Electrical Distribution for Photovoltaic Panels

IES Aviation Lighting Seminar
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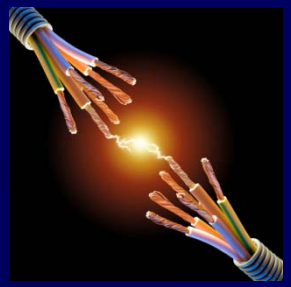
SUMMARY

1. ***Presentation***
2. ***What's the problem***
3. ***Some MV examples***



4. ***Photovoltaic solar production***
5. ***Solar farms in Airport fields***
6. ***Current discussion in Airports***

1. Presentation

"Energy Distribution" in AIRPORT fields,
& the specific application for
Photovoltaic panels

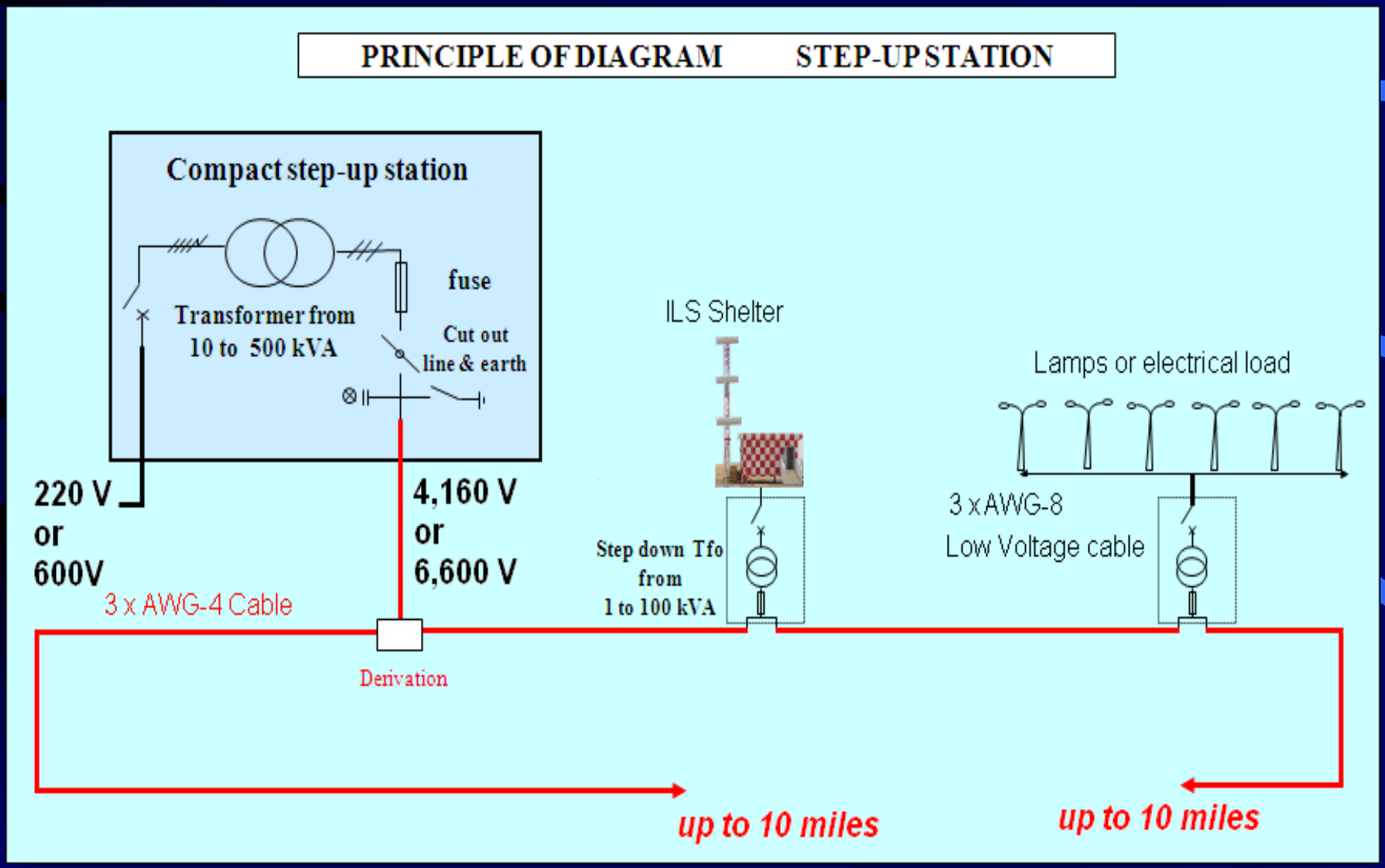
Energy distribution from ***600 V to 4,160 V*** *(up to 6,600 V)*

(Voltages are fonction of countries and local standards)

<u>Typical applications:</u>

- *ILS, nav. aids, weather stations, vertical signs, …*
- *Lighting of car parks and access roads to terminals*
- *Lighting of Apron (aircraft parks)*
- *FUTURE : Power from Photovoltaic panels*

2. What's the problem?



3. Some MV examples

- *Outdoo*

- *Futuring energy collecti* *ar farm*

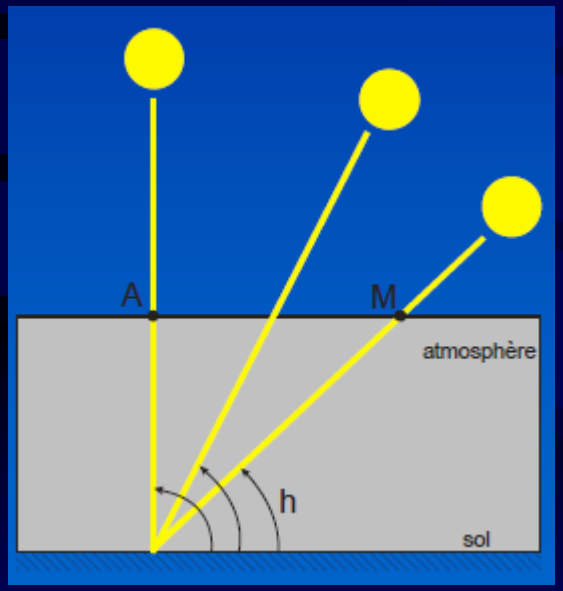
4.1. Photovoltaic Solar production

Solar energy & Atmosphere:

INFLUENCE of the ATMOSPHERE

- *Solar power is 1,637 W/m² OUTSIDE ATMOSPHERE*

→ *only 1,000 W/m² INSIDE ATMOSPHERE with sun at its zenith*



INFLUENCE of CLOUDS

100 - 500 W/m² with some clouds

< 50 W/m² for bad weather

EQUIVALENT SUN HOURS

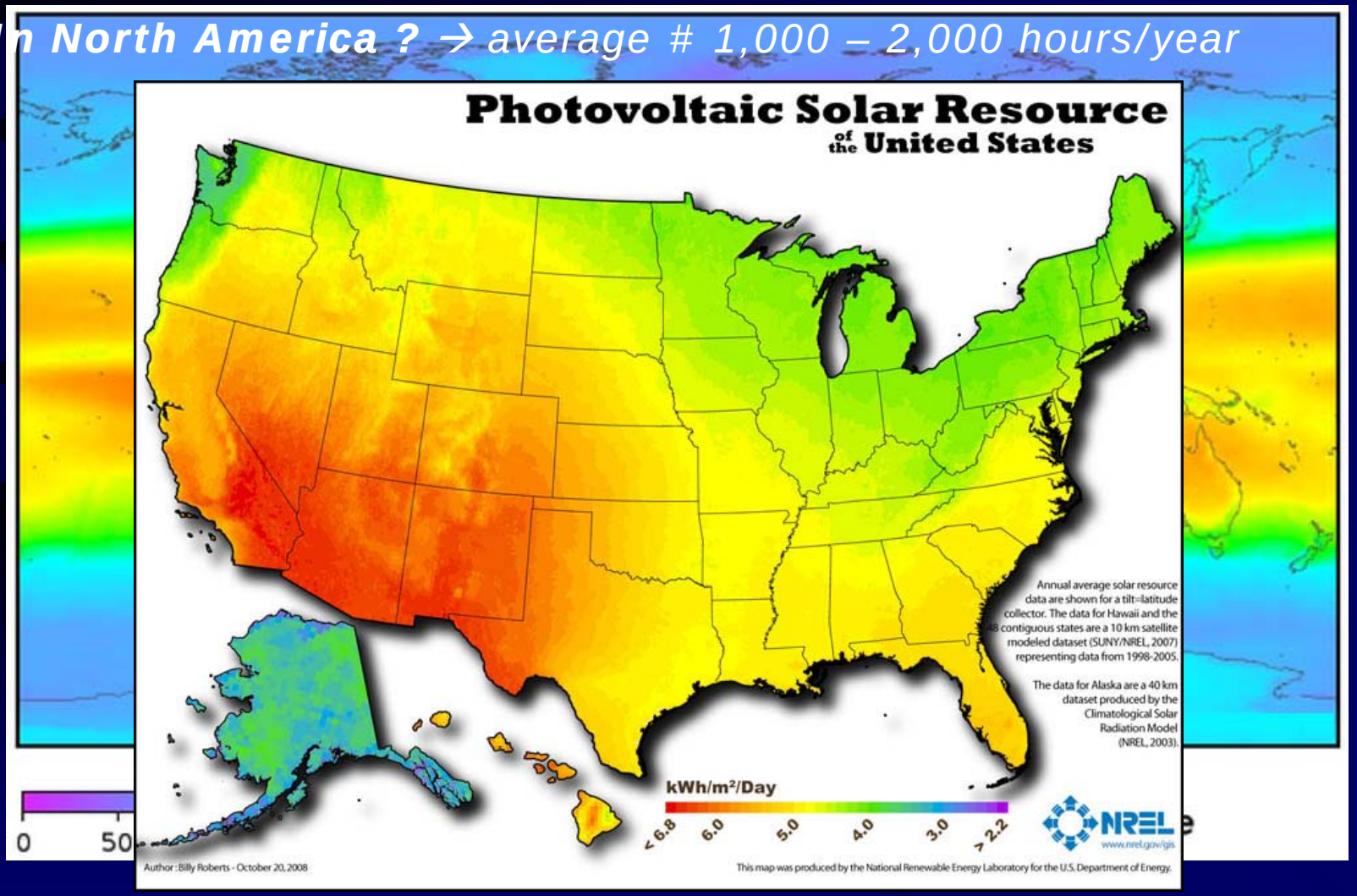
Calculation of an average (Wh/m²/day):

- *Geographic position,*
- *Month of the year,*
- *Direction (South, South-East, …*
- *Tilting position*

4.2 Solar farms
Sun reflexion

Where are the best "sun zones" in the world?

In North America ? → *average # 1,000 – 2,000 hours/year*



4.3. Photovoltaic Solar production

Photovoltaic cells & panels:

Photovoltaic technologies:

- *Cristallin silicon - Mono or POLY (less efficient → better ratio W/US$)*
- *Thin film solar cells - Micro-cristallin, CdTe, GICS, Amorphous*

  (50% less efficient but US$/m² better → 2 times more space)

Power from photovoltaic panels:

- *Sun gives # 1 kW / m² → Cells efficiency: 10 – 20% → # 100 Wp/m²*
- *Production from 0.5 (California) to 1 kWh/m²/day (African sahel desert)*

Cost of PV solar KW:

Price: 5 – 10 US$/Wp for different types of cells

→500 – 1,000 US$/m²

Average of equivalent sun hours: Madrid # 1,400 h/y → « USA »

4.4. Photovoltaic Solar production

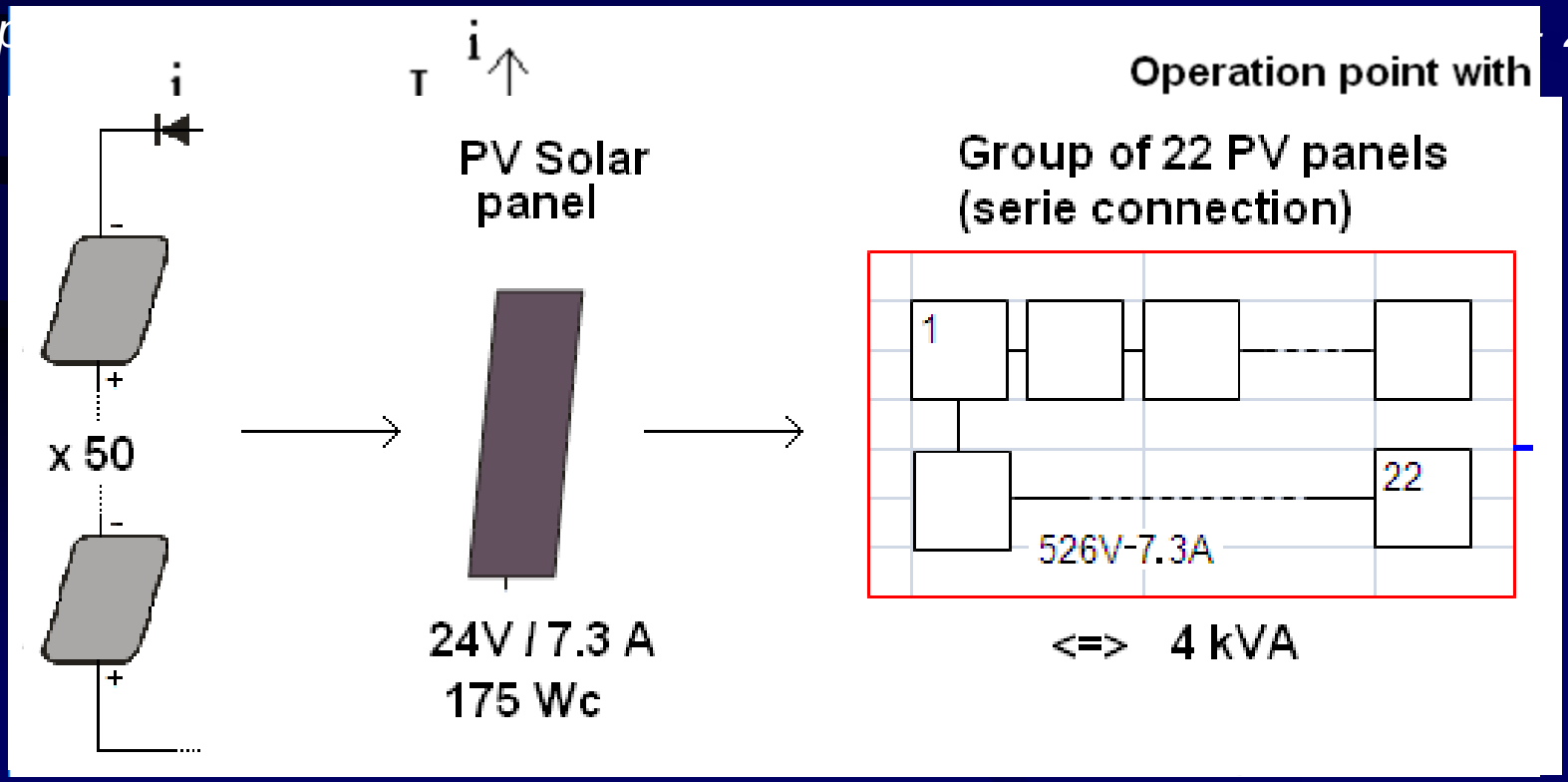
Electrical protections:

Photovoltaic panel output:

- *Open circuit on PV panel output → MAX of VOLTAGE at the output*

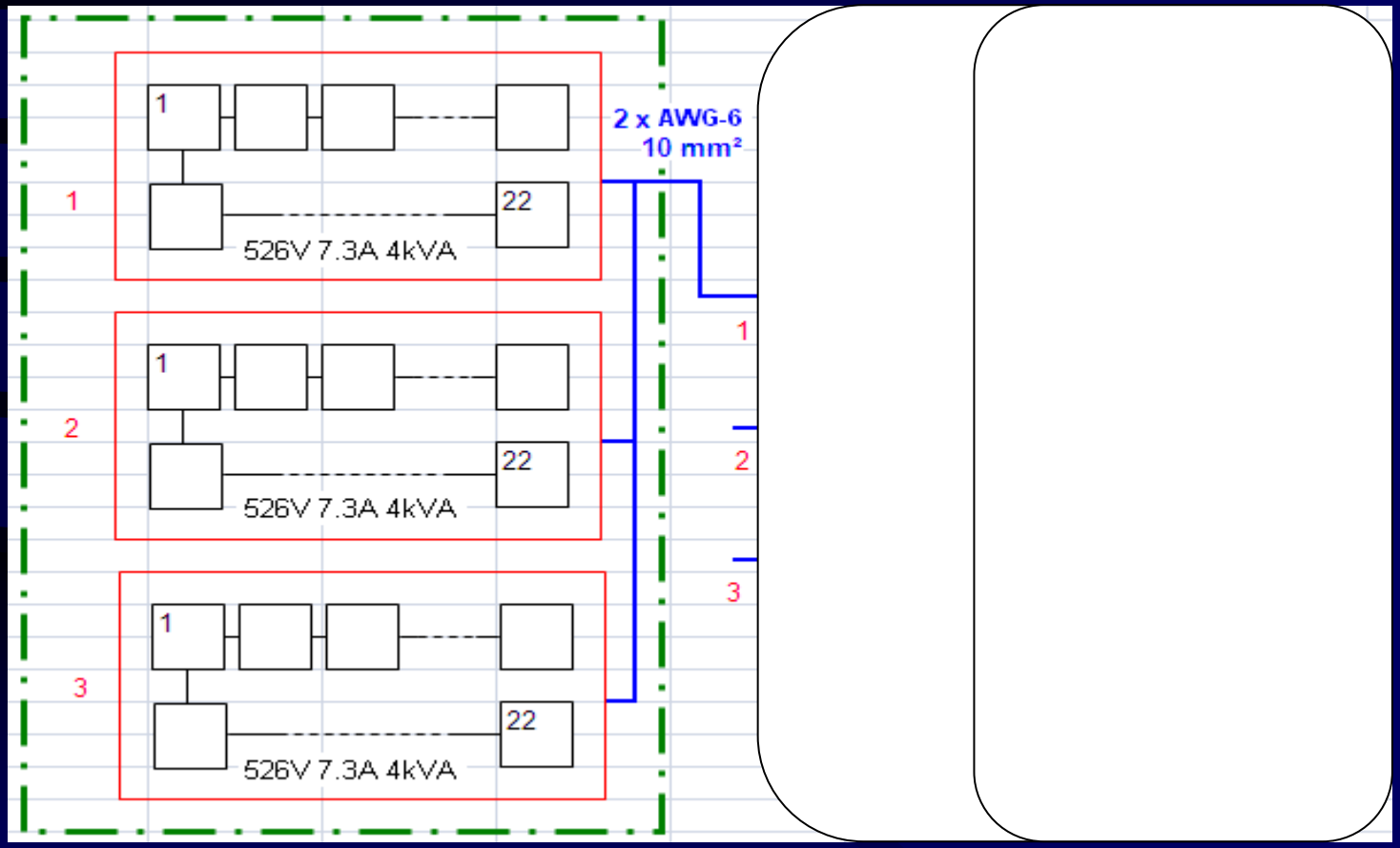
→ NECESSARY to short circuit the PV panel output (people safety !)

Typ *24V*



4.5. Photovoltaic Solar production

Electrical distribution & PV cells failure:



4. Serie distribution *(worse in parallel distribution)*

If one PV cell is out, all group will follow → ***Power rating falls down !!!***

4.6. Photovoltaic Solar production

Batteries storage or Water pumping ?

Interes of « Water Pumping » for POWER suppliers

→ *Storage of the daily energy for the night with a good efficiency & cost*

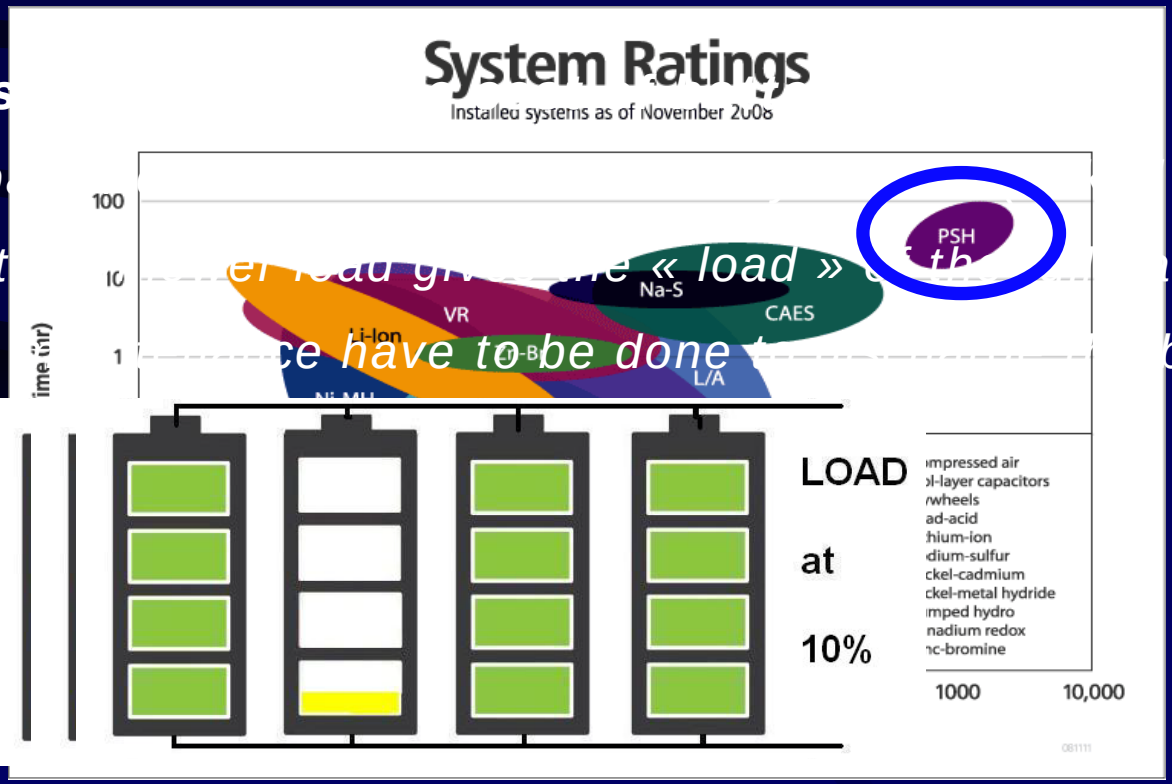
→ *Airport has no reason to store the energy in costly batteries*

Initial cos ***NiMH)***

→ *Power b* *serial & //)*

→ *The unit* *ttery*

→ *Regular* *battery*



4.7. Photovoltaic Solar production

STANDARD DISTRIBUTION in SQUARE FIELDS

Targets for the energy collection from PV panels:

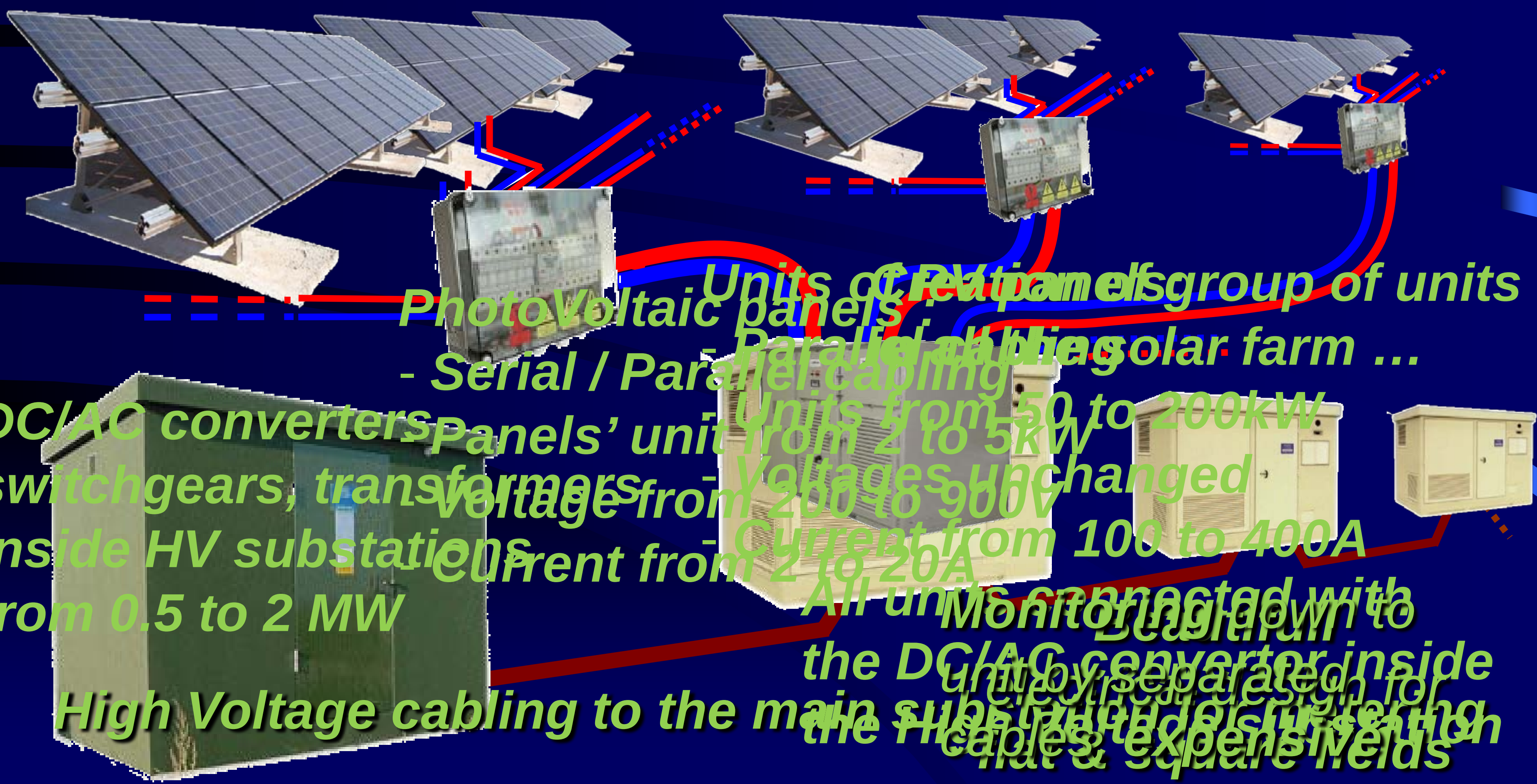
- *Reducing the financial investment*
- *Reducing the operation costs*
- *Increasing the efficiency (for a quicker money feedback)*
- *Increasing the MTBF (with strong outdoor solutions)*
- *Reducing the MTTR (with an efficient monitoring system)*

95% of the farms use DC distribution

4.8 Photovoltaic Solar Standard distribution

Electricity distribution of ***DC current***

up to the HV substations



PhotoVoltaic panels

- Serial / Parallel cabling

- Panels' unit from 2 to 5kW

- Voltage from 200 to 900V

- Current from 2 to 20A

Units of PV panels

- Parallel cabling

- Units from 50 to 200kW

- Voltages unchanged

- Current from 100 to 400A

Creation of group of units in a large solar farm …

DC/AC converters, switchgears, transformers inside HV substations from 0.5 to 2 MW

All units connected with the DC/AC converter inside the High Voltage substation

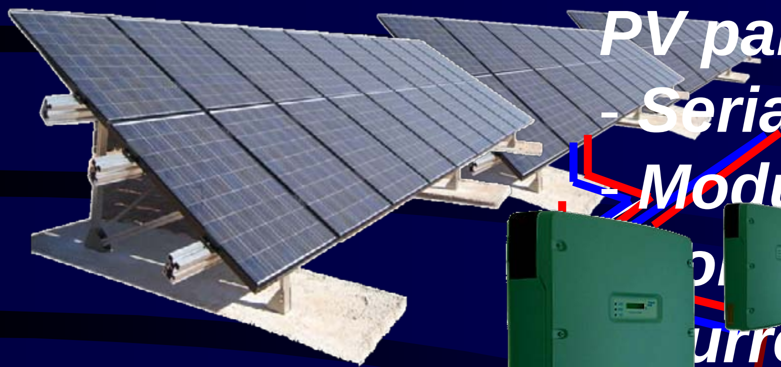
Monitoring down to unit by separated cables & expensive

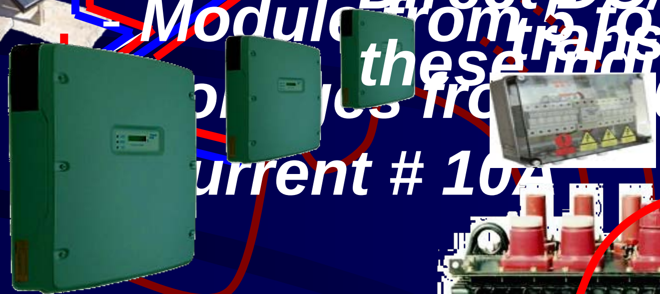
Beautiful electrical design for flat & square fields

High Voltage cabling to the main substation

4.9 Photovoltaic Solar Long distance site (1)

*Electricity distribution of **AC current** up to the HV substations*

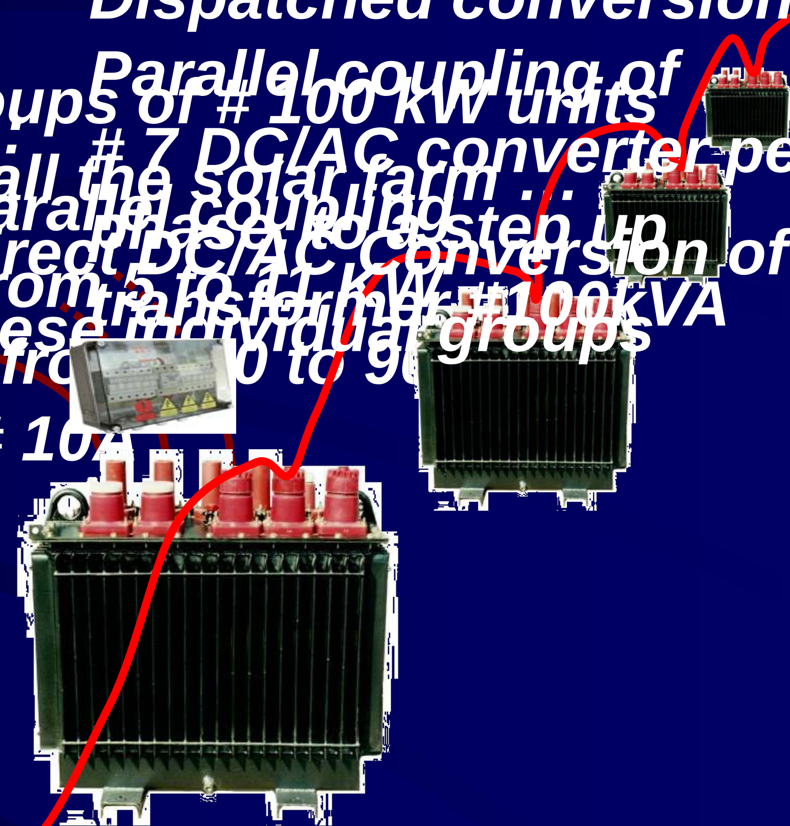


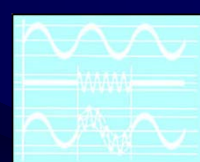


PV panels :
- **Serial / parallel coupling**
- **Module from 5 to 11 kW**
- **Voltages from [illegible]0 to 90[illegible]**
- **Current # 10A**

Groups of # 100 kW units on all the solar farm ... Direct DC/AC Conversion of these individual groups

Dispatched conversion: Parallel coupling of # 7 DC/AC converter per phase to step up transformer #100kVA





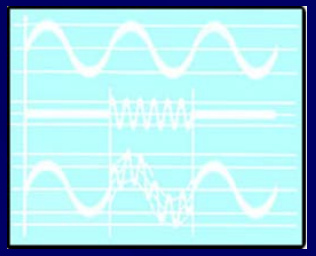
4.2 kV switchgears and transformers installed in only 1 substation for 4 to 8MW or the power company

4.2 kV network from 10 to 16 step up transformers 32-160 kVA to the 4.2 kV switchgear building

4.10 Photovoltaic Solar Long distance site (2)

Advantages *of the AC current distribution*

- *Cabling (DC & AC Low Voltage and AC 4.2 or 6.6 kV):*
  - *Smaller cross sections and length of cables*
  - *Reduce « copper » losses in thicker cables*
- *Substations :*
  - *Reduce the number or disappear !*
  - *Suppression of some indirect costs.*
- *Maintenance :*
  - *Increase the safety of operation*
  - *Separated in smaller groups, securized by earthing connection*
- *Monitoring & remote control:*
  - *By Power Line Carrier: NO separated network*
  - *Information in the main substation (& GSM ?)*



4.11 Examples of field buriable substations

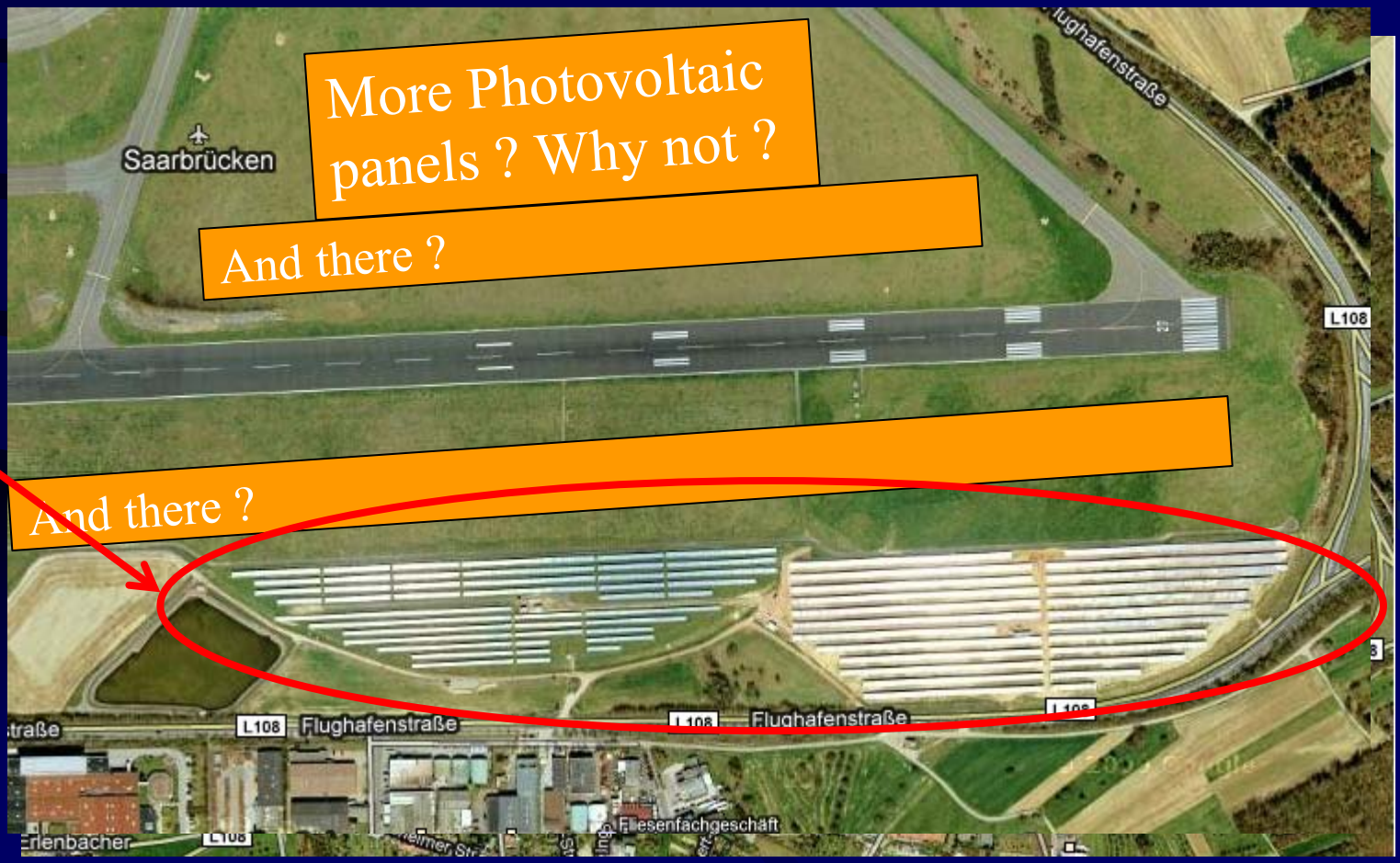
5.1 Solar farms in Airport fields

European airports already develops solar PV farms

Photovoltaic panels on top of buildings, car parks but not only !

Saarebruken Airport, in Germany, already starts green solar electricity production

AND THERE ? Discussion in a couple of slides !

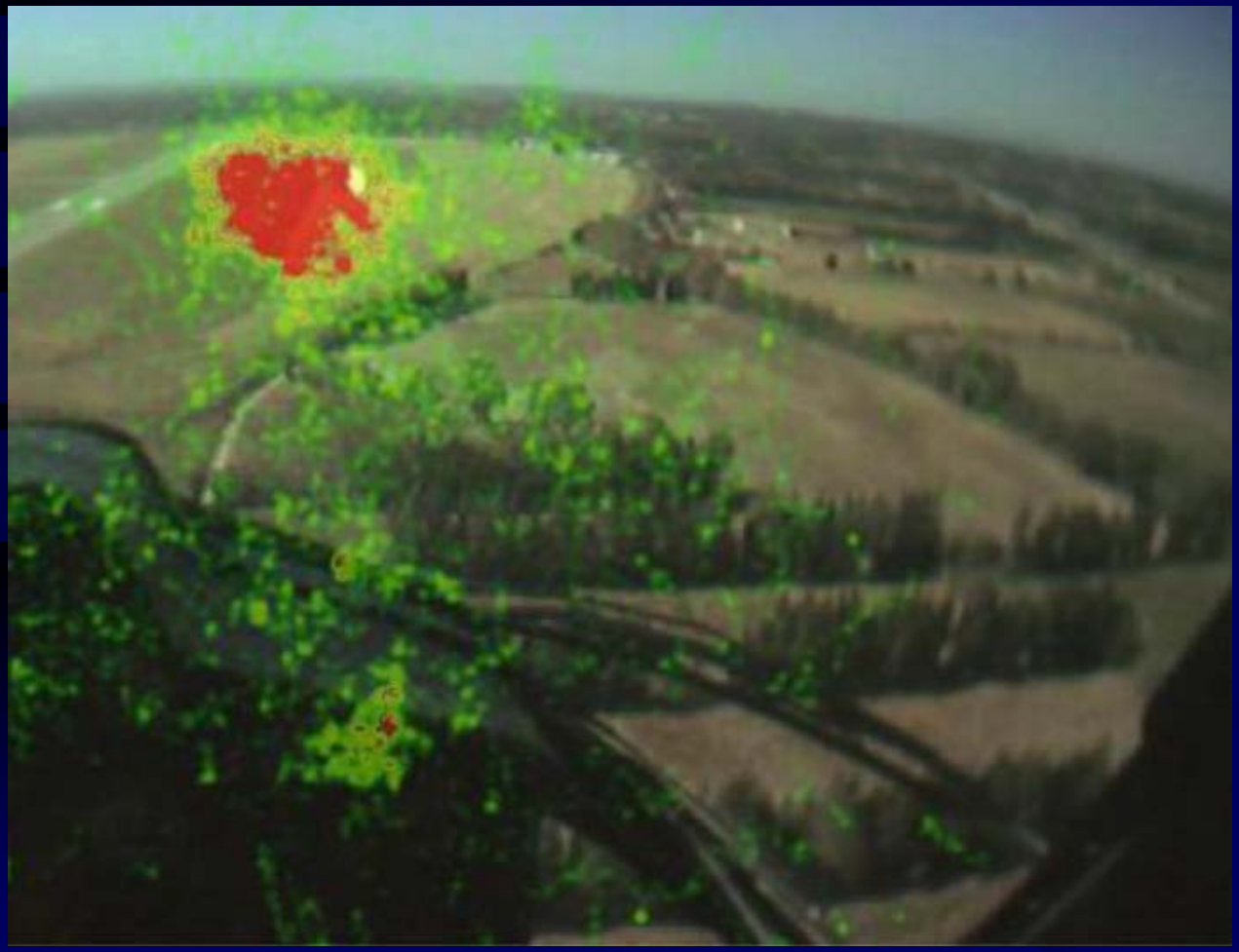


5.2 Specific application of Solar PV in airports

Questions:	*Answers:*
SOLAR FARM < 0.5 MW *at more than 0.5 mile from substation*	*MV NETWORK 4,160 (or 6,600 V) behind a step up transformer*
LONG *instead of square fields?*	*See distribution in 4,160 V AC* *« Long distance distribution (1) »*
ELEC. SAFETY *in solar panels*	*Output short circuit if open circuit detected*
SAFETY of firemen *& passengers*	*See last page « Crash situation »*
SUN REFLEXION *on the panels?*	*New generation of glass with low level of reflexion (St Gobain, API …)*
Europ ***CIVIL AVIATIONS*** *position?*	*Successfull tests with aircraft pilots*
See the 2 following slides	*→ French info note dated 31 Aug 10*

5.3 Solar farms
Sun reflexion

Tests & results in a French airport :



on airport specific panels ***with glass treatment***

5.4 Solar farms
French Civil Aviation

DGAC – Direction Générale de l'Aviation Civile → ***French FAA ...***

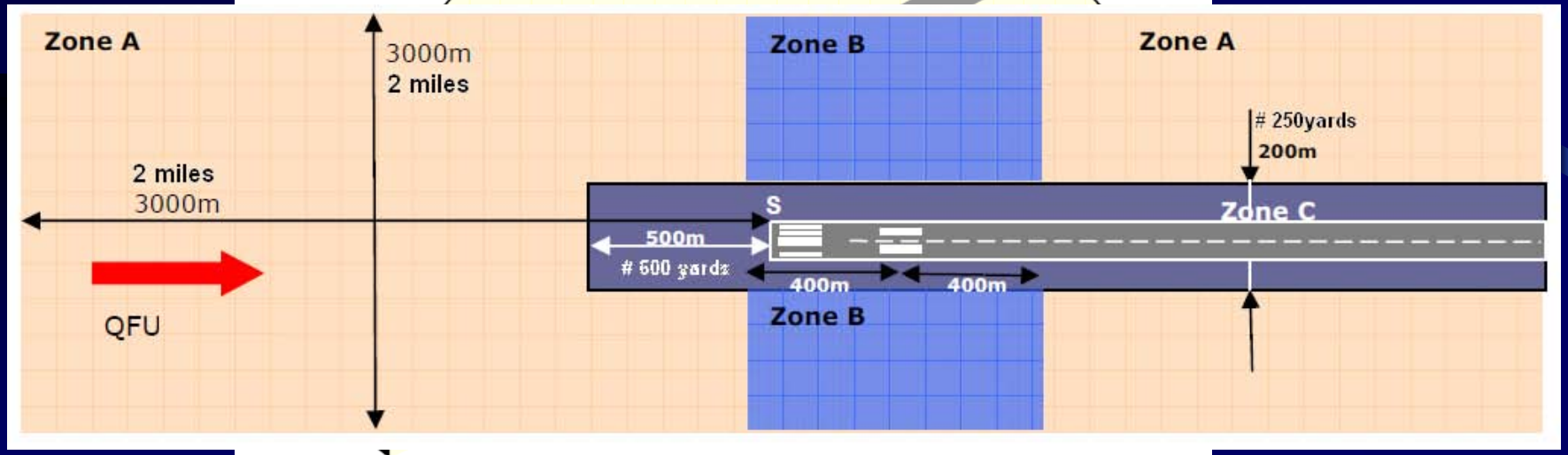
Info. note « Agreement of photovoltaic projects around airport »
(Edition 2, dated 31 August 2010)

See website : http://www.developpement-durable.gouv.fr

Zone < 2 miles around the Tower → *Luminous reflexion* ***< 20 000 cd/m²***

In the fie ***runways:***

Zone A: < 20 000 cd/m² - ***Zone B: < 10 000 cd/m²*** ***ne C: 0 !!!***



Protection zone around the control TOWER

6.1 Current discussion around airports

2 visions in function of the traffic of the airports:

1) Lower traffic airport (< 100 000 passengers per year):

- *Looking for new business (e.a. renting the field for solar farms)*
- *Electrical maintenance team has time to optimize the solar production by cleaning panels and checking daily production*
- *« Green » balance between airport consume & production*

2) Higher traffic airport (> 500 000 passengers per year):

- *Ready for PV solar production on building and car parks*
- *Against PV panels in the field due to many aircrafts traffic (It's difficult to maintain the AGL equipment ! Please don't add PV !)*
- *« Green » solar prodution: difficulties to reach airport consume …*

6.2 Current discussion around airports

What to do with 1$ per passenger ticket ?

<u>30 international airports:</u>

→ Traffic from 33 to 90 M passengers per year

AN EXAMPLE:
*Roofs & Pavement at the **Atlanta Hartsfield-Jackson Airport** (**ATL**) is estimated at >70,500,000 square feet.*
*If 25% can be utilized for PV, ATL can install a **1.50 GW "solar".***

With $1 surcharge, ATL would collect $90M annually.
*If 1 "KW PV" is # $9,000 → **120 MW PV installed in 10 years**.*

During this 10 year period,
*Total accumulated PV capacity **could exceed the peak load of ATL**.*

6.3 CRASH situation with Solar panels

RISKS:

Aircraft leaving « slowly » the runway

Aircraft leaving « quickly » the runway

Aircraft stopped inside the farm

< 1% of chance but …

Electrical protections for airports firemen

SOLUTIONS:

Aircraft stopped inside the 150 m (164 yard) band from runway axis

Aircraft crossing the solar farm

PV panels with frangible supports

PV panels will limit speed of aircraft

PV panels will have to fall down:

- *Electromagnetic relay on supports*
- *PV panels laid on a concrete floor !*

Open circuit detection in each panel => PV panel output = short circuit

+ Remote control of short-circuit

... Thank you for your attention

Any question ?

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