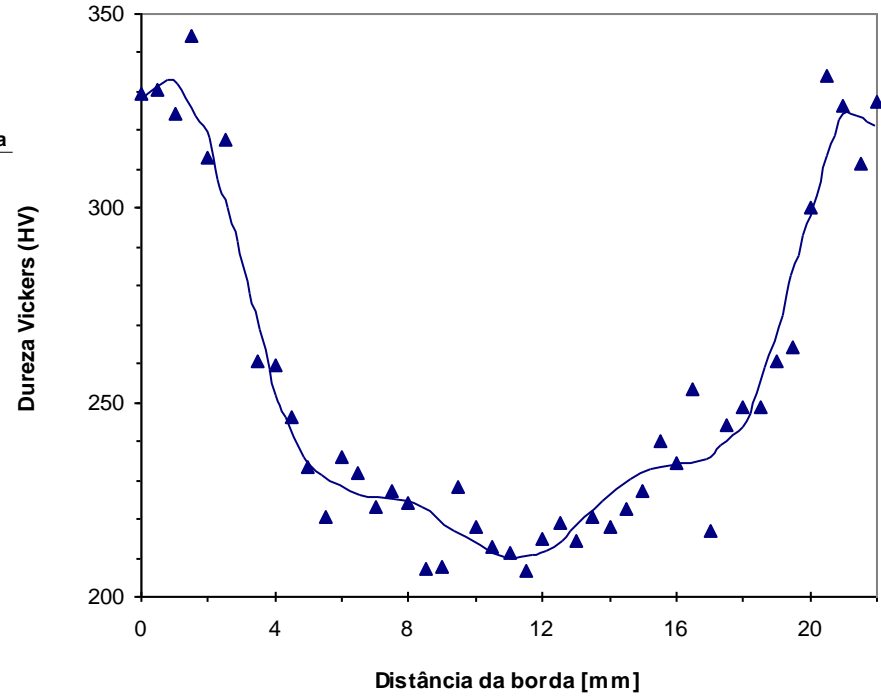
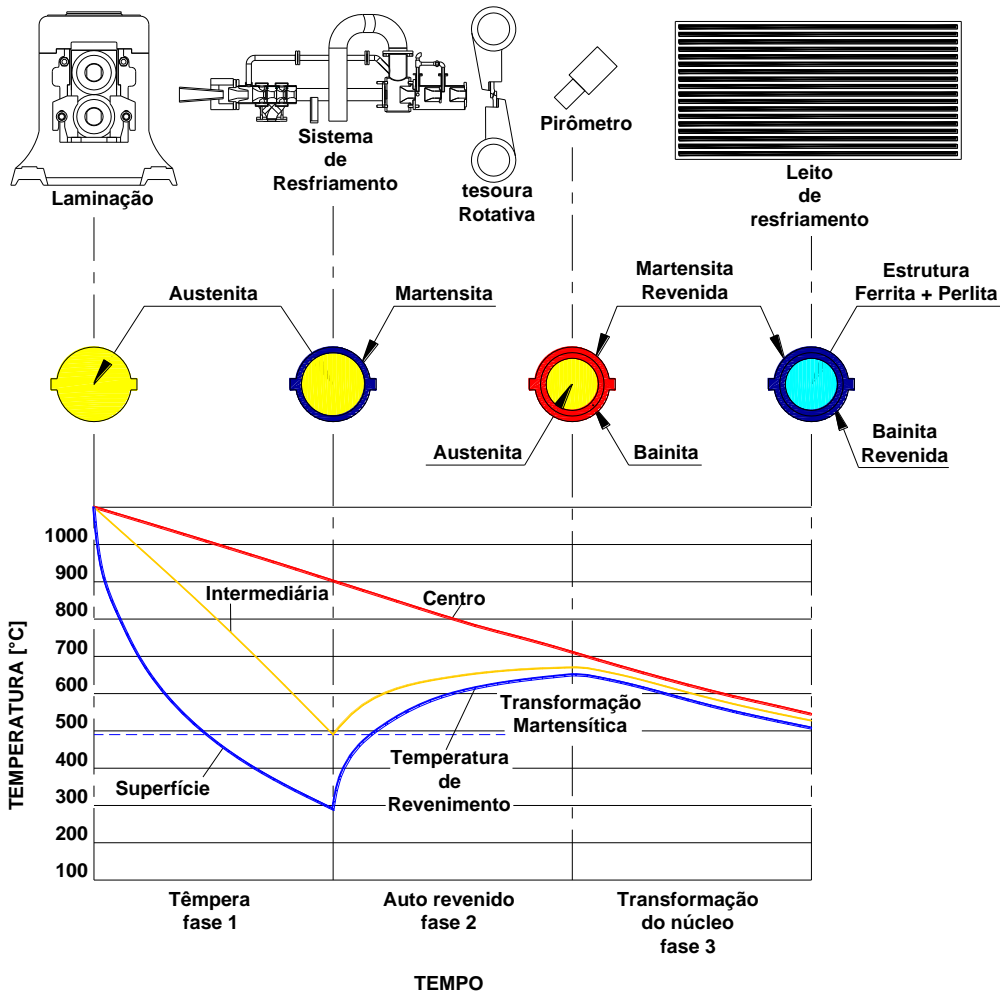


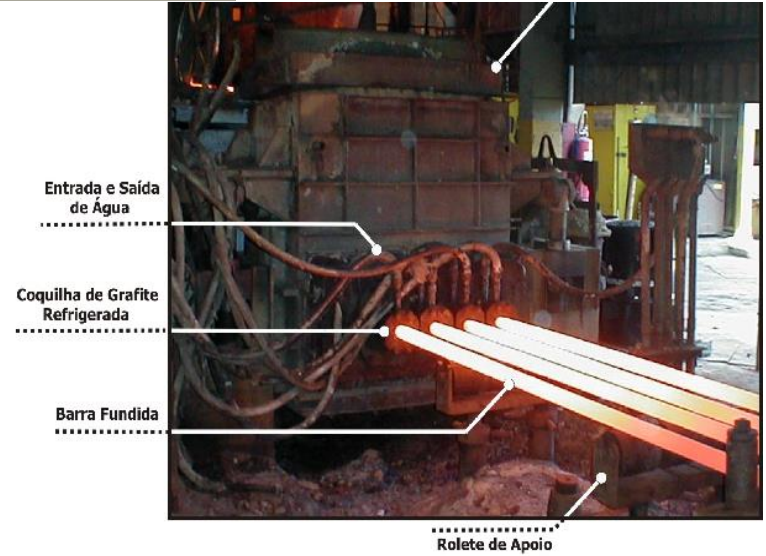
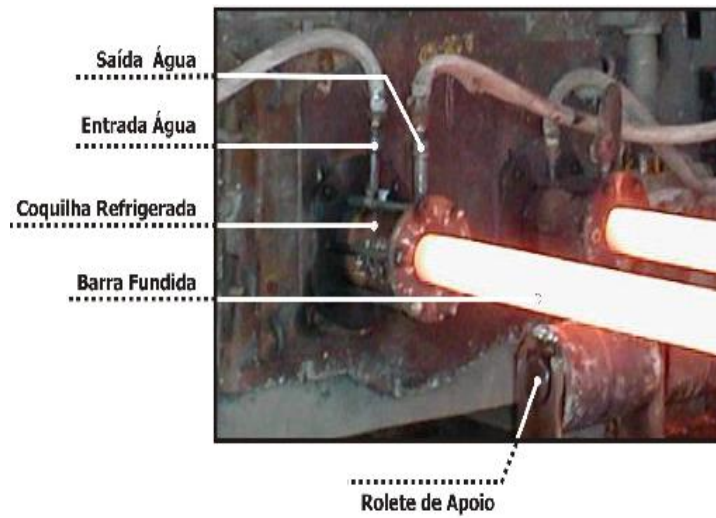
40-140 140-240 240-340 340-440 [°C]

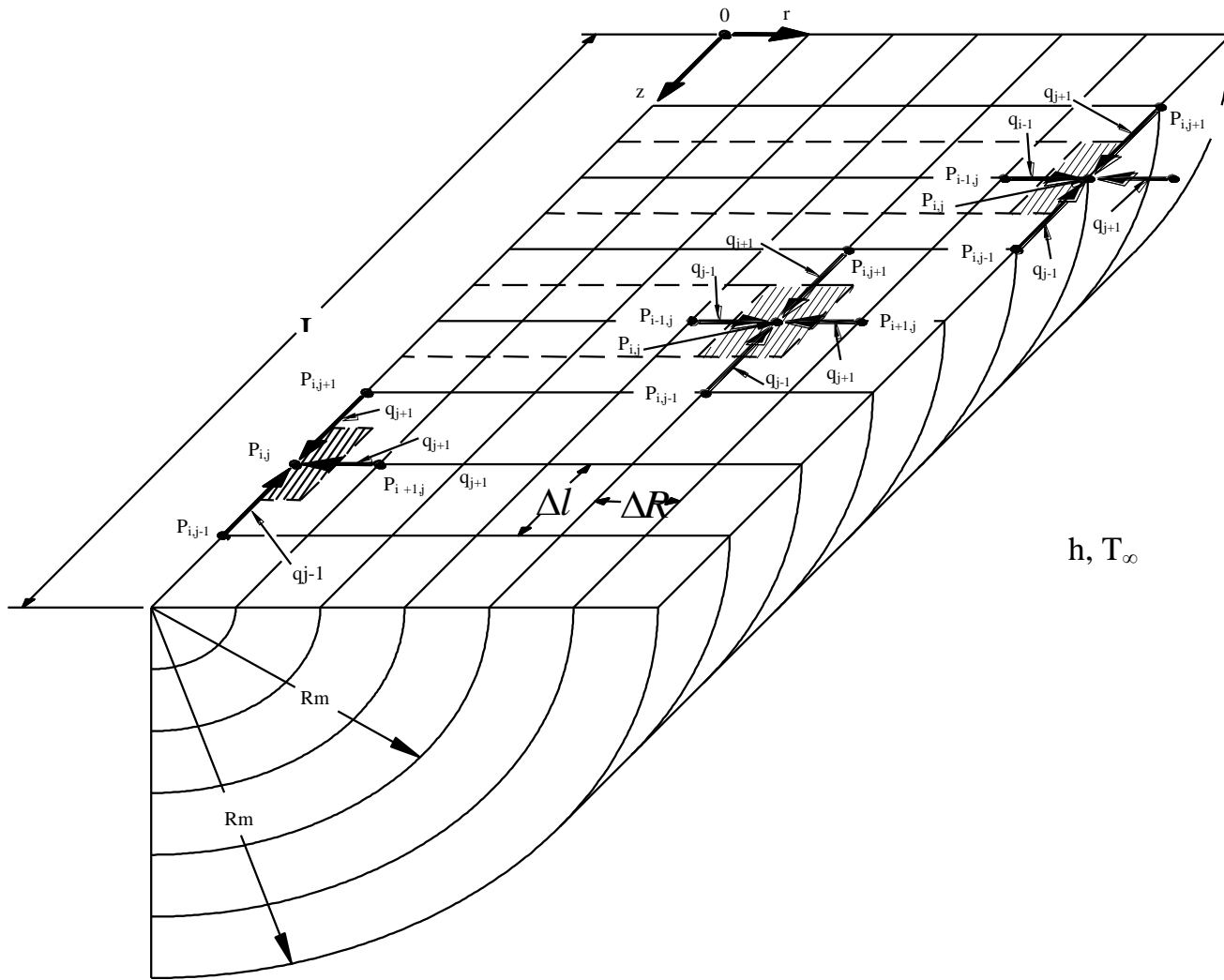


30-85 85-140 140-195 195-250 [°C]

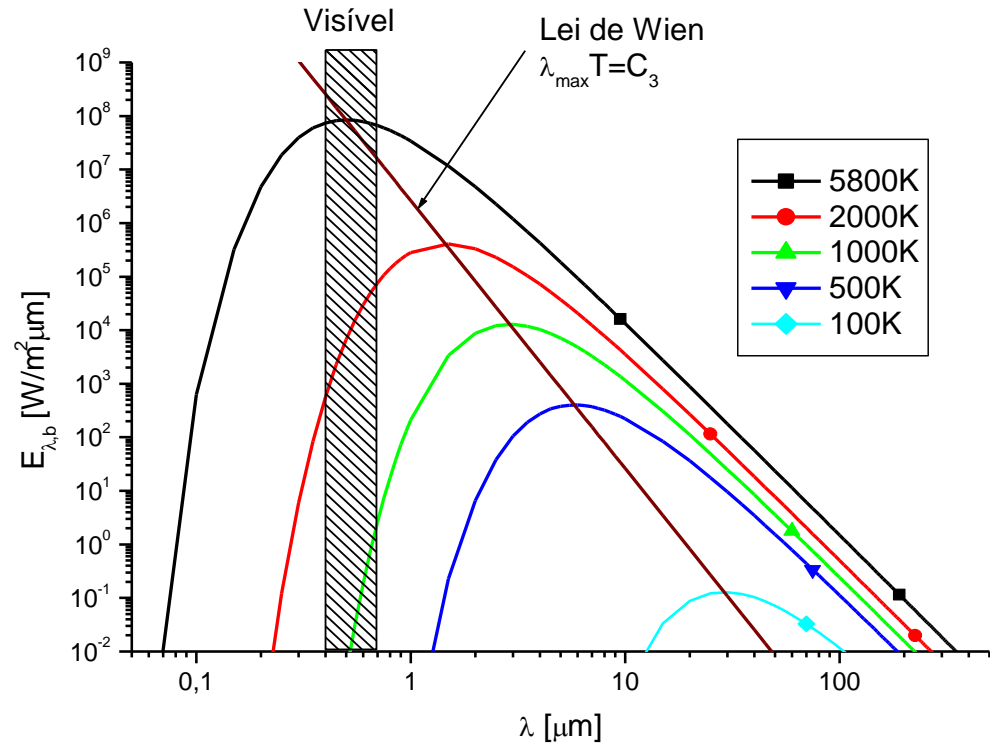
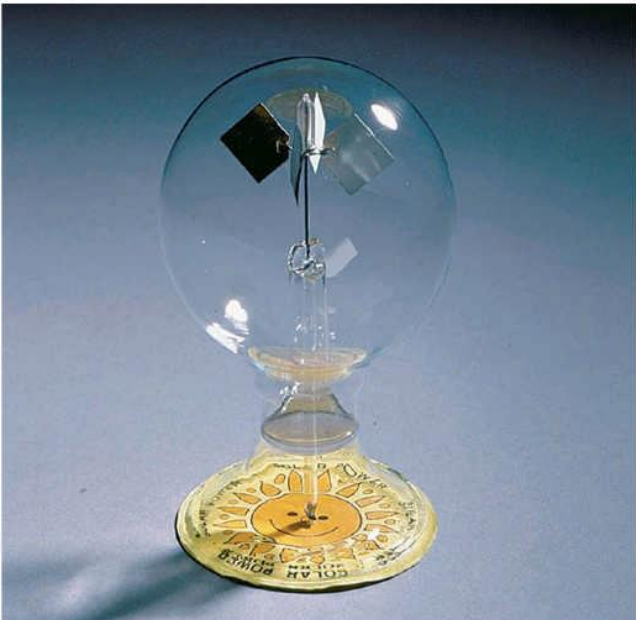








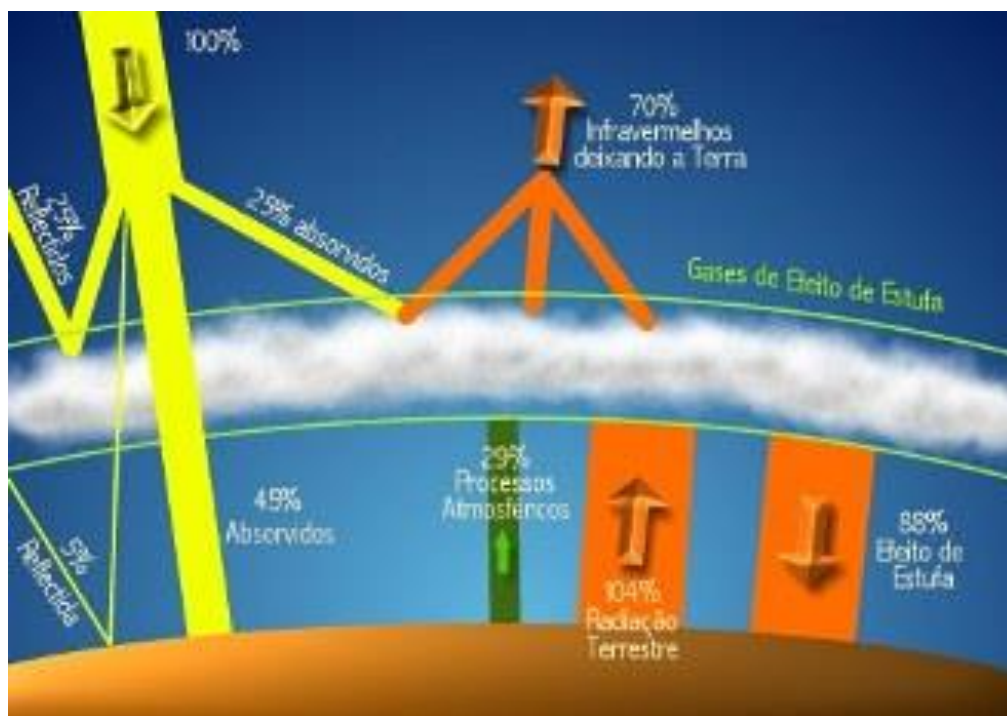
Radiação



Crookes Radiometer

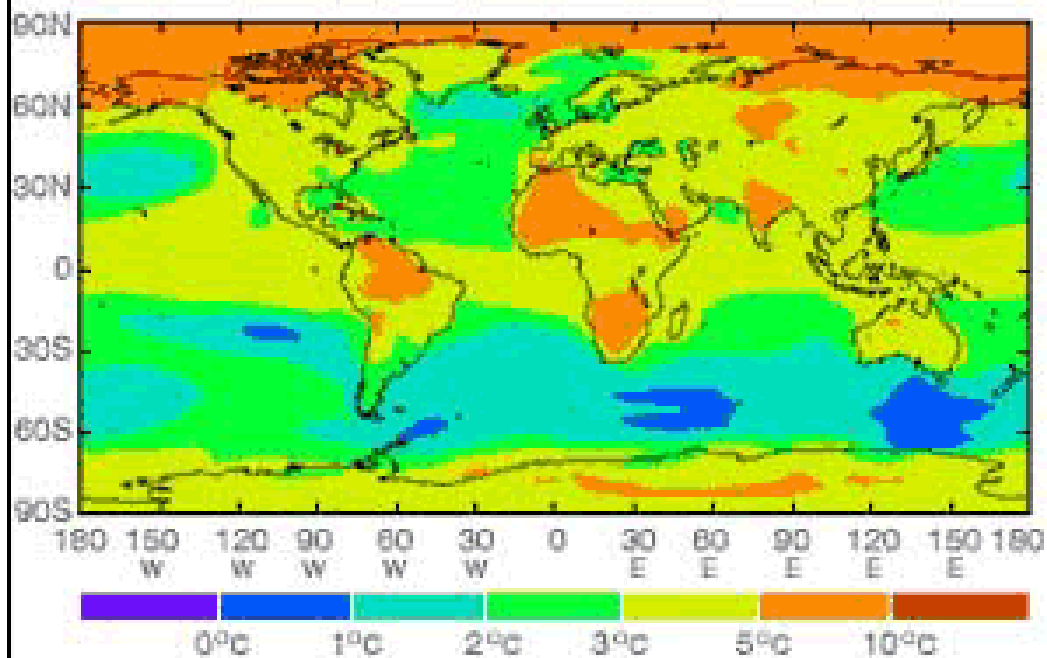


Efeito Estufa



Mudança prevista na temperatura média do ar na superfície

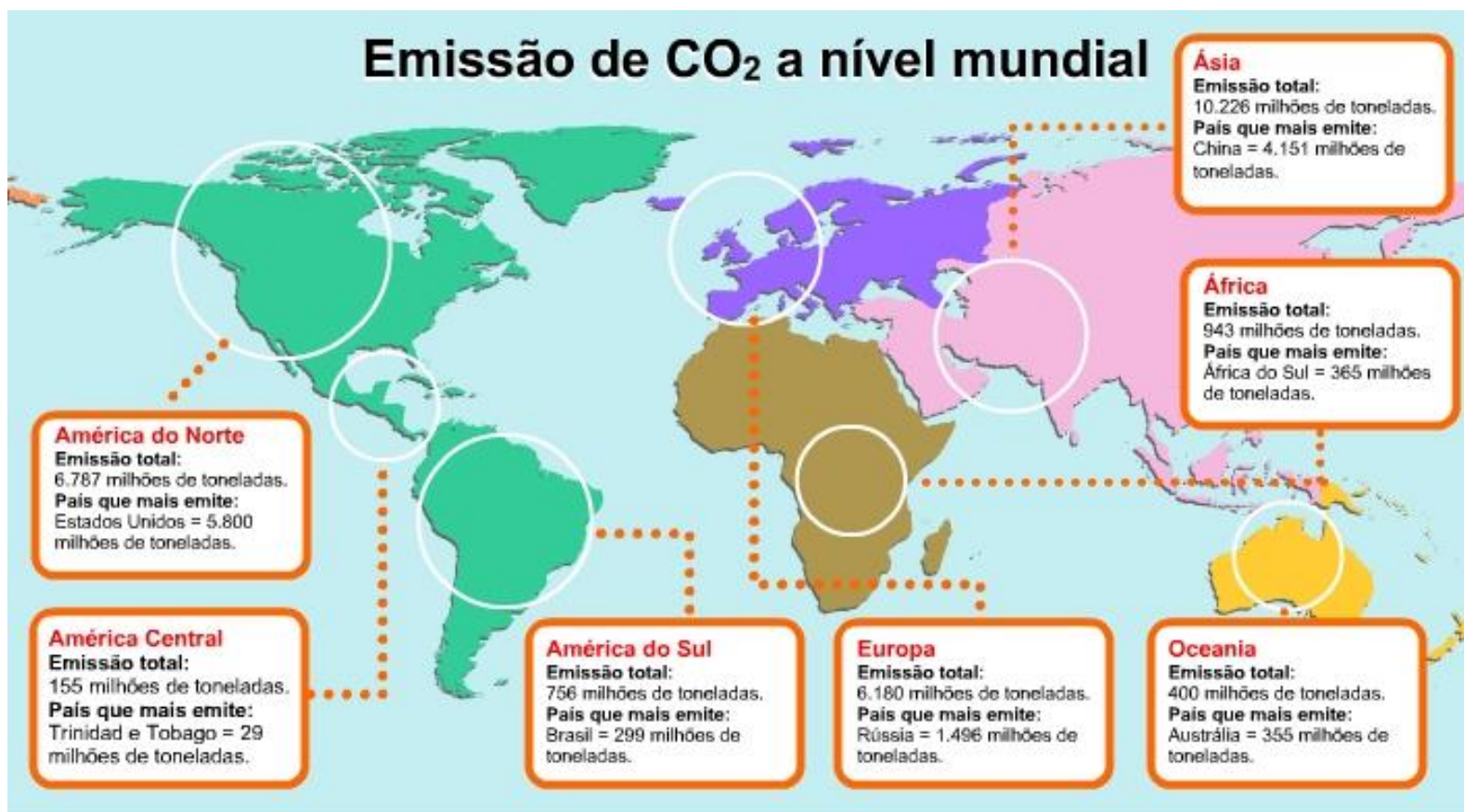
Período: 1960-1990 até 2070-2100



Fonte: Centro Hadley



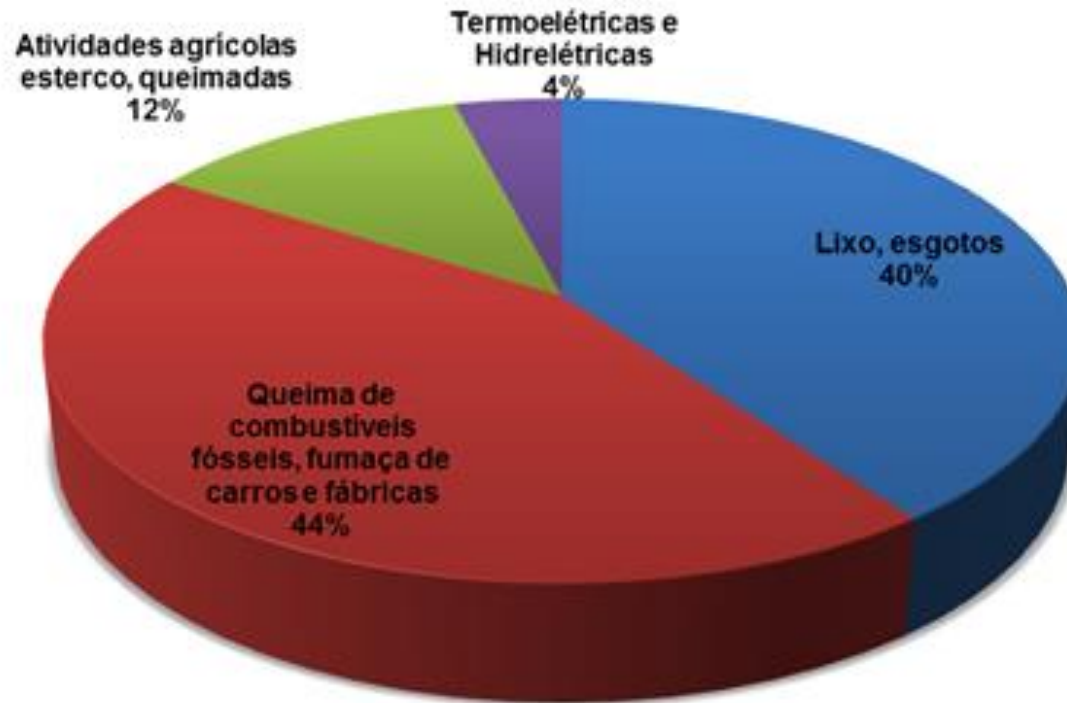
O impacto no clima com energia gerada por fontes convencionais



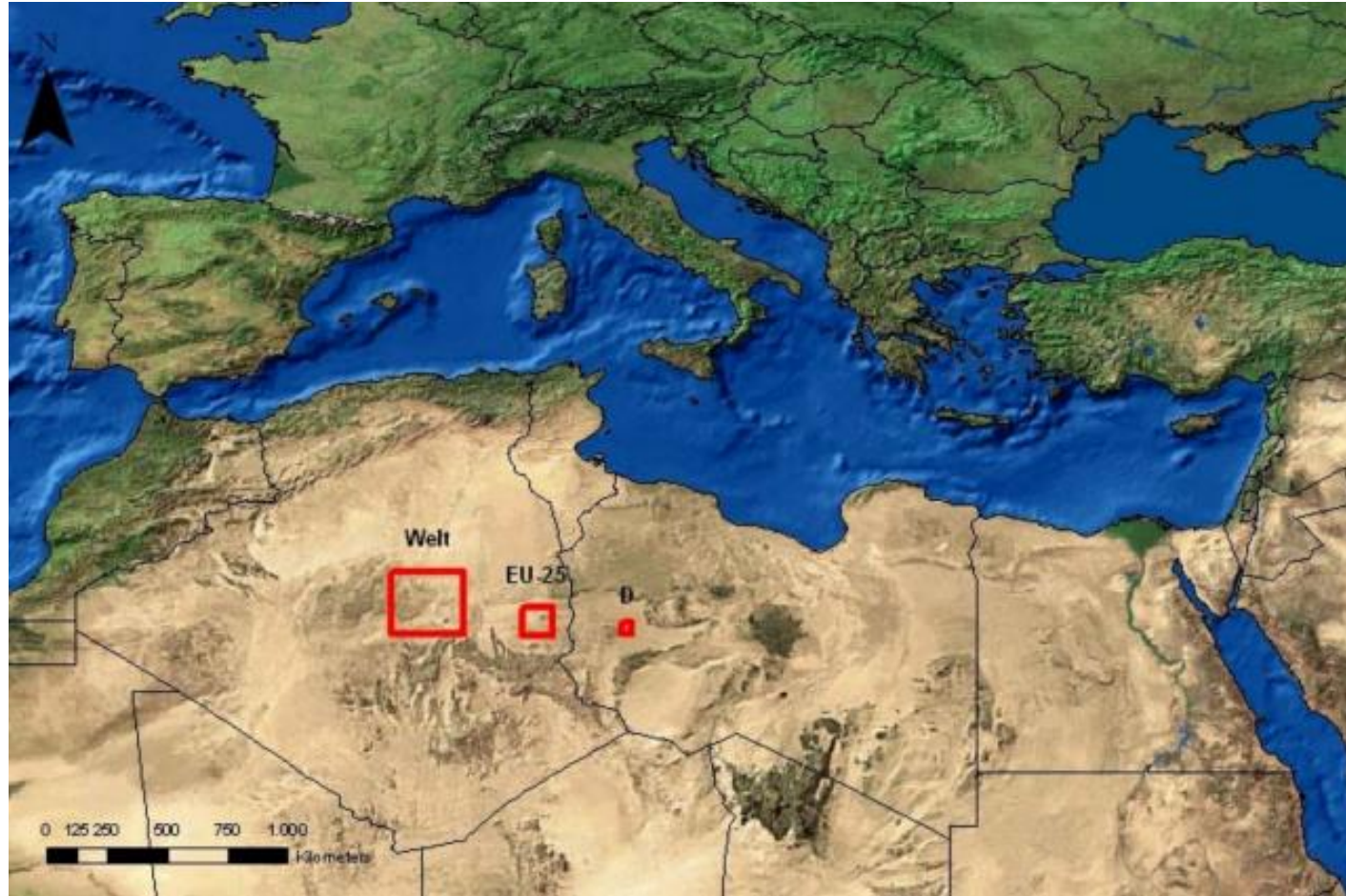
Fonte: Departamento de Assuntos Económicos e Sociais das Nações Unidas (UNDESA), Centro de Análise de Informações sobre dióxido de Carbono (CDIAC) do Departamento de Energia dos Estados Unidos.

O impacto no clima com energia gerada por fontes convencionais

Gráfico 01: Quais são os geradores de gases de efeito estufa como o CO₂?

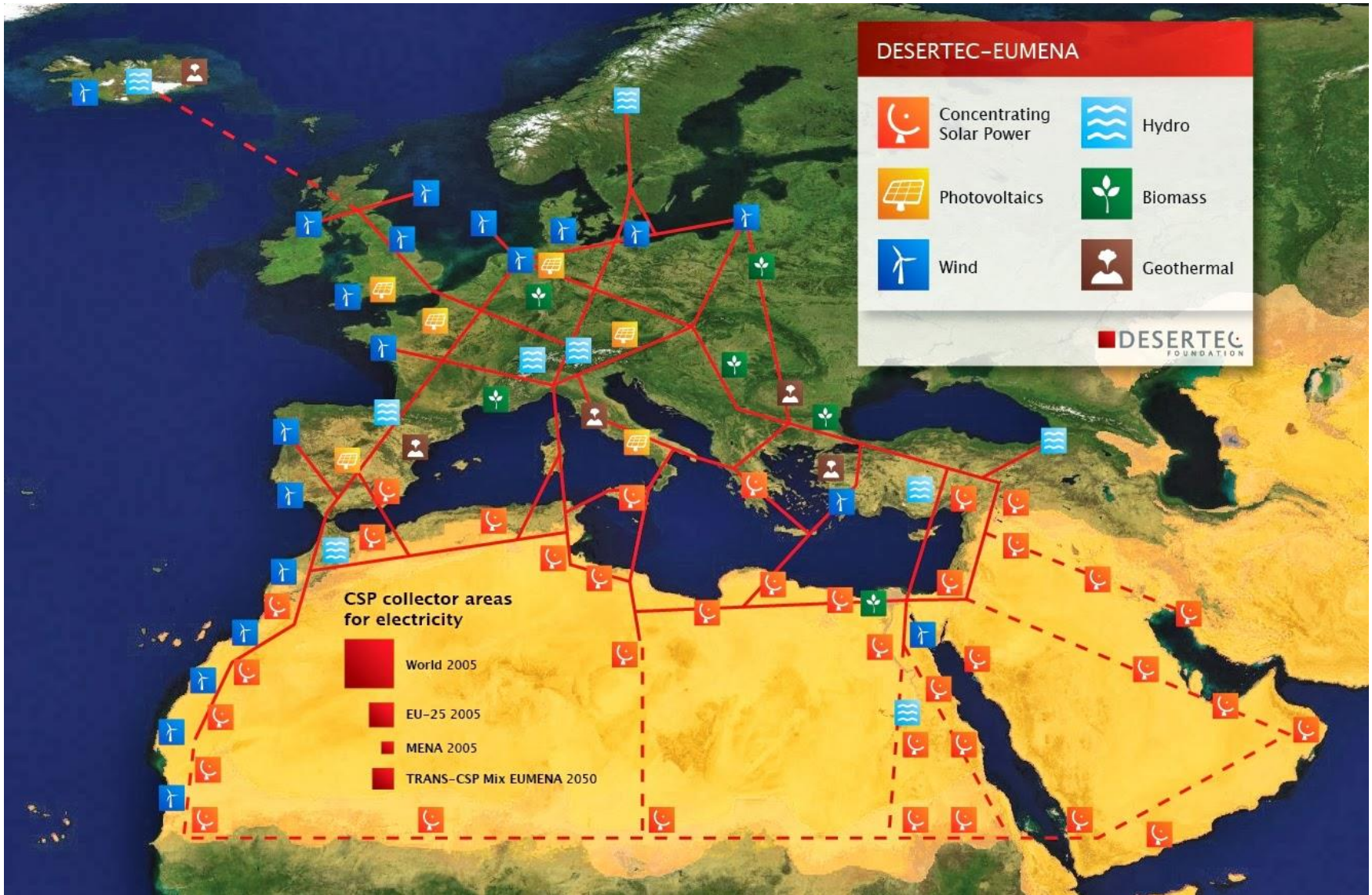


In 2009, the total global electricity consumption was 20,279,640 GWh.
The image has three red boxes showing what area would need to be covered for Germany (De),
Europe (EU-25), and the entire world, using Solar Energy.



How Much Room Do We Need To Supply The Entire World With Solar Electricity?

June 24, 2014 | by Lisa Winter



As iniciativas em energias renováveis



Termossolar



Solar fotovoltaica



Eólica

(Luís Mauro Moura)

Usinas Termossolares

Strobel et al., 2012



Almeria, Espanha



Manzanara, Espanha
15-MW plant project



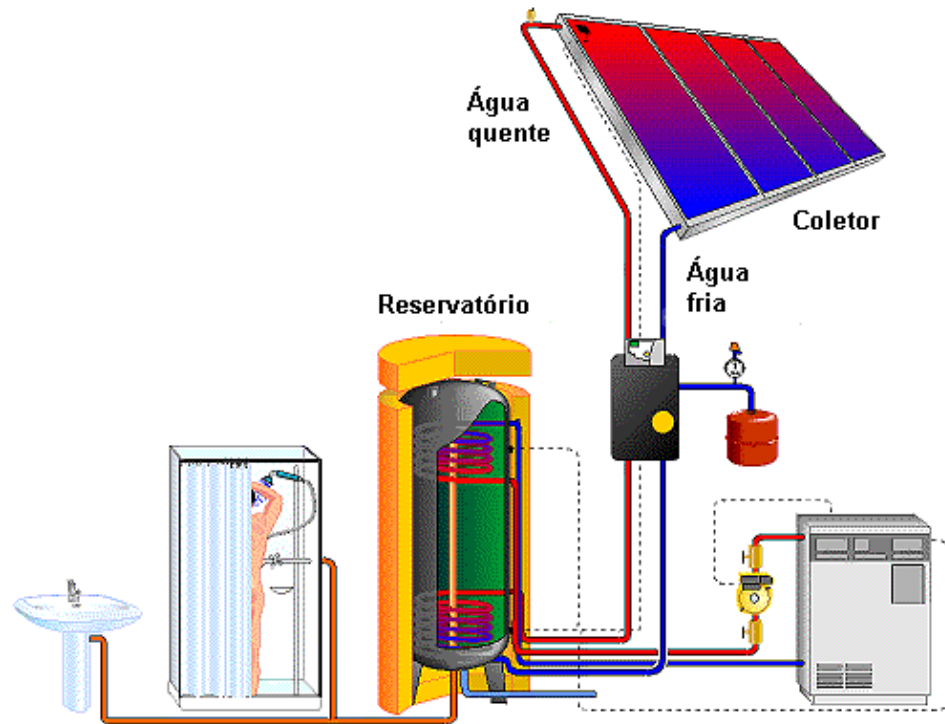
Montanha Solar
Elioth (2010)

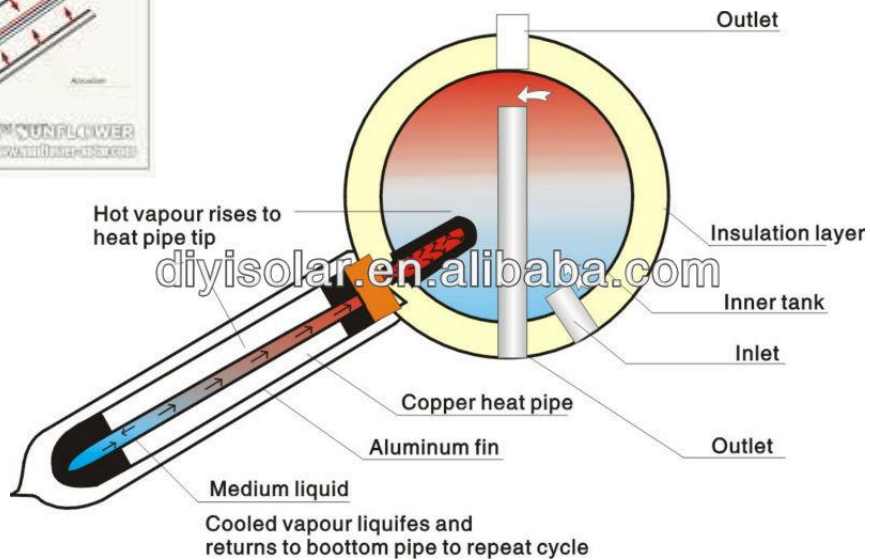
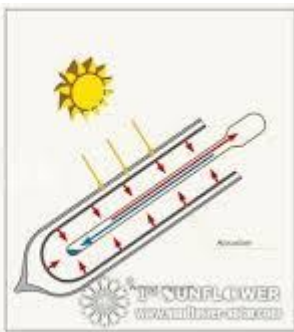
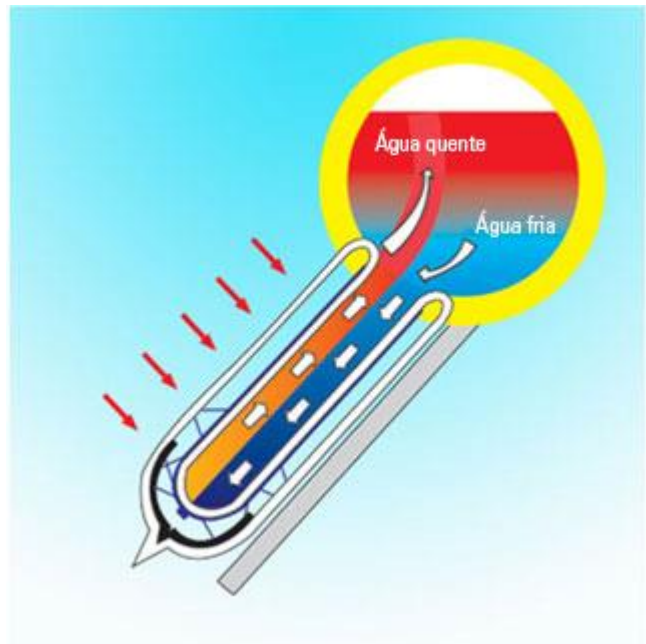


7MW

200 MW Solar Tower is planned to commence construction in Australia, at Burrong Station, in the Riverland area of New South Wales

Aquecimento Solar





Tubo com 3 camadas de Absorção







<http://www.psa.es/>

Heliostatos





11MW – produção anual de 23 GWh



Vista Aérea da Plataforma Solar de Almería



7 MW

Ciclo Stirling

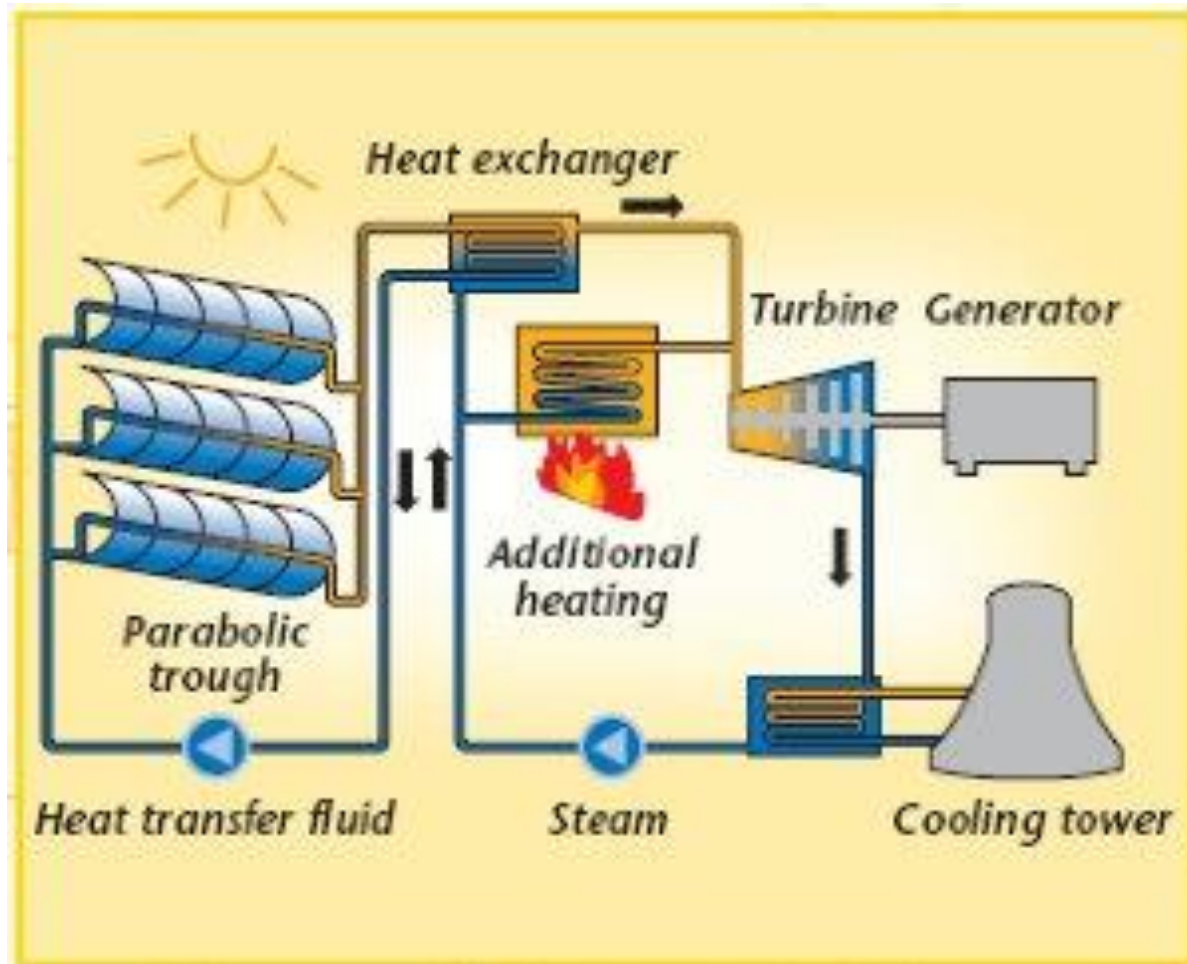


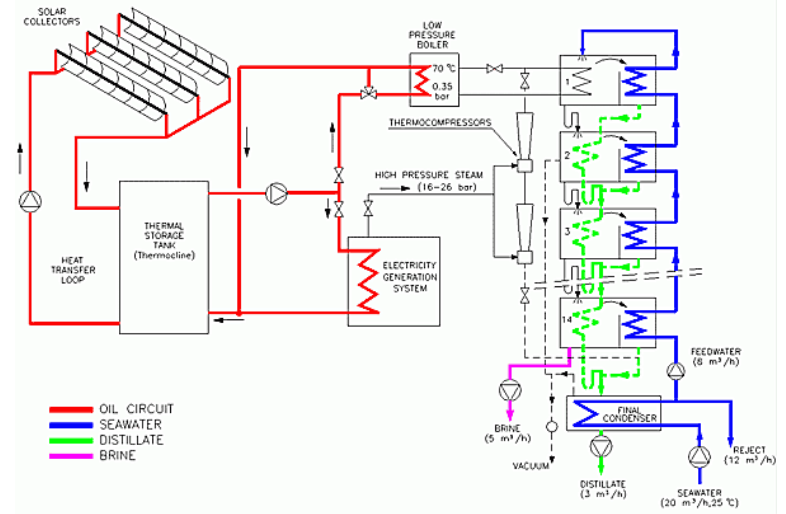
Diâmetro de 7,5 m e 40 kWt de energia
Ciclo Stirling

<http://www.psa.es/>

Nevada Solar Thermal Plant Breaks New Ground

350-acre solar power





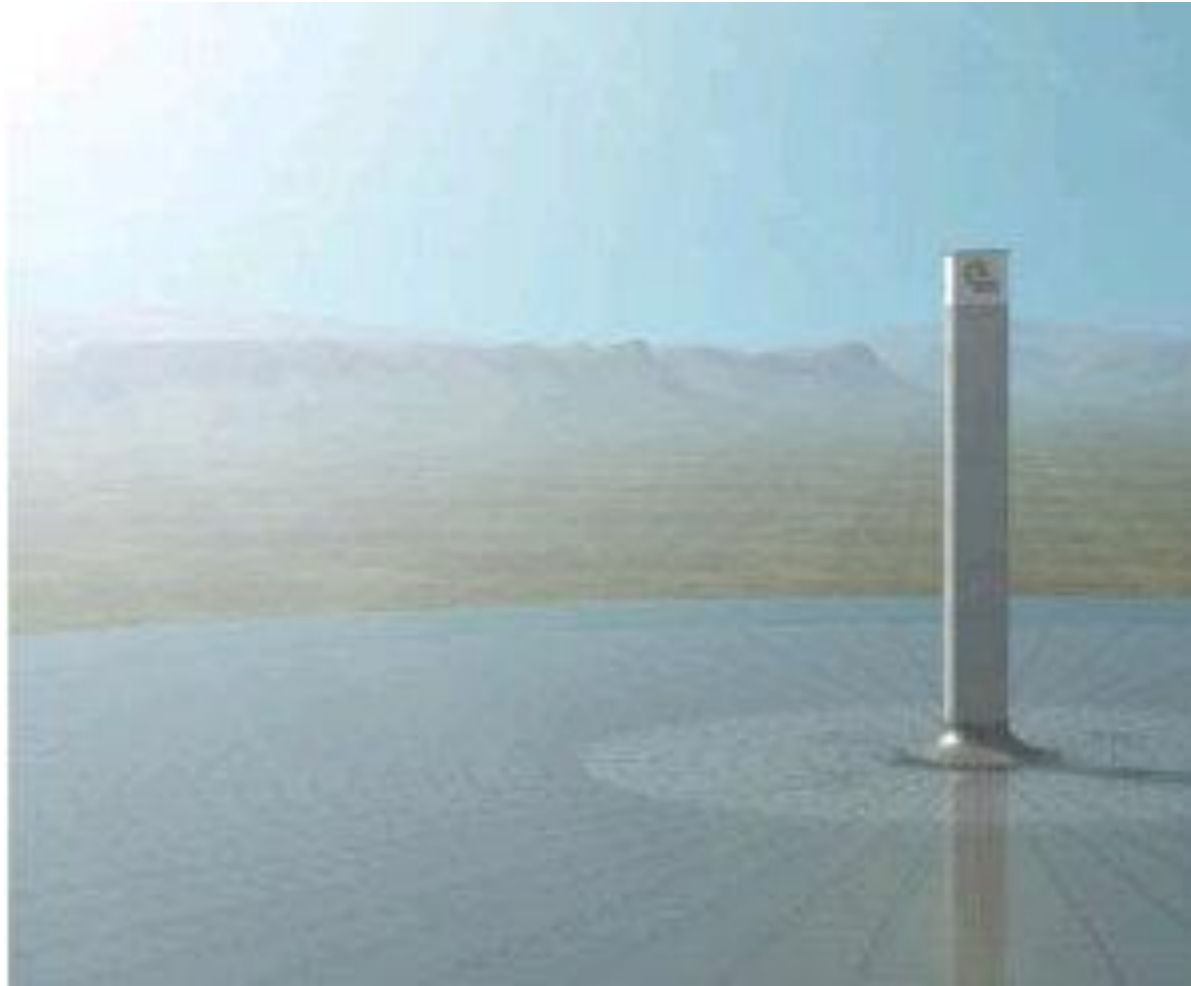
<http://www.psa.es/>

Coletores parabólicos



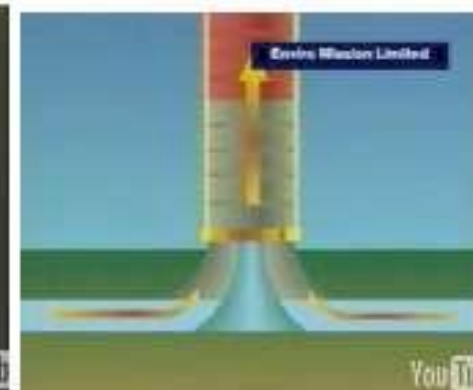
<http://www.dlr.de/>

http://peswiki.com/index.php/Directory:Solar_Tower

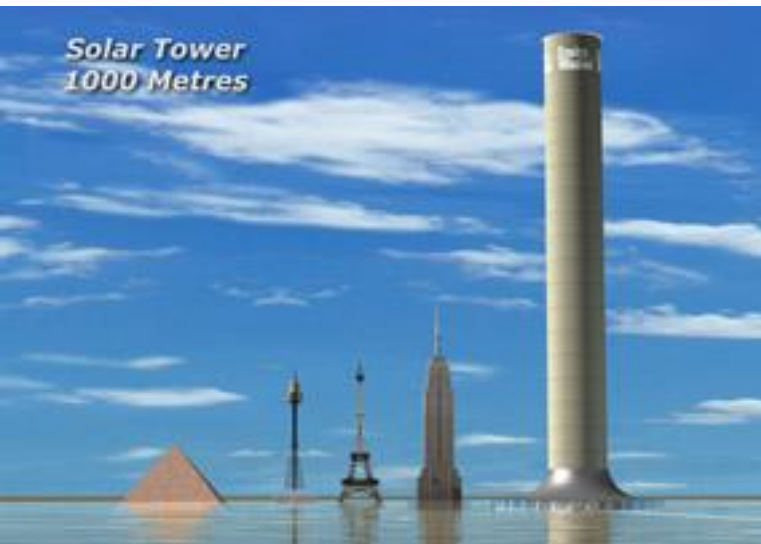


200 MW Solar Tower is planned to commence construction in Australia in 2006, at Burronga Station, in the Riverland area of New South Wales

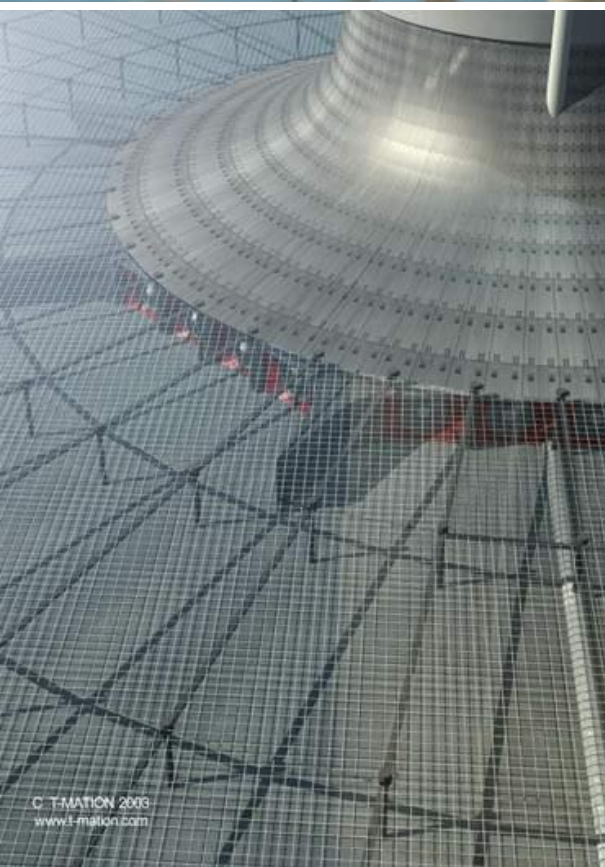
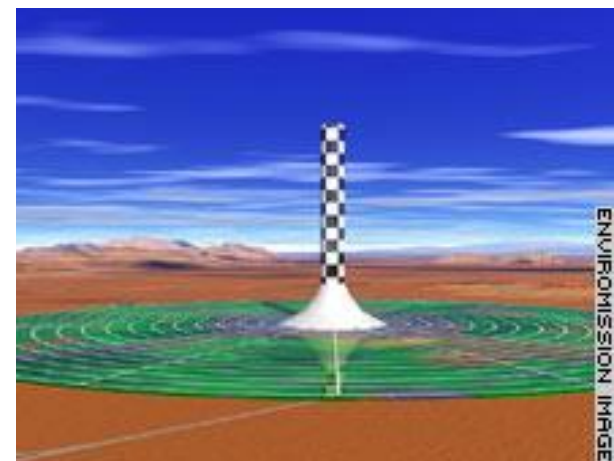
http://peswiki.com/index.php/Image:Solar_Tower_Spain_collage_700.jpg



Solar Tower
1000 Metres



ki.com/index.php/Directory:Solar_Tower



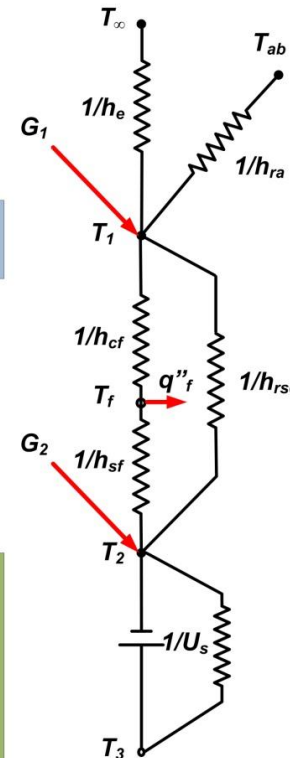
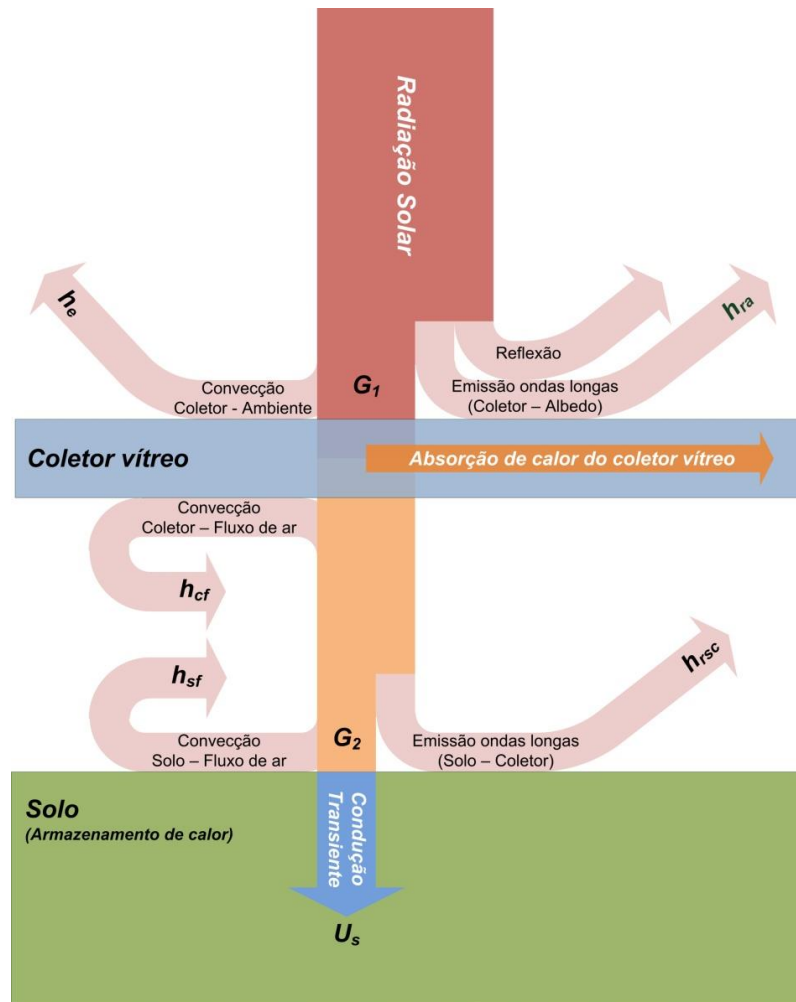
50kW prototype Solar Tower plant



15-MW plant project

Tese Strobel, 2012

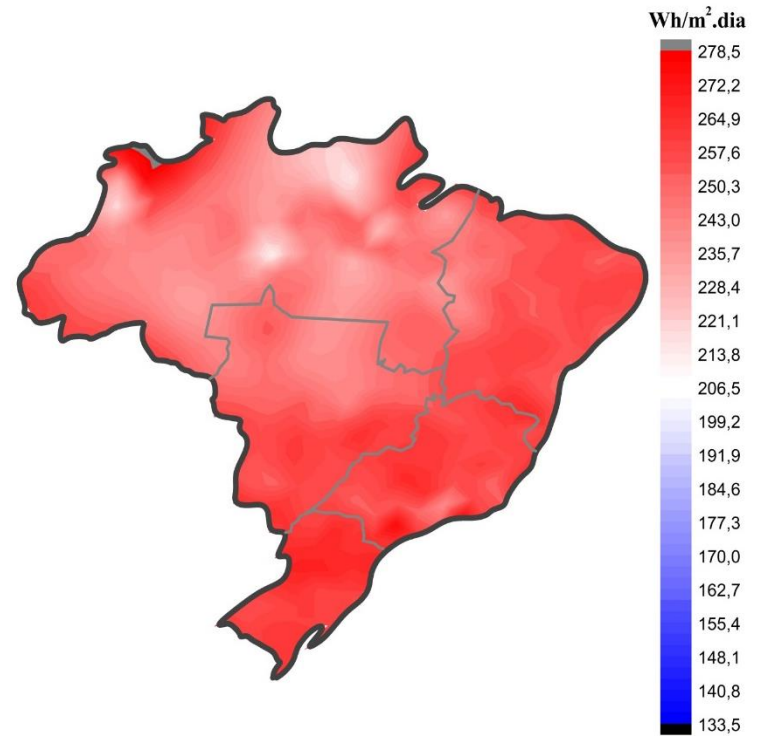
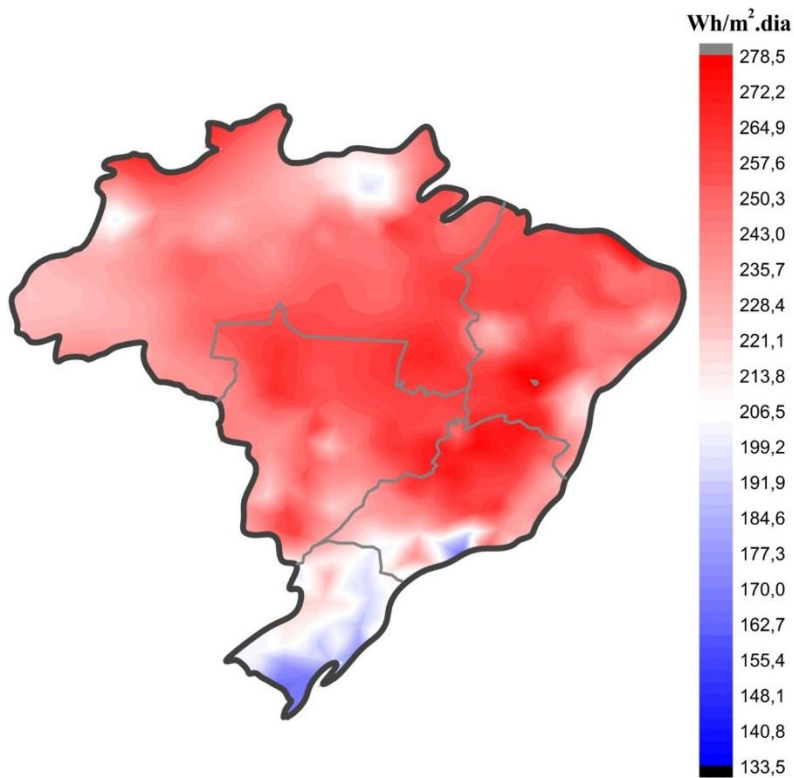
$$\begin{bmatrix} (U_e + h_{cf} + h_{rsc}) & (-h_{cf}) & (-h_{rsc}) \\ (h_{cf}) & -(h_{cf} + h_{sf} + \psi) & (h_{sf}) \\ (-h_{rsc}) & (-h_{sf}) & (h_{sf} + h_{rsc} + U_s) \end{bmatrix} \cdot \begin{bmatrix} T_1 \\ T_f \\ T_2 \end{bmatrix} = \begin{bmatrix} (G_1 + h_e T_\infty + h_{ra} T_{ab}) \\ -\psi T_{f,e} \\ (G_2 + U_s T_{2,0}) \end{bmatrix}$$

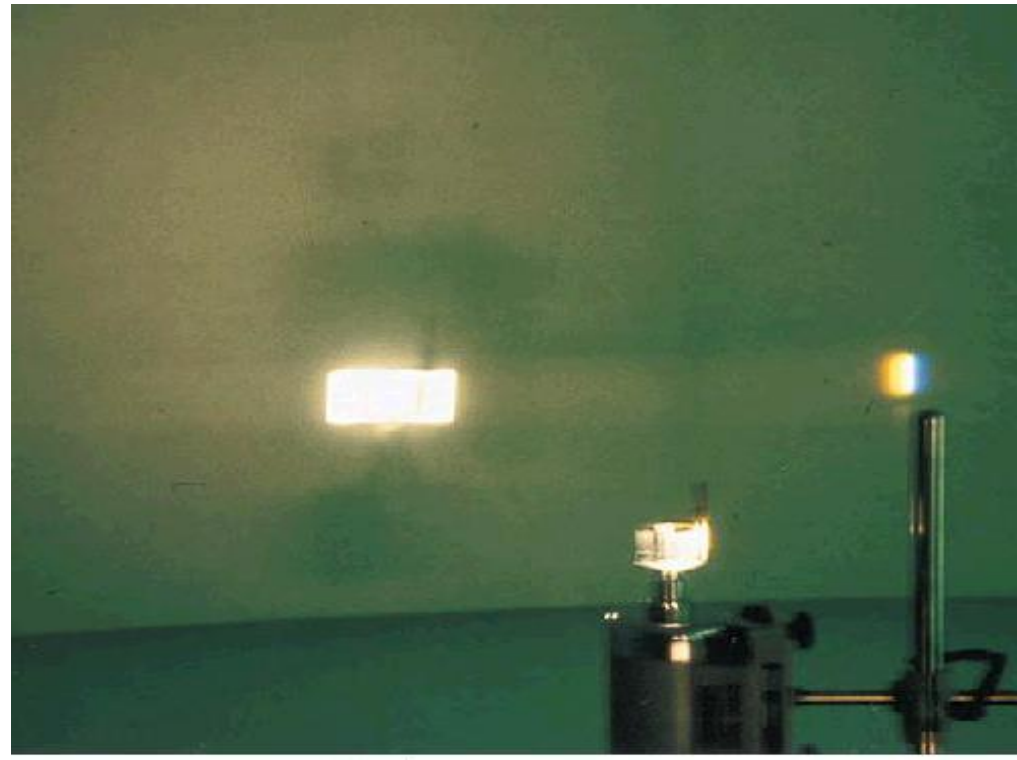


Distribuição do potencial de energia fotovoltaica diária por un. de área

inverno

verão





Fresnel solar furnace

<http://www.xenotechresearch.com>

- Fresnel solar furnace



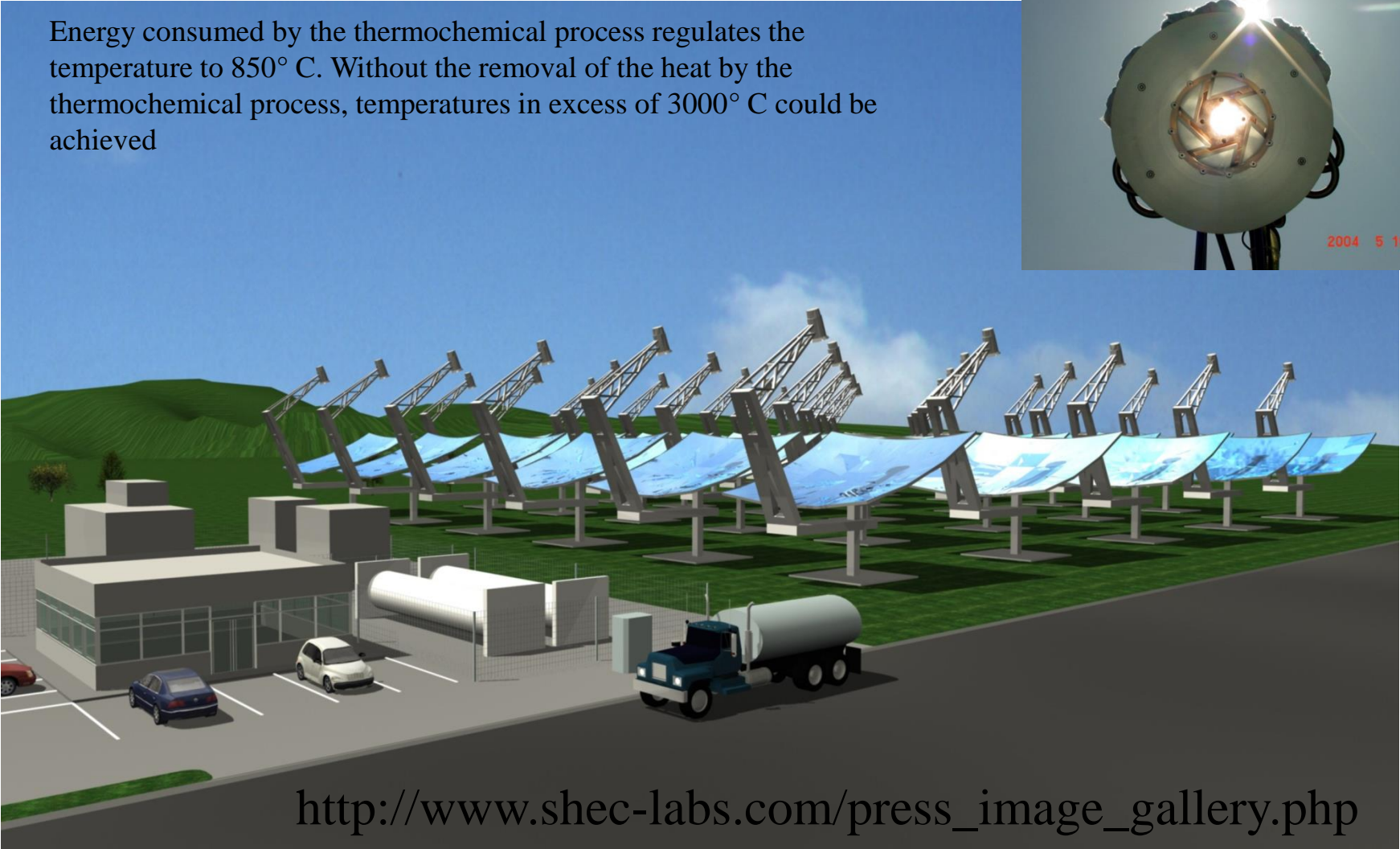
<http://www.xenotechresearch.com/solfurn2.htm>



Solar Hydrogen Production station

Each solar array measures 13 x 13 meters and is capable of generating 40,000 kg of hydrogen per year

Energy consumed by the thermochemical process regulates the temperature to 850° C. Without the removal of the heat by the thermochemical process, temperatures in excess of 3000° C could be achieved

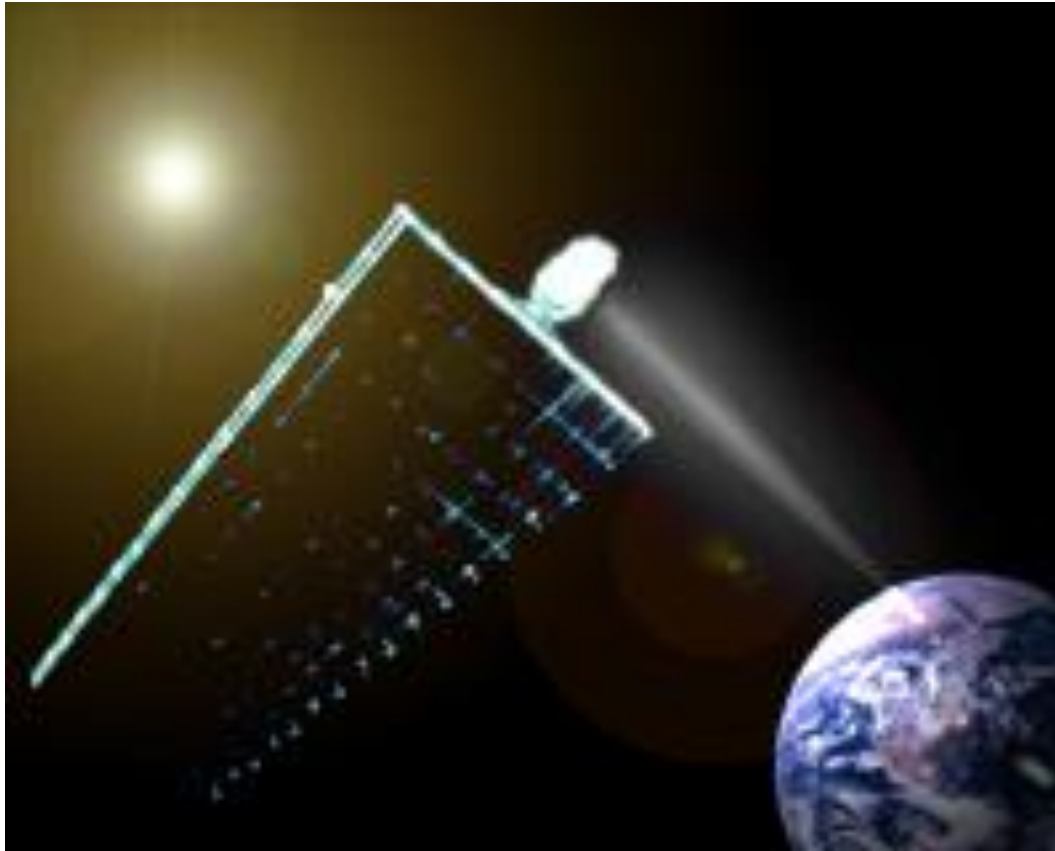


Painéis Fotovoltaicos

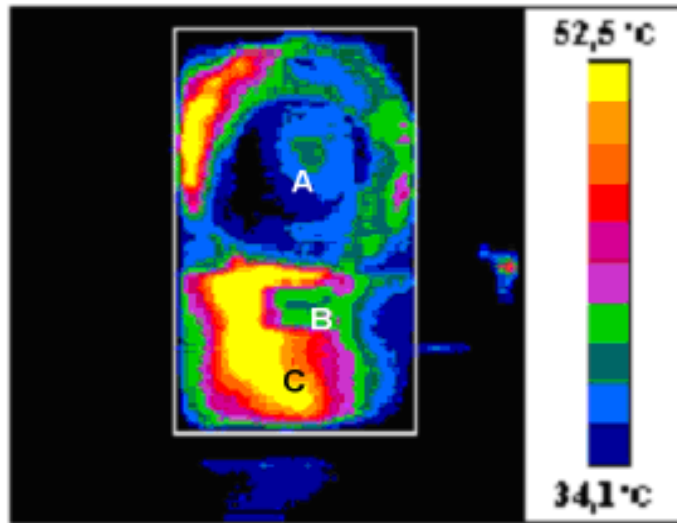


One Amonix 25 kW unit was installed at the Center for Energy Research at the University of Nevada in Las Vegas in March of 2004

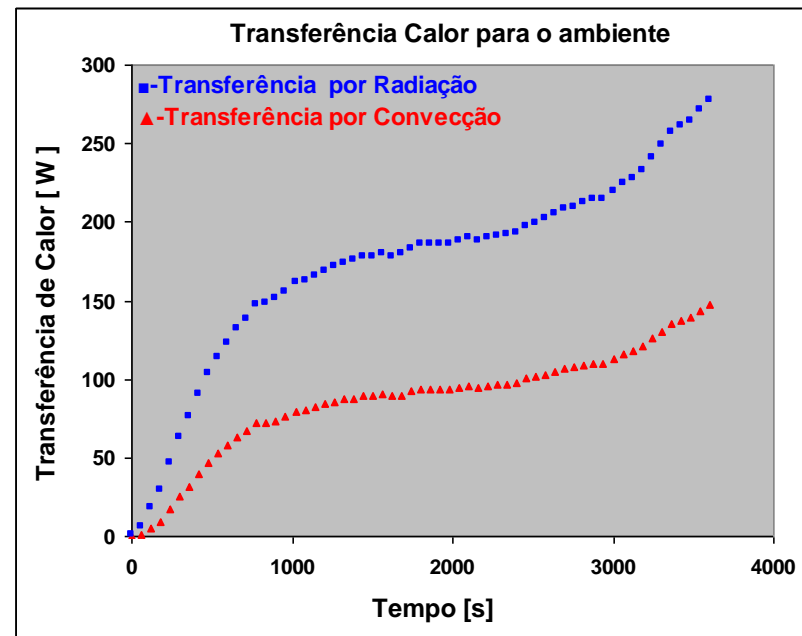
Futuro

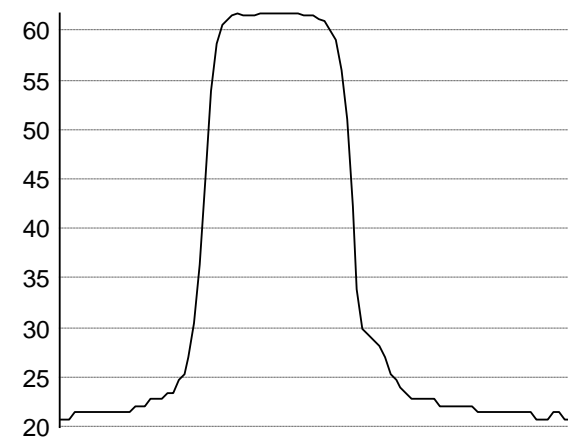
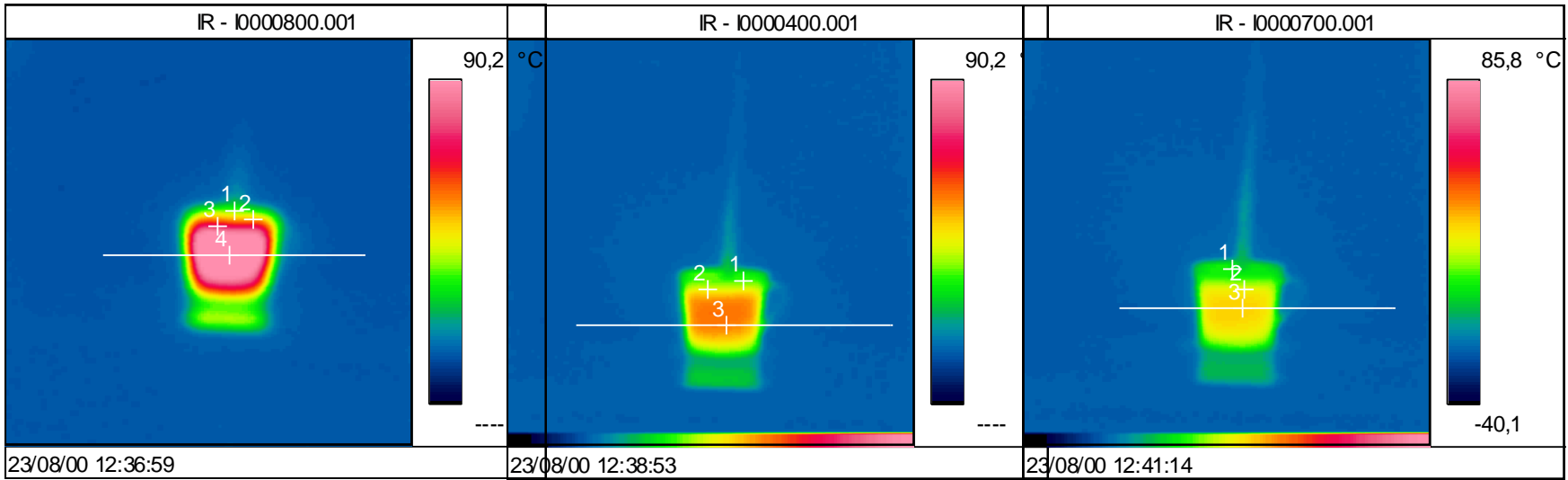


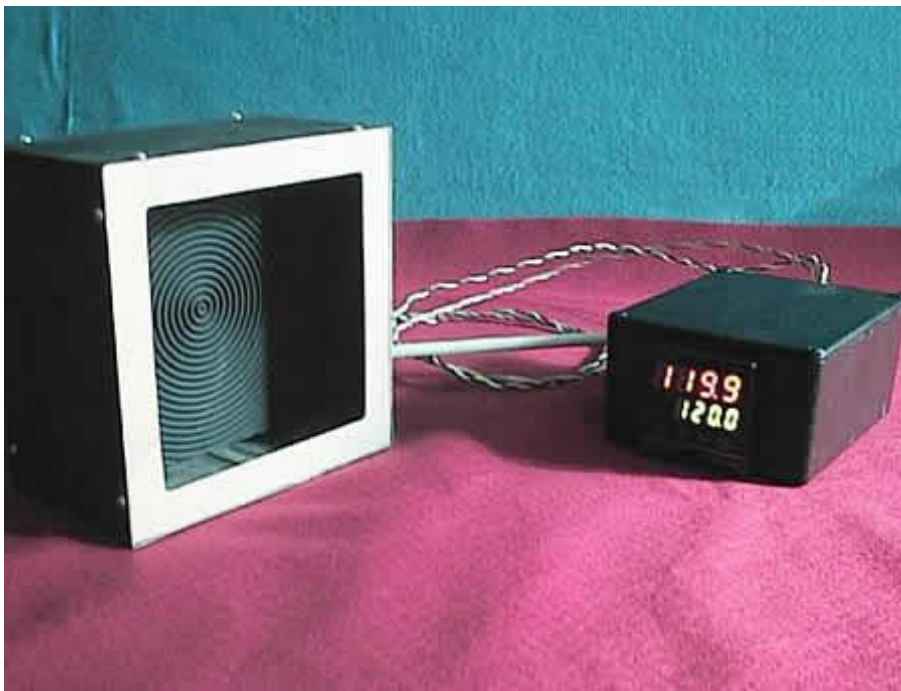
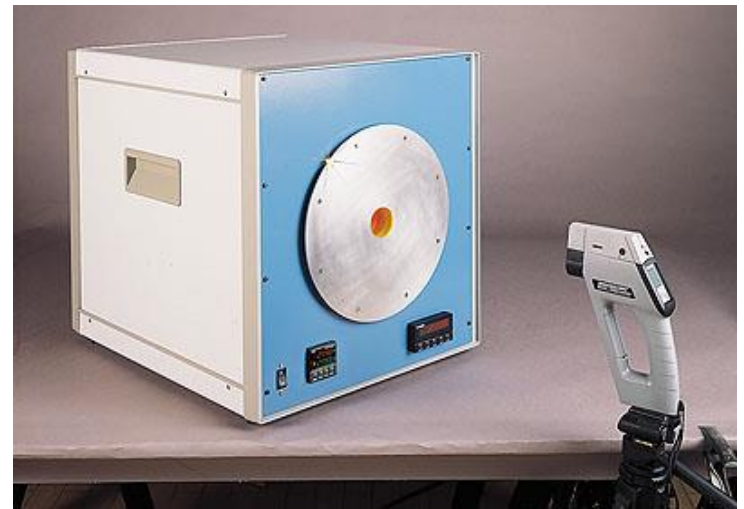
http://www.powersat.com/powersat_main.html



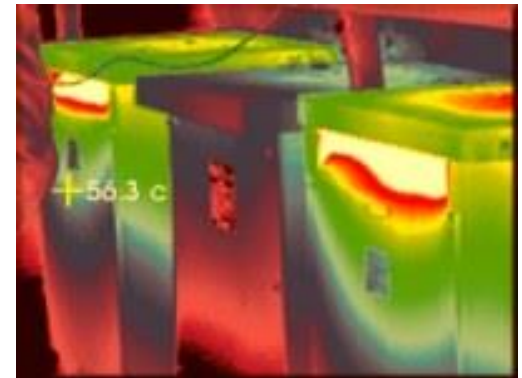
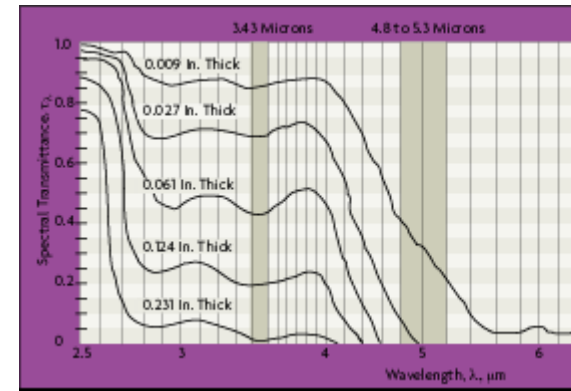
A= Tambor de secagem
B= Caixa Coletora de Fiapos
C= Saída do ar proveniente do tambor de secagem







Operator calibrates a transfer standard (lower foreground)—an infrared thermometer with 0.1°C resolution—with a blackbody calibration source that provides temperatures from 600°C to 3000°C.



Spot 25.7 °C
Circle
Max. 31.9
Min. 25.4

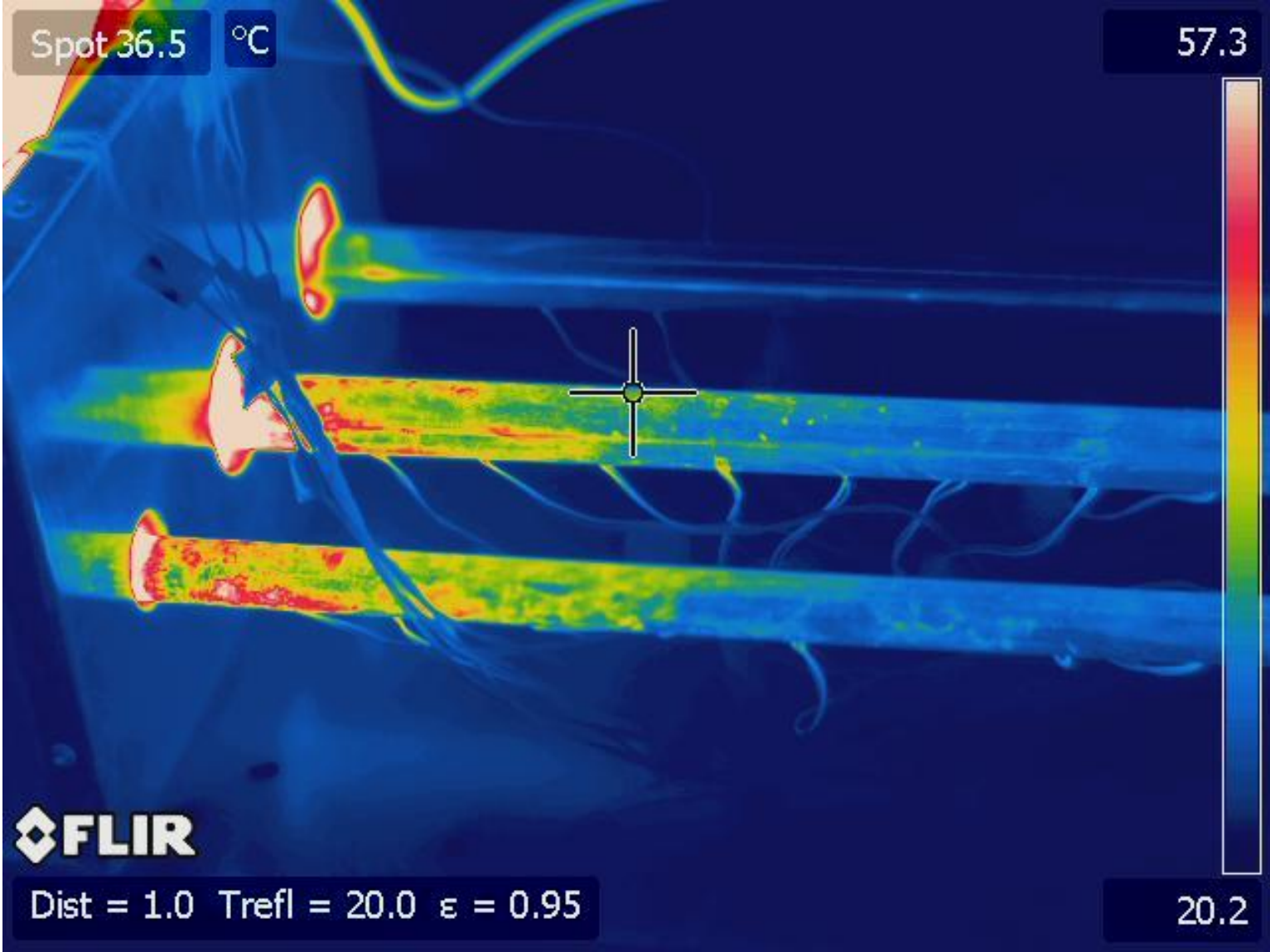
31.5

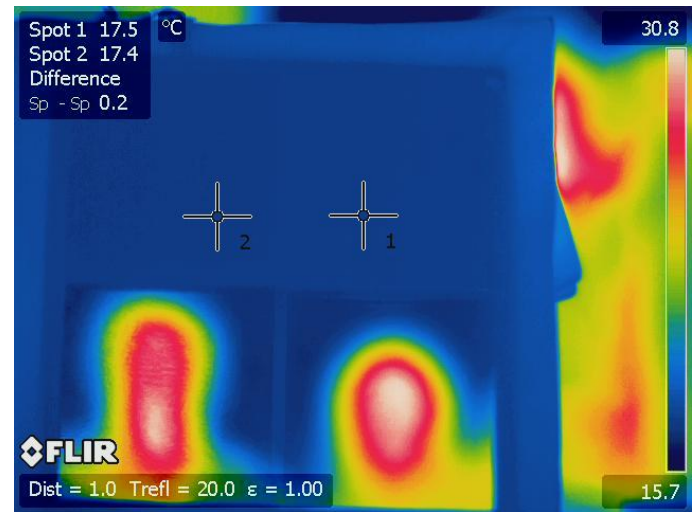


FLIR

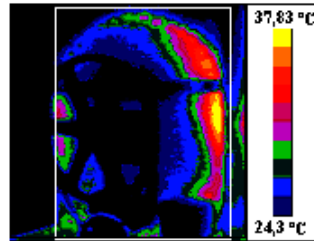
Dist = 1.0 Trefl = 20.0 ϵ = 0.95

21.5

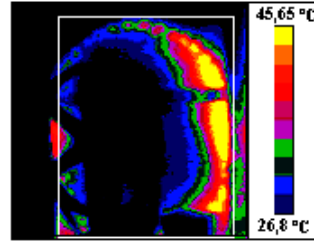




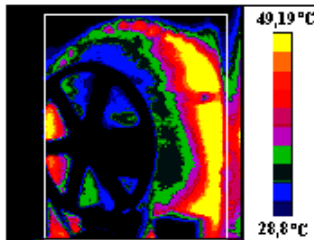
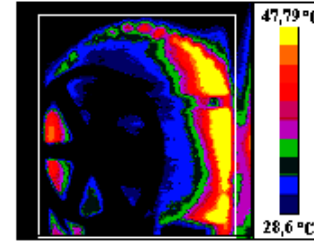
Tempo: 5 minutos e 36 segundos



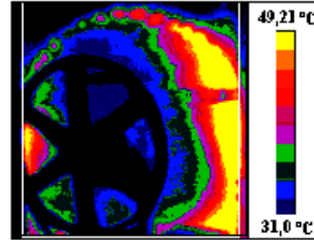
Tempo: 10 minutos e 10 segundos



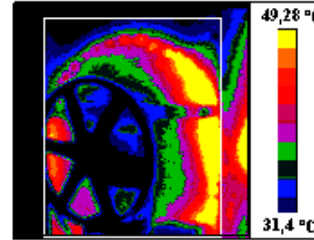
Tempo: 15 minutos e 35 segundos



Tempo: 20 minutos e 25 segundos

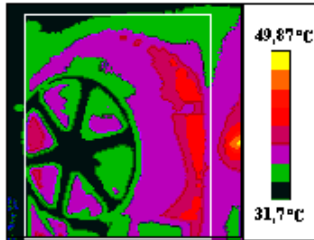


Tempo: 25 minutos e 35 segundos

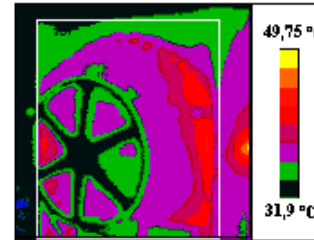


Tempo: 30 minutos e 10 segundos

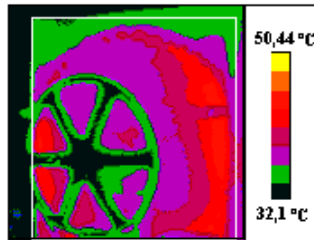
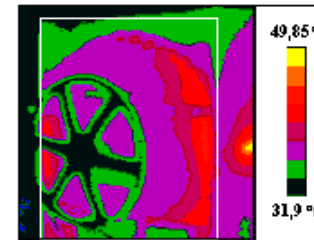
Tempo: 35 minutos e 50 segundos



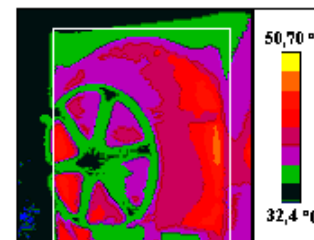
Tempo: 40 minutos e 40 segundos



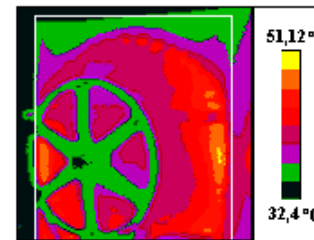
Tempo: 45 minutos e 45 segundos



Tempo: 50 minutos e 20 segundos



Tempo: 55 minutos e 20 segundos



Tempo: 60 minutos e 44 segundos



Small-scale measurement applications include:

- Thermal barrier coatings for combustor components
- Hard nitride, boride and diamond coatings for reduced mechanical wear
- Semiconductor manufacture (epitaxial layer growth) in RTP reactors
- Optical and magnetic coatings for re-writable recording media
- In-situ temperature and thermal measurements for integrated circuit components
- Contact resistance in integrated circuits
- The adhesion of plastic and metal films to a substrate
- Thermal measurements of food
- The characterisation of human tissue, particularly in-vivo
- Properties of composite and anisotropic materials

Thermal properties of a printed circuit board are important for heat management and quality control

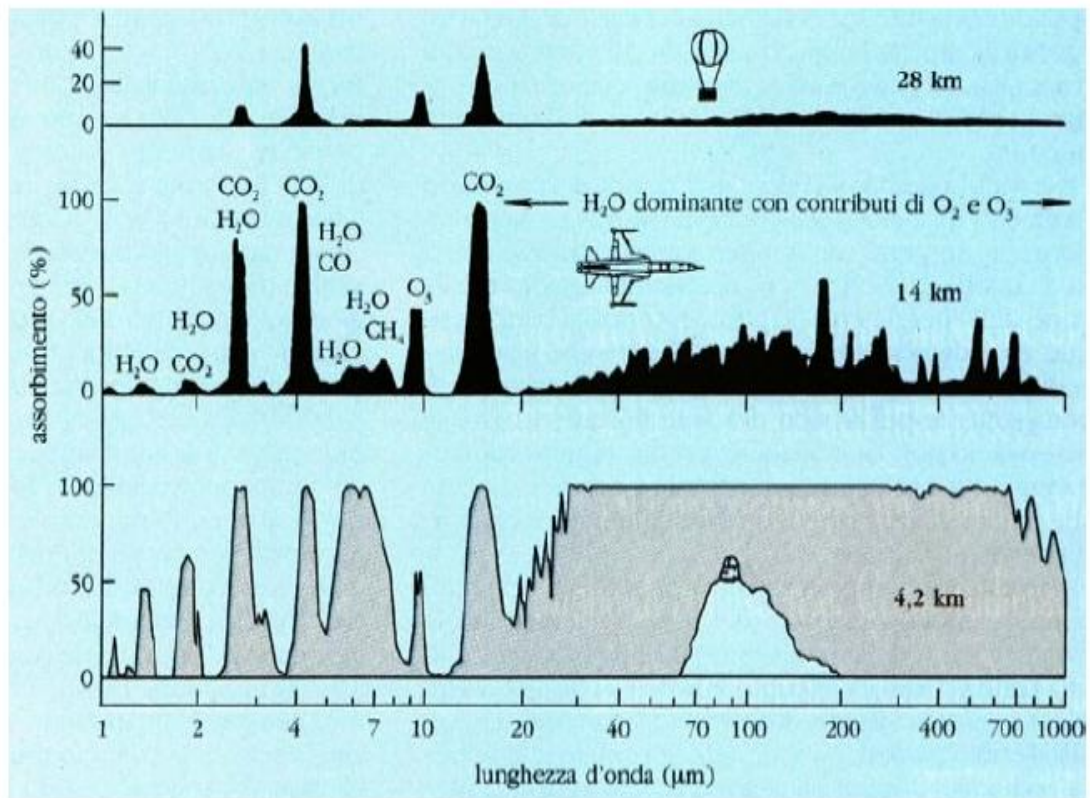


Fig. 1: Rappresentazione schematica della trasparenza atmosferica alla radiazione infrarossa cosmica in corrispondenza di varie altezze dal suolo.