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Future of PV technology

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Durham
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EPSRC
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What does “Sheffield Solar” do?

1. Sheffield Solar Farm

www.shef.ac.uk/solar

2. Collection, aggregation and analysis of UK PV generation data

www.microgen-database.org.uk

3. Next generation PV technology Plastic photovoltaics

www.epmm.group.shef.ac.uk

4. Future PV-inclusive energy systems

www.facebook.com/SolarEnergyInFutureSocieties

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EPSRC funded research projects

EP/I052541/1

Photovoltaics for future societies

EP/K022229/1

Whole System Impacts and Socio-economics of wide scale PV integration (WISE-PV)

EP/I028641/1

Polymer/fullerene PV: New materials and processes for manufacturability

EP/J017361/1

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What's this talk about?

The Big MACC
PV cells, costs and learning curves
Future Technology – “OPV” and others
The problem of disruptive Markets
The Big MACC revisited

3. Next generation PV technology Plastic photovoltaics

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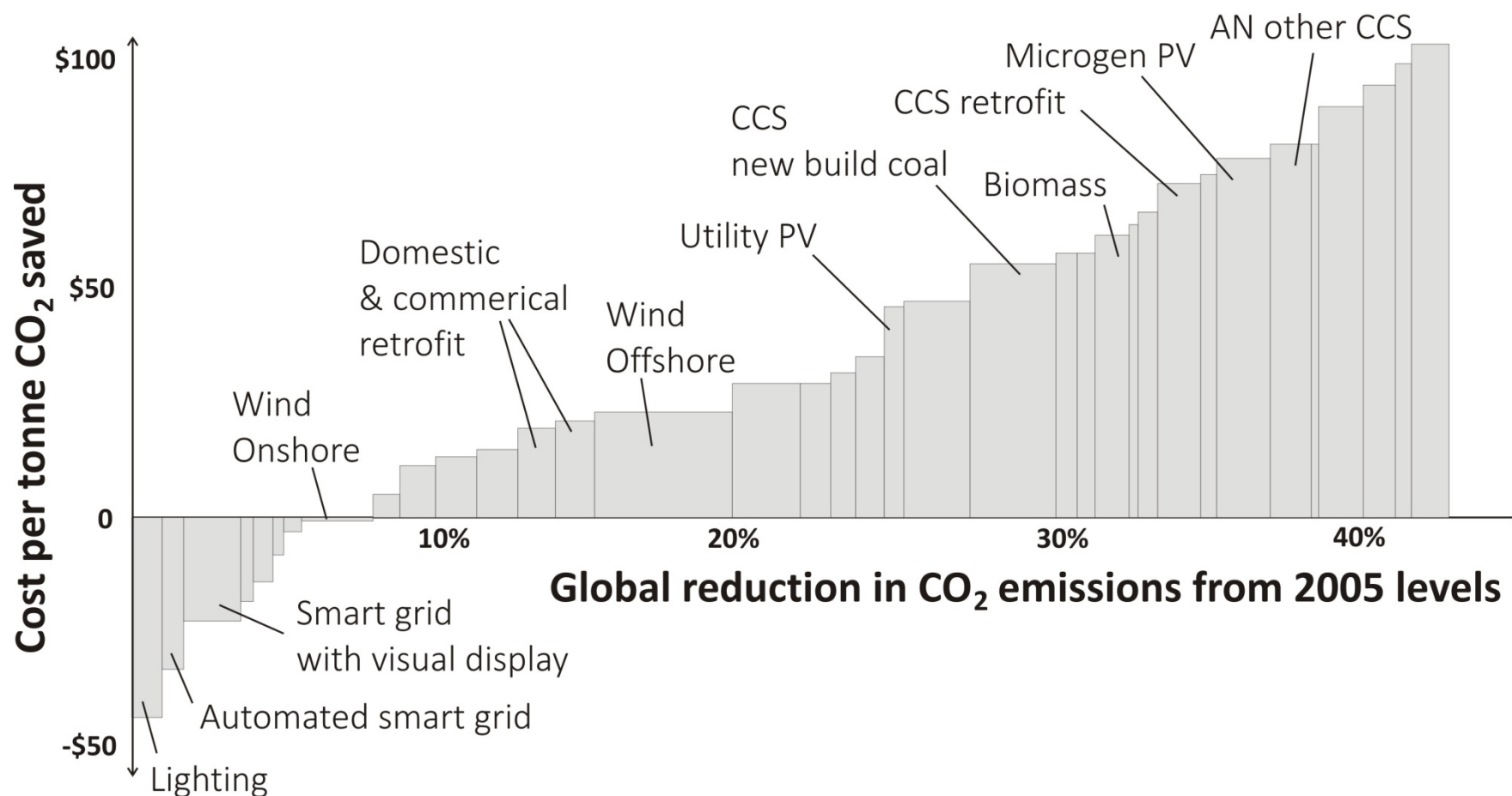
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Here's one way to think about it *The MACC approach...*

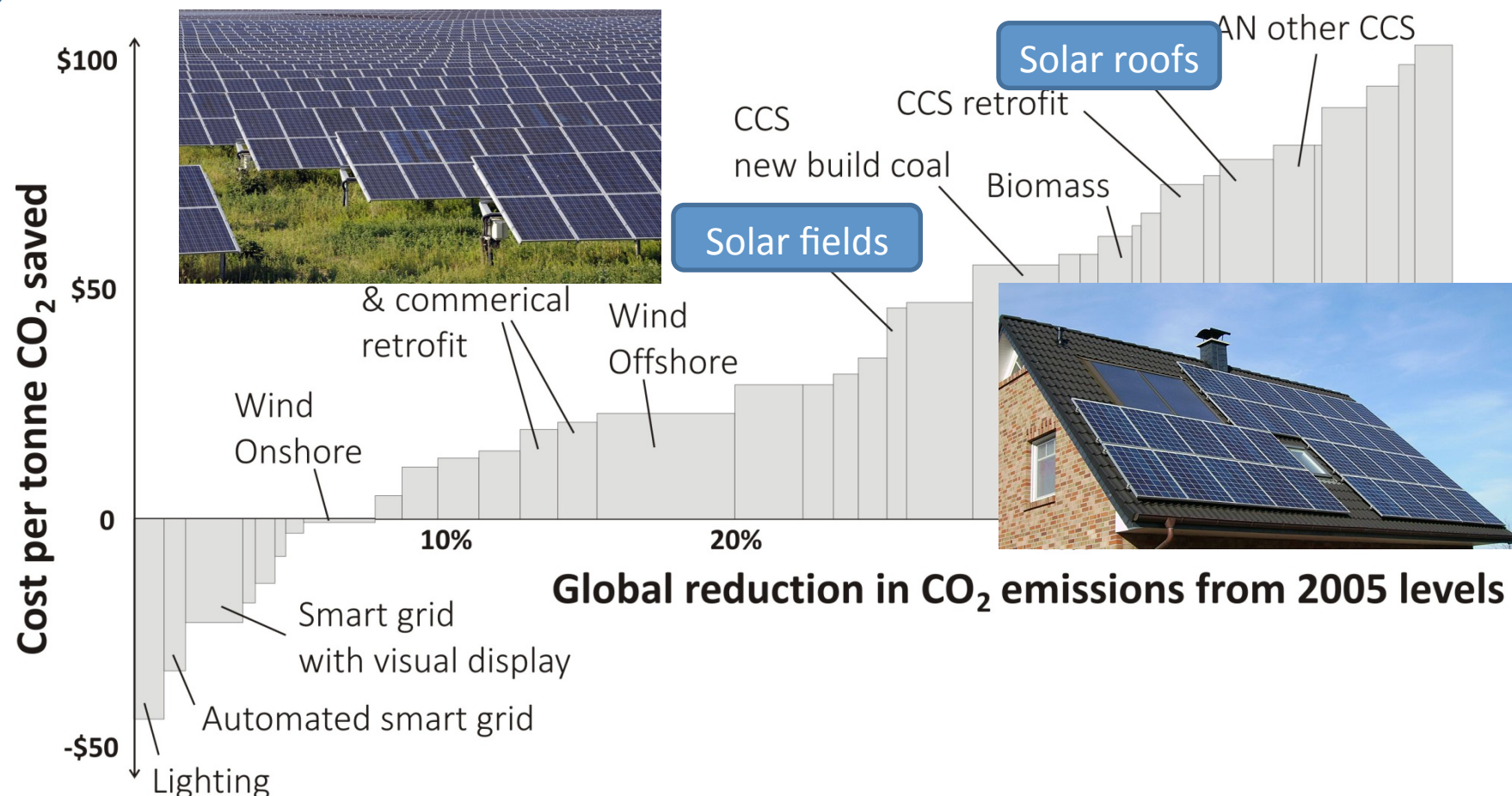


Adapted from Bloomberg new energy finance



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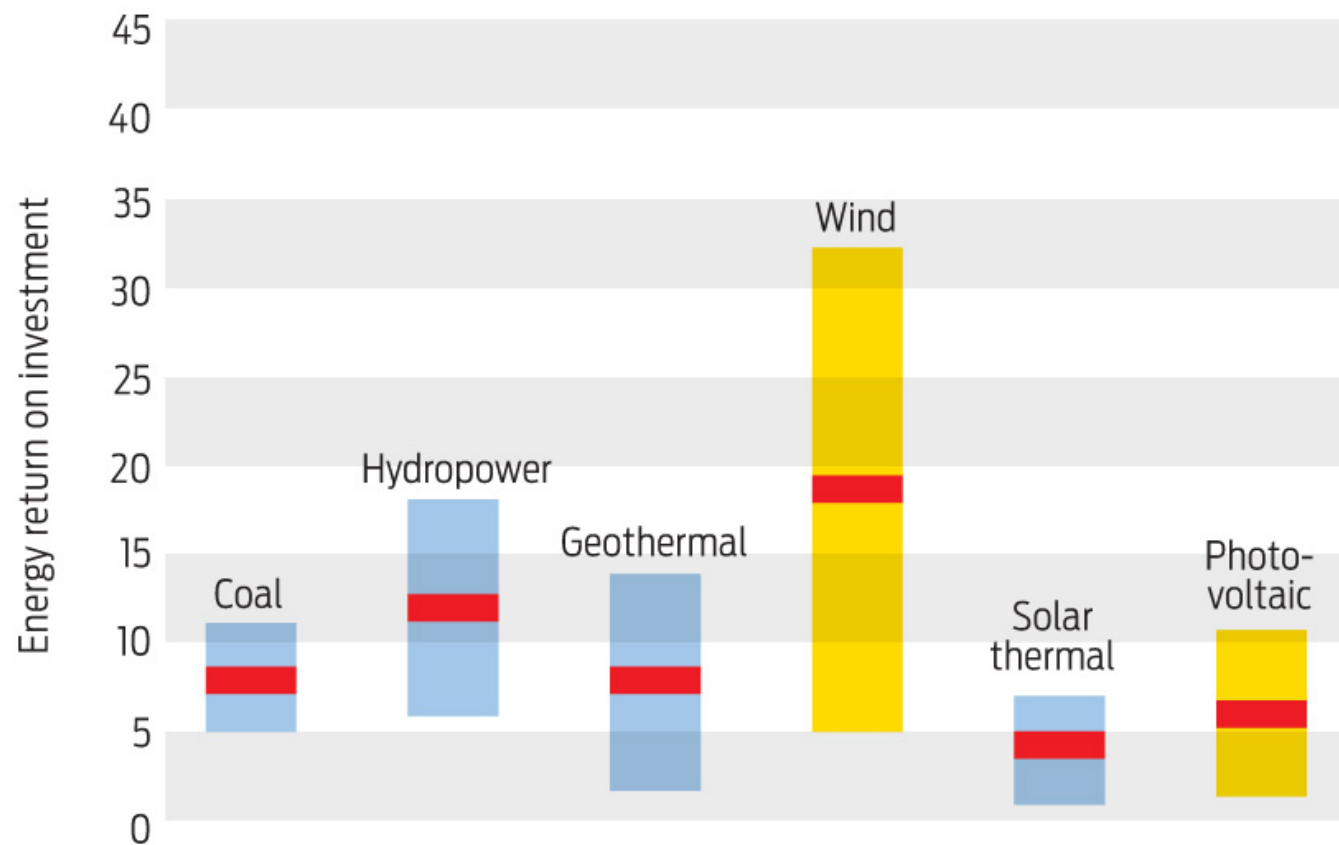


Adapted from Bloomberg new energy finance



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Here's another way to think about it
The "EROI" approach...





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EROI and MACC

The Big MACC is all about today

EROI is all about the possible

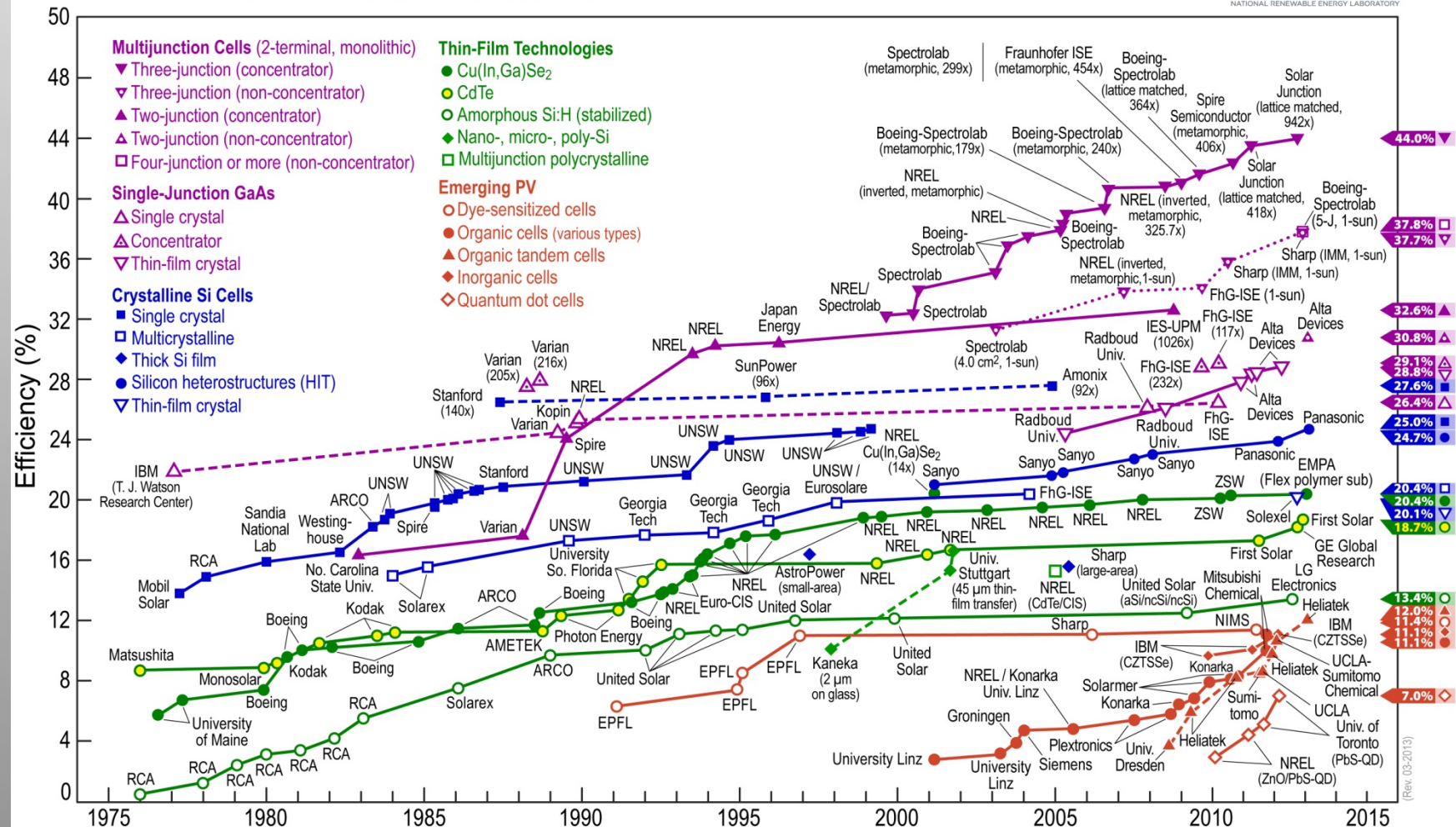
PV needs to cost less ££ and less energy

How?



Different technologies

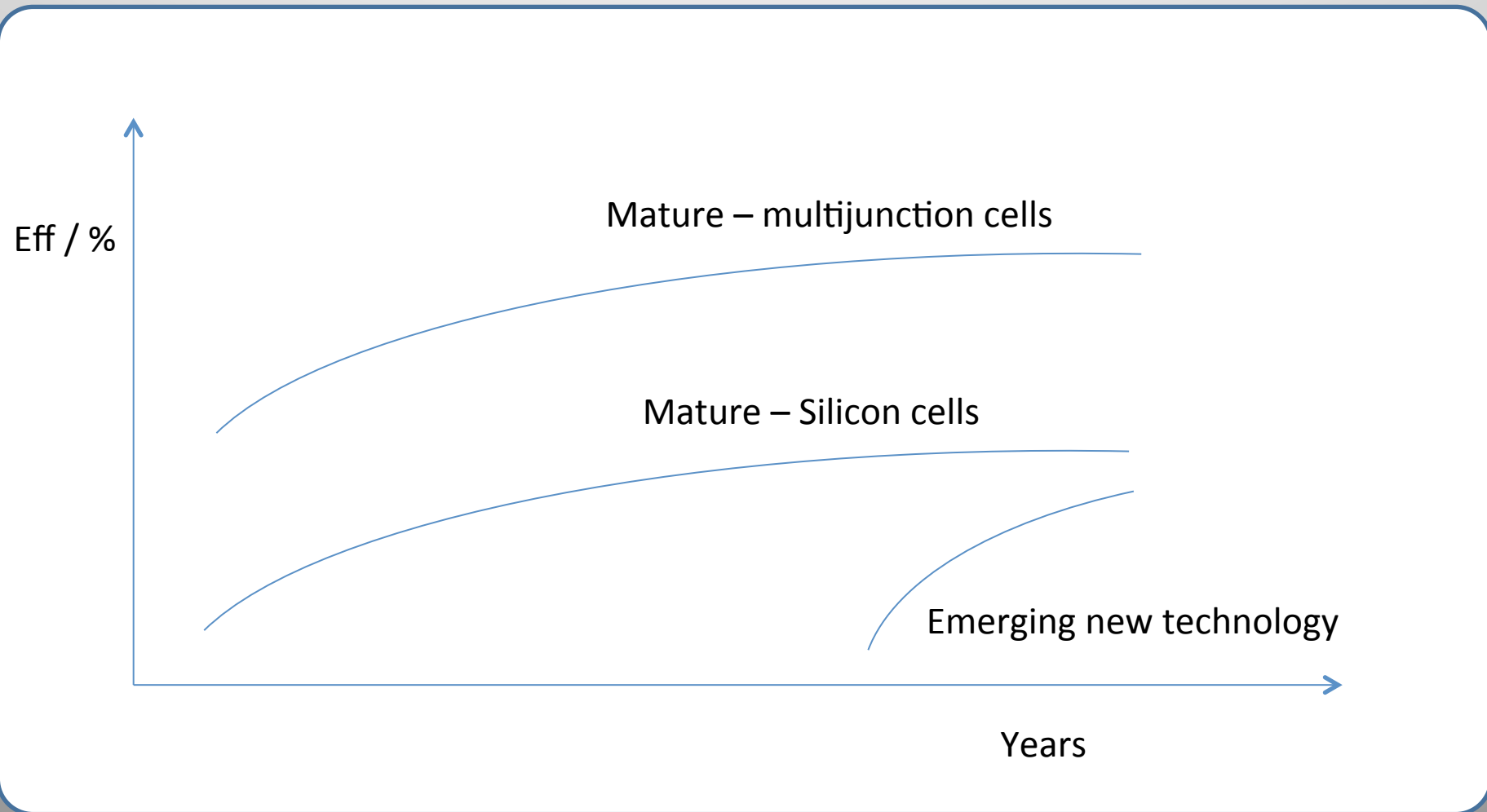
Best Research-Cell Efficiencies





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Solar Cell Efficiency

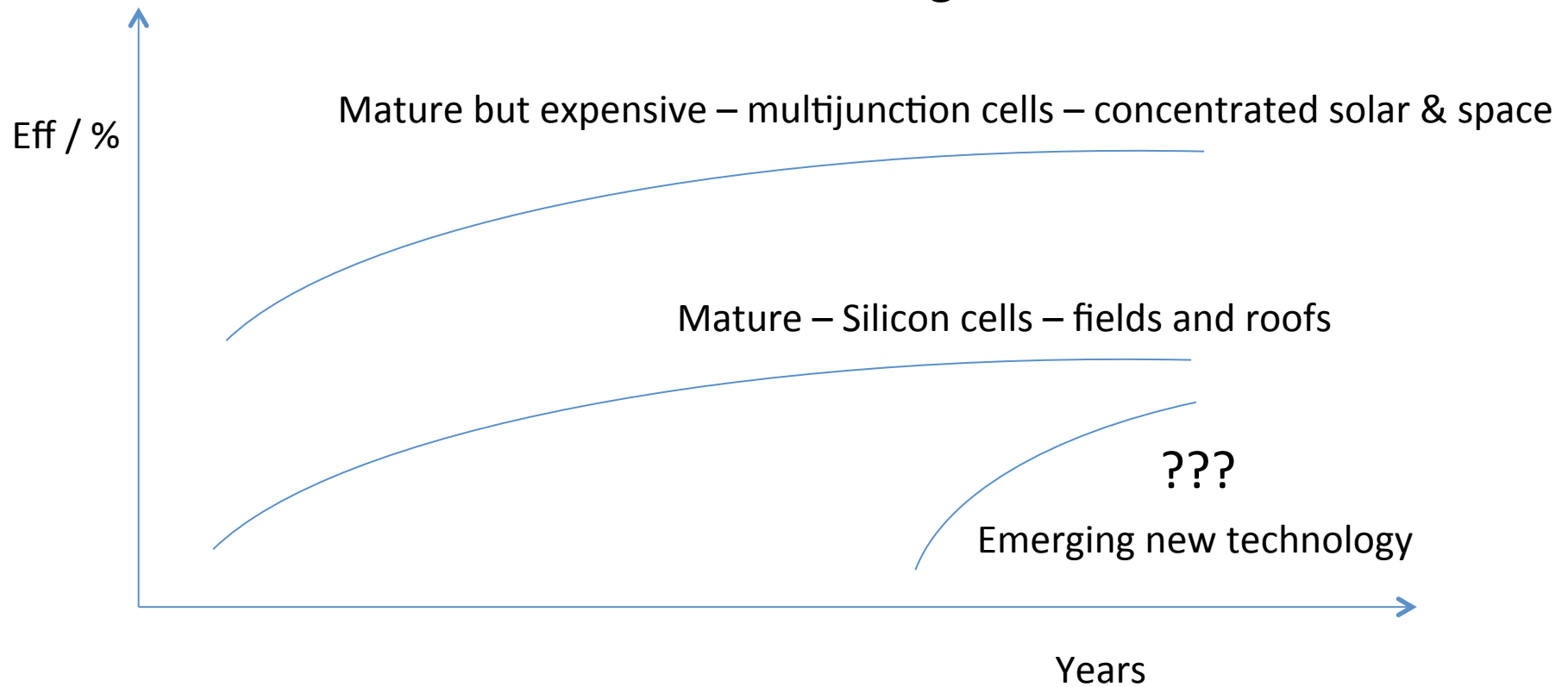




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Solar Cell Markets

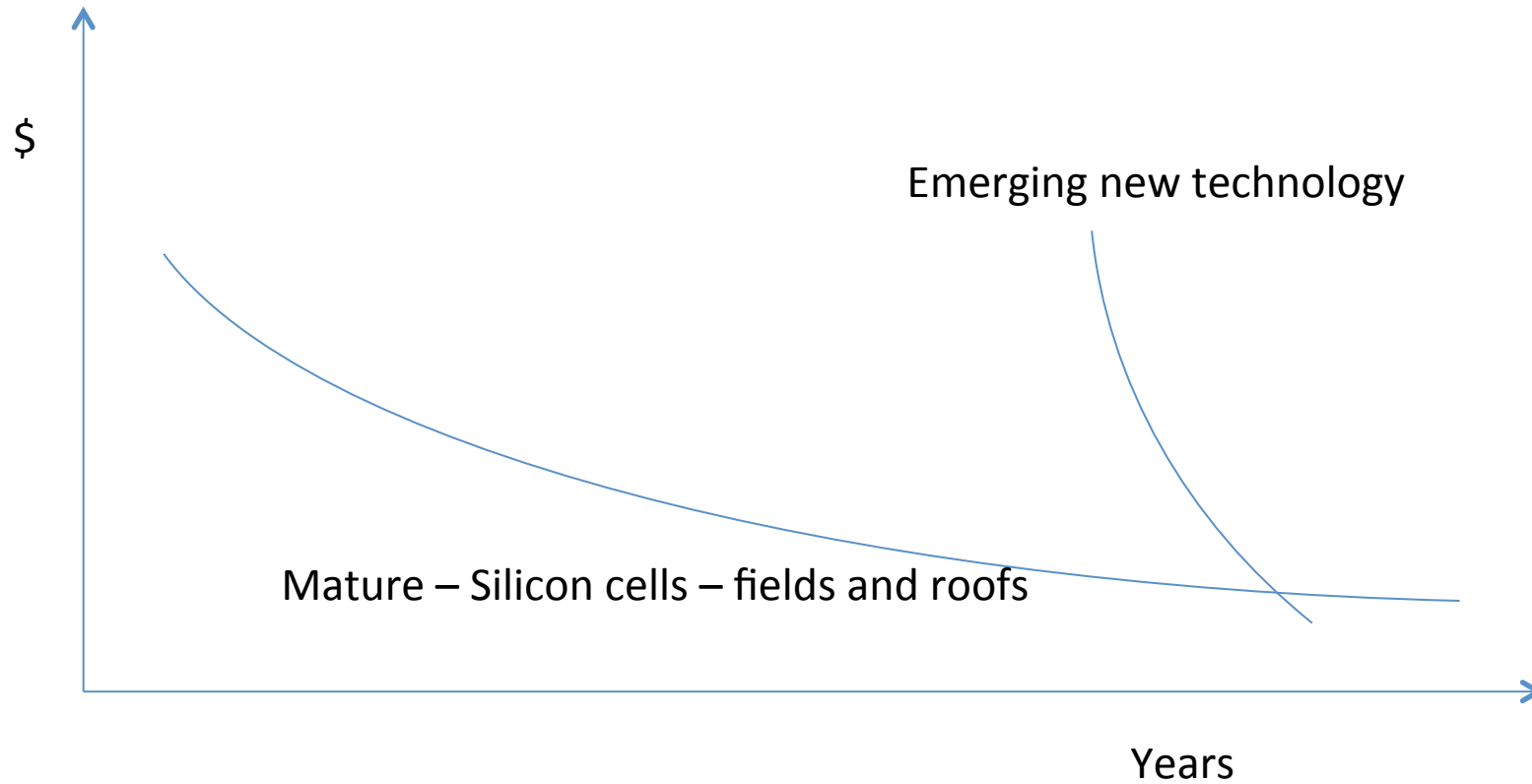
Market segmentation





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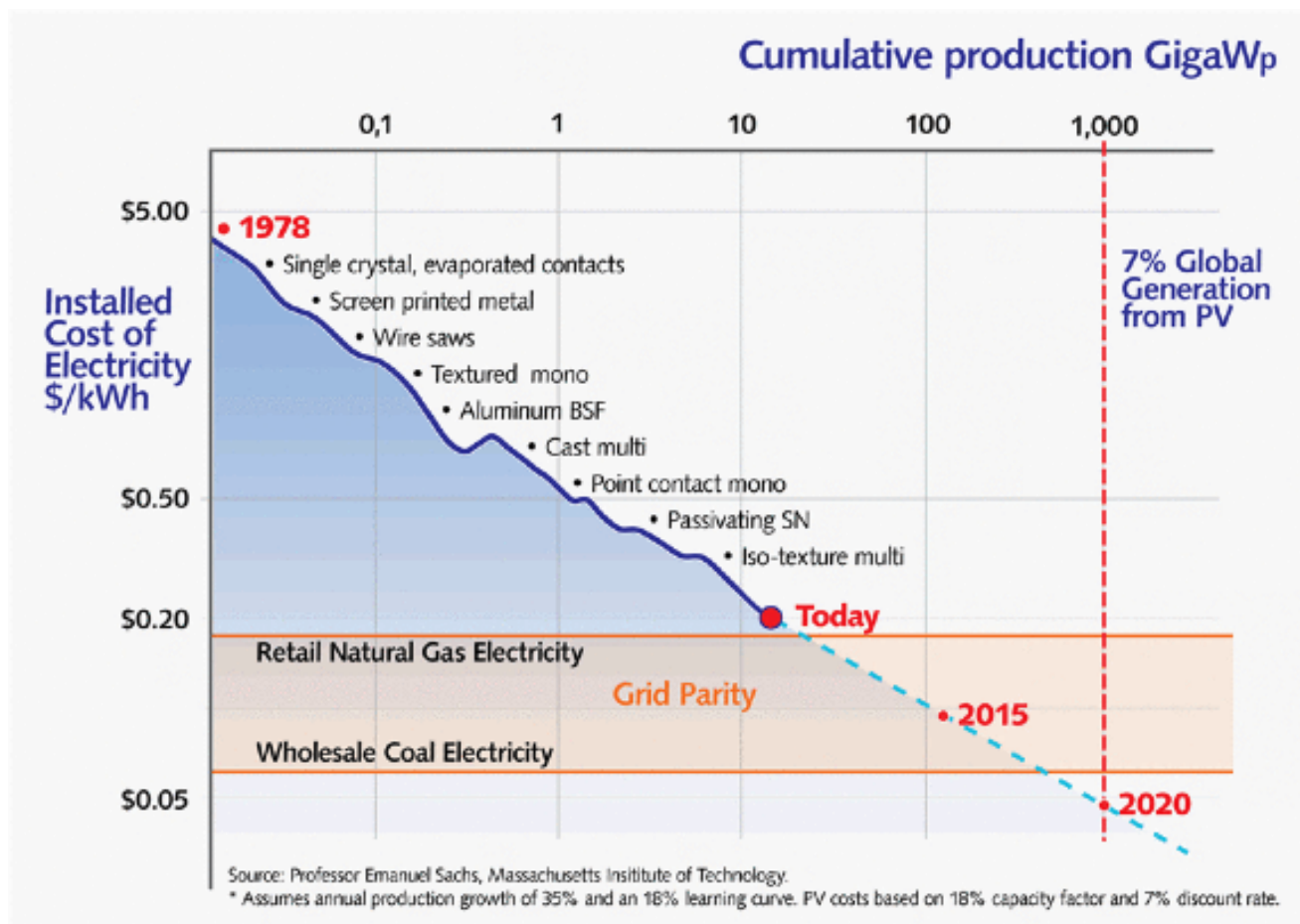
Solar Cell Cost – Learning Curve





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Solar Cell learning Curves

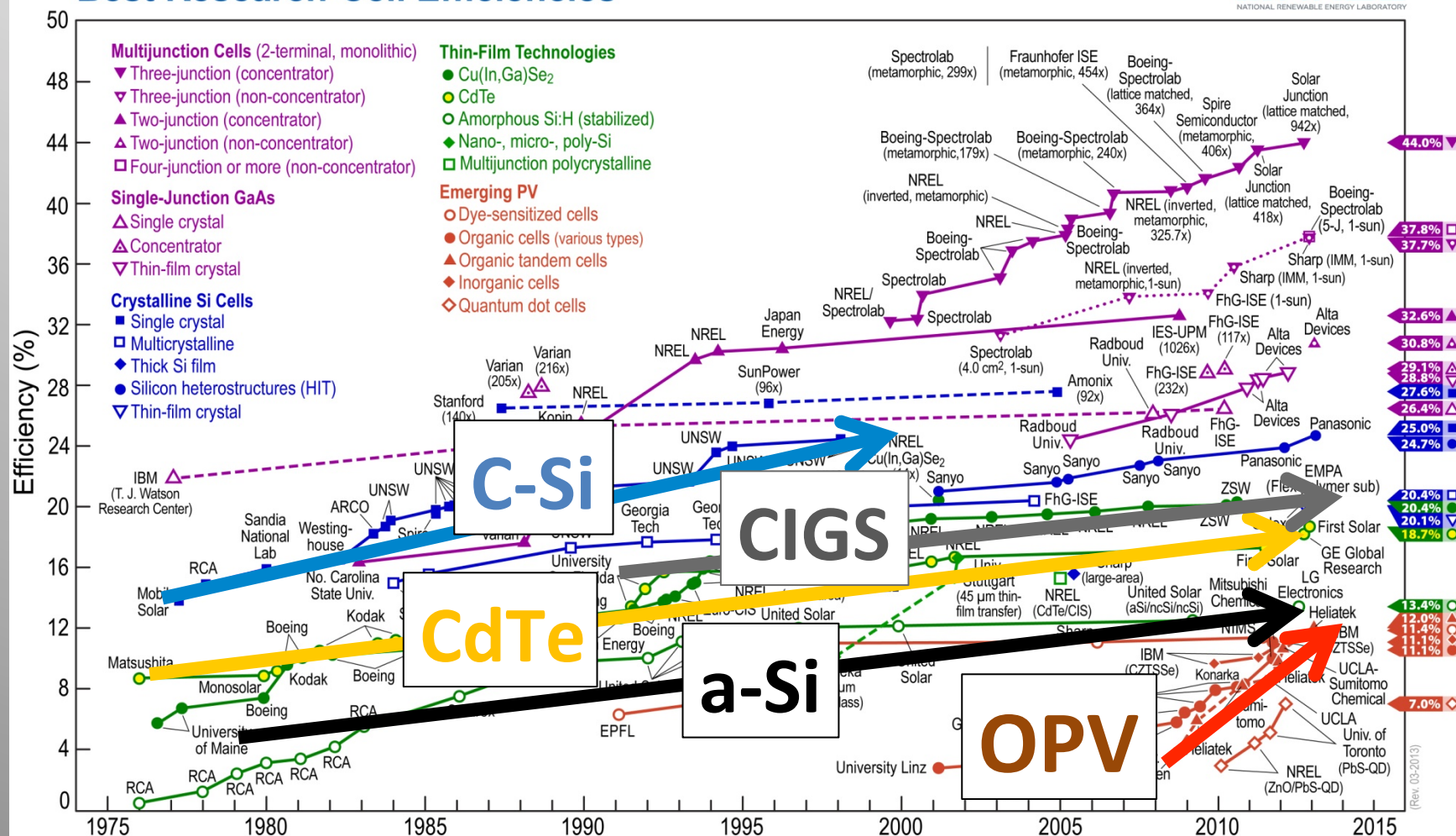




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Future technology

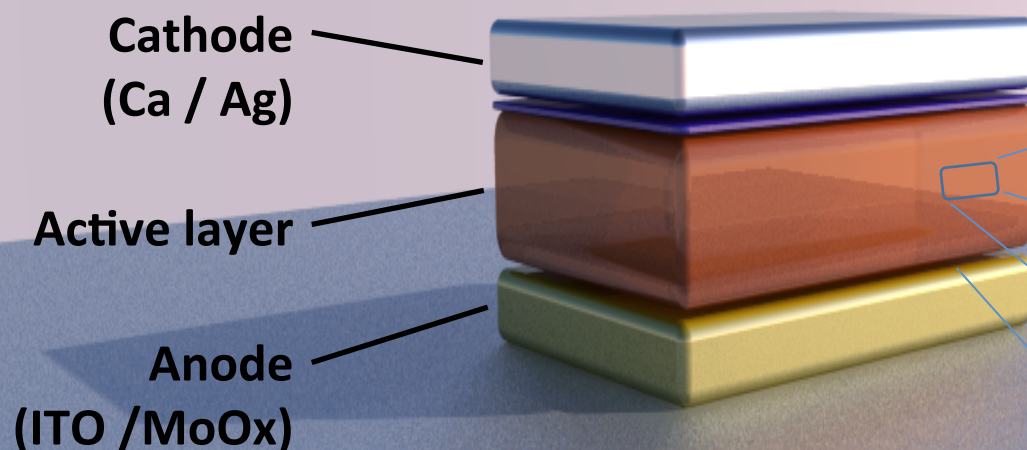
Best Research-Cell Efficiencies



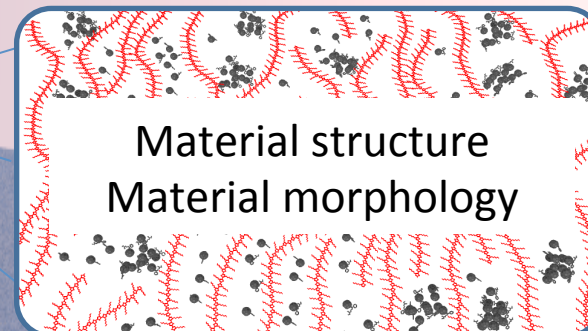


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Organic solar cells



Device processing



Material structure
Material morphology

Interface science

Simple cell architectures and processing

Motivated by:

- lower production costs
- lower embodied energy

Use Spray deposition to construct complete cell.

EP/I028641/1

Polymer/fullerene PV: New materials and
processes for manufacturability

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<http://www.youtube.com/watch?v=7CUTUFxsefo>



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Disruptive markets

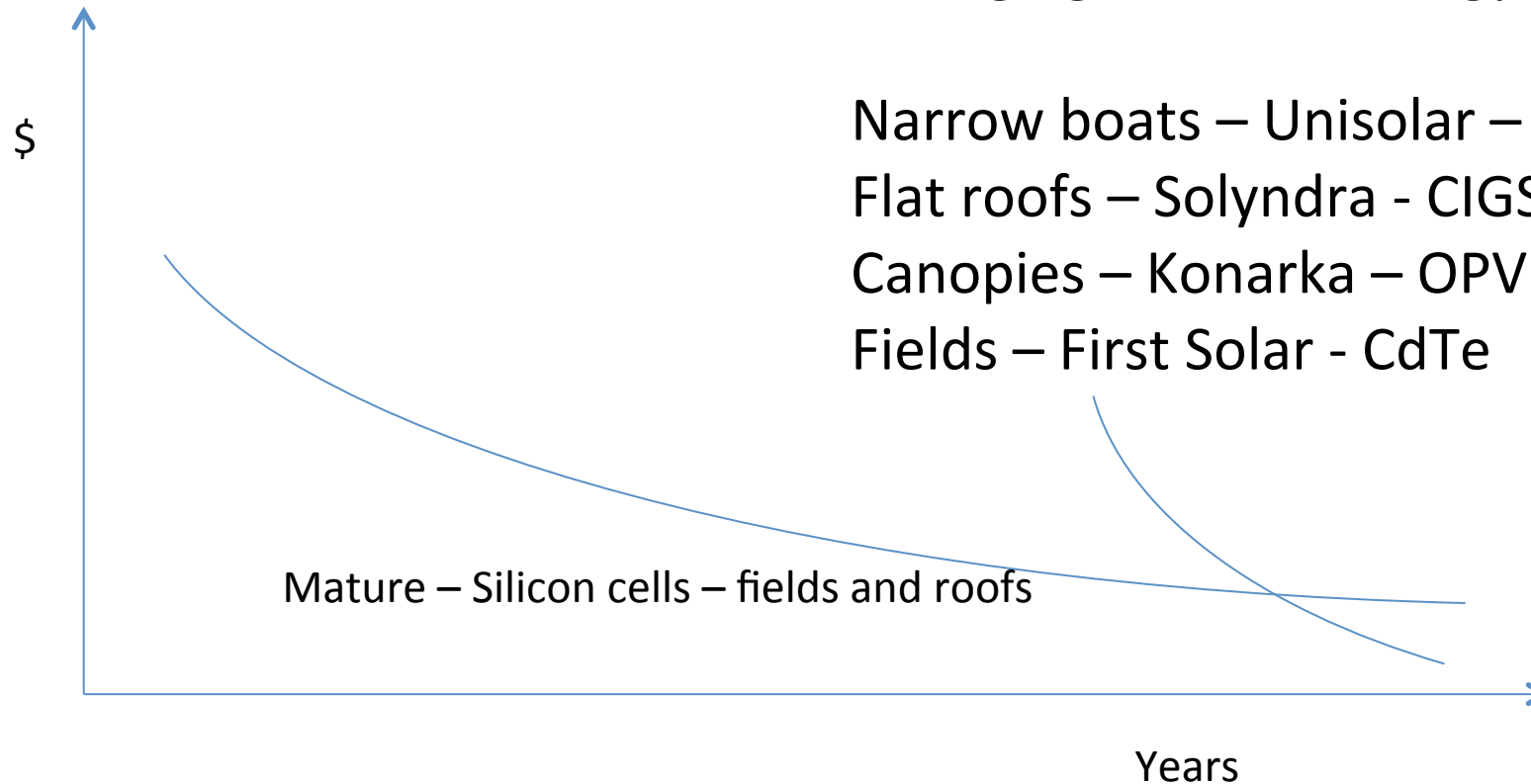
Emerging new technology

Narrow boats – Unisolar – a-Si

Flat roofs – Solyndra - CIGS

Canopies – Konarka – OPV

Fields – First Solar - CdTe

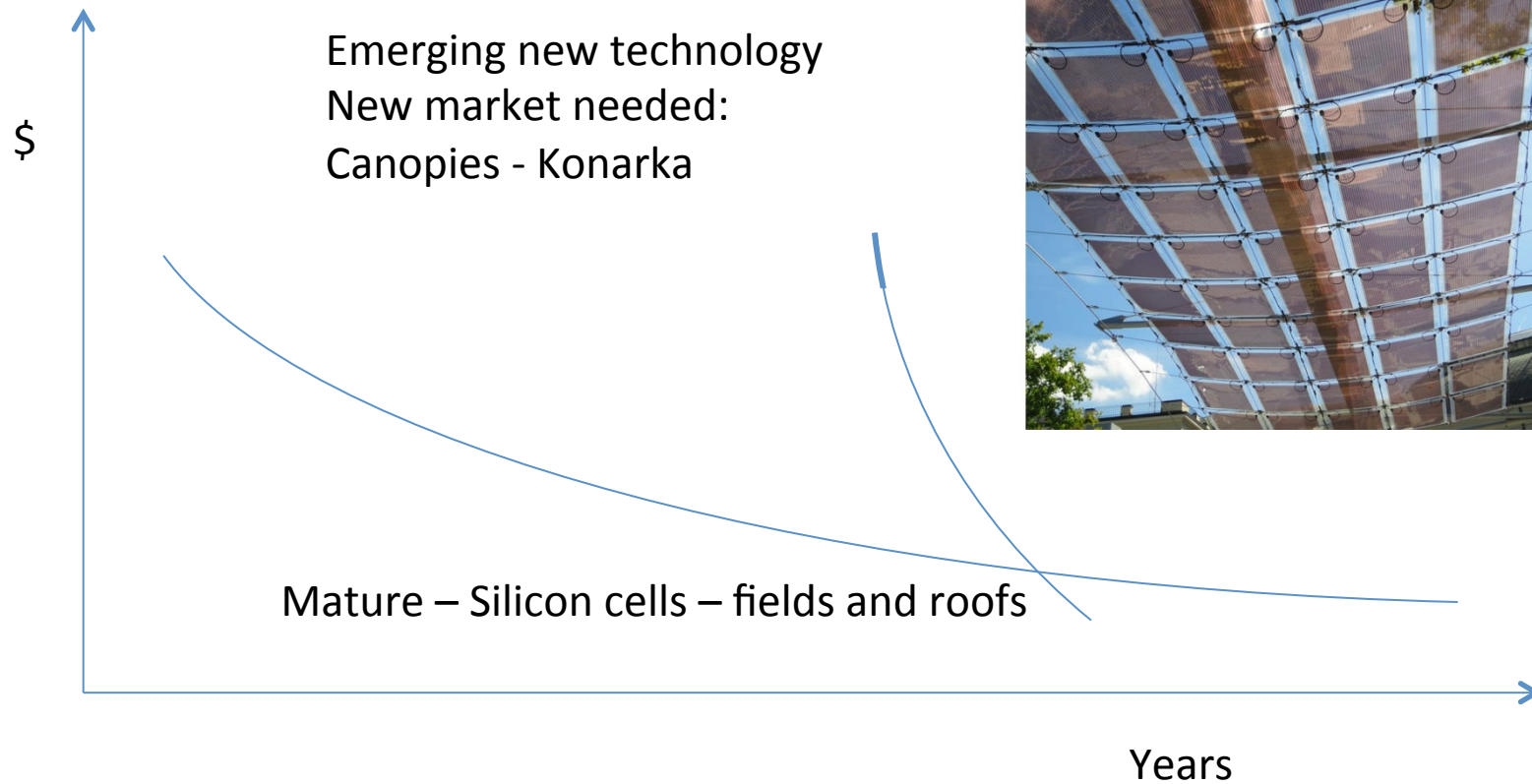




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Solar Cell Cost and Efficiency

Konarka - OPV

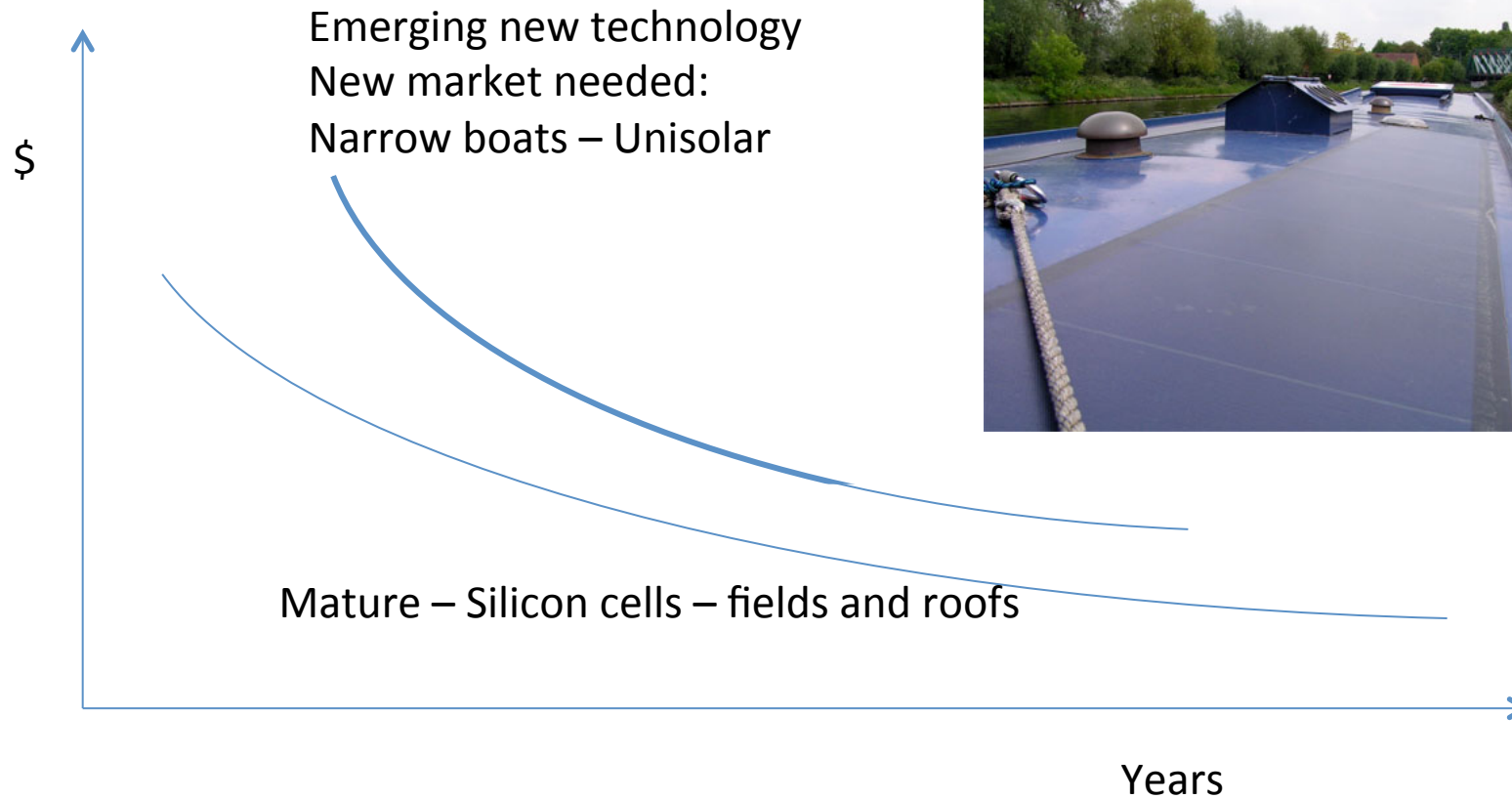




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Solar Cell Cost and Efficiency

Unisolar – thin film a-Si

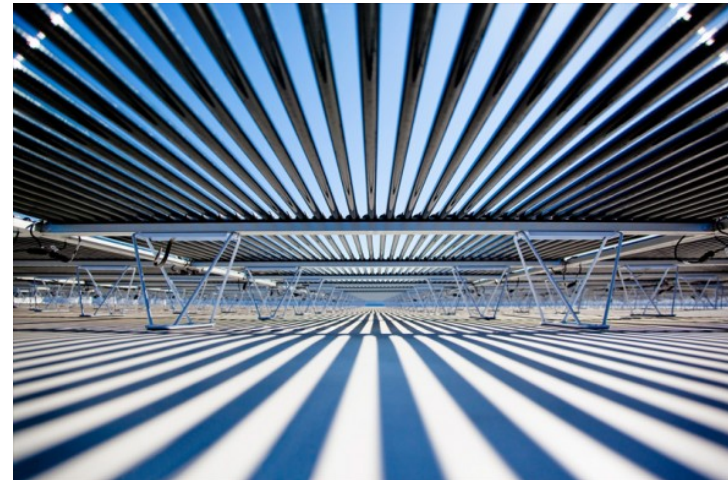
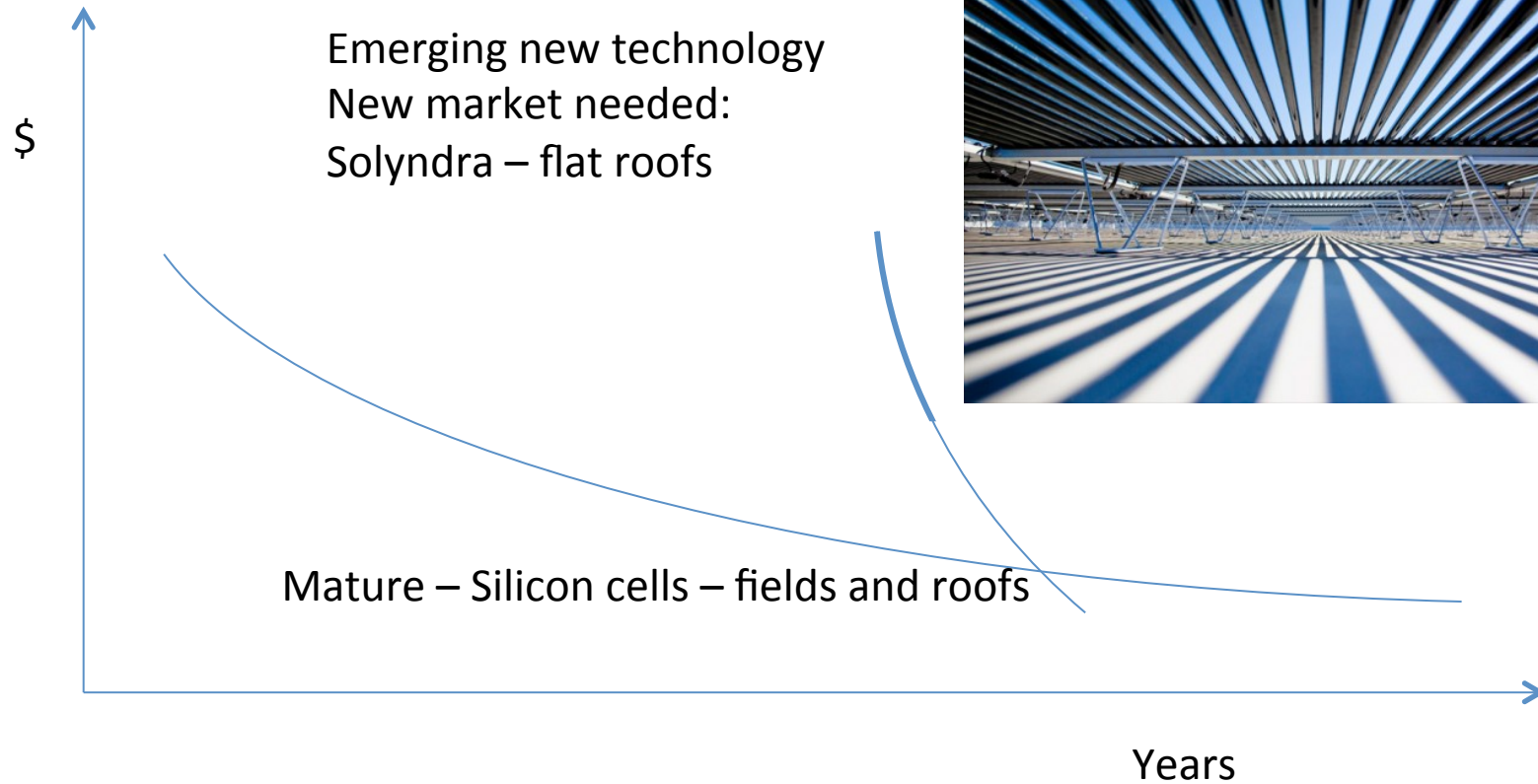




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Solar Cell Cost and Efficiency

Solyndra - CIGS

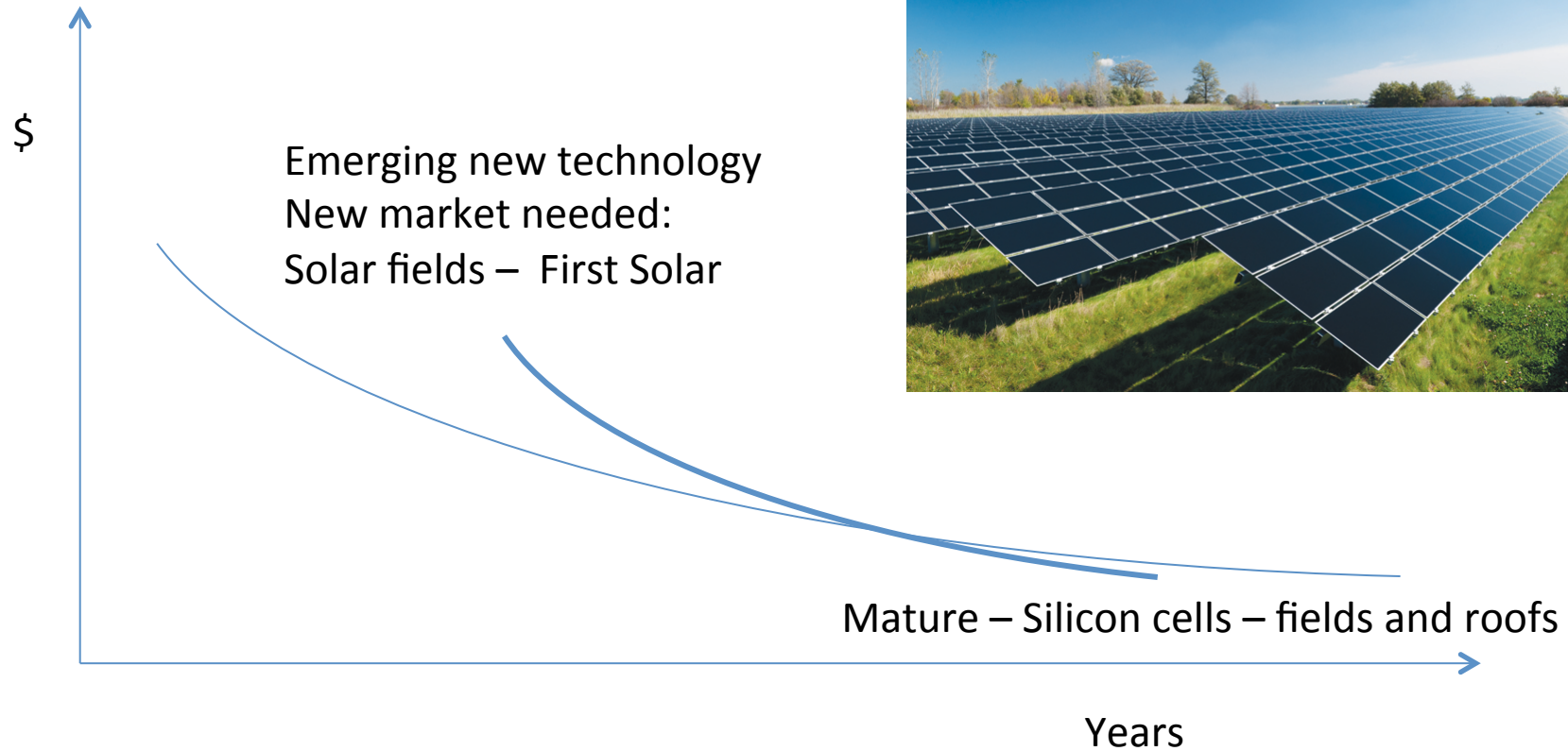




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Solar Cell Cost and Efficiency

First Solar - CdTe





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Solar Cell Cost and Efficiency

Loads of potentially great technologies that will provide much better energy economics in the long run

But

The route to market is fraught with risk

And

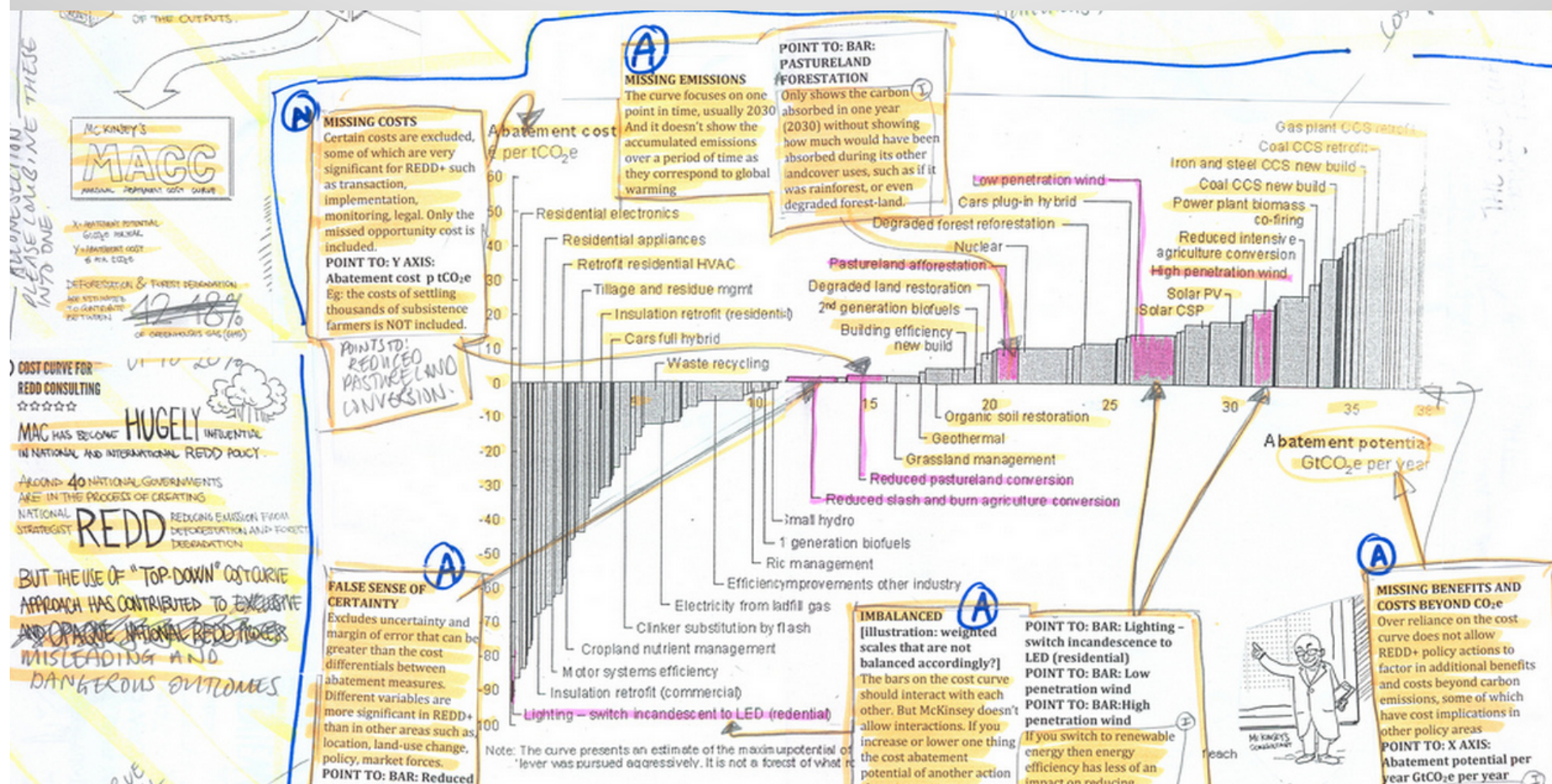
Its real money that counts in the short term...



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The Technology Green Bag

The Big MACC approach... problems?



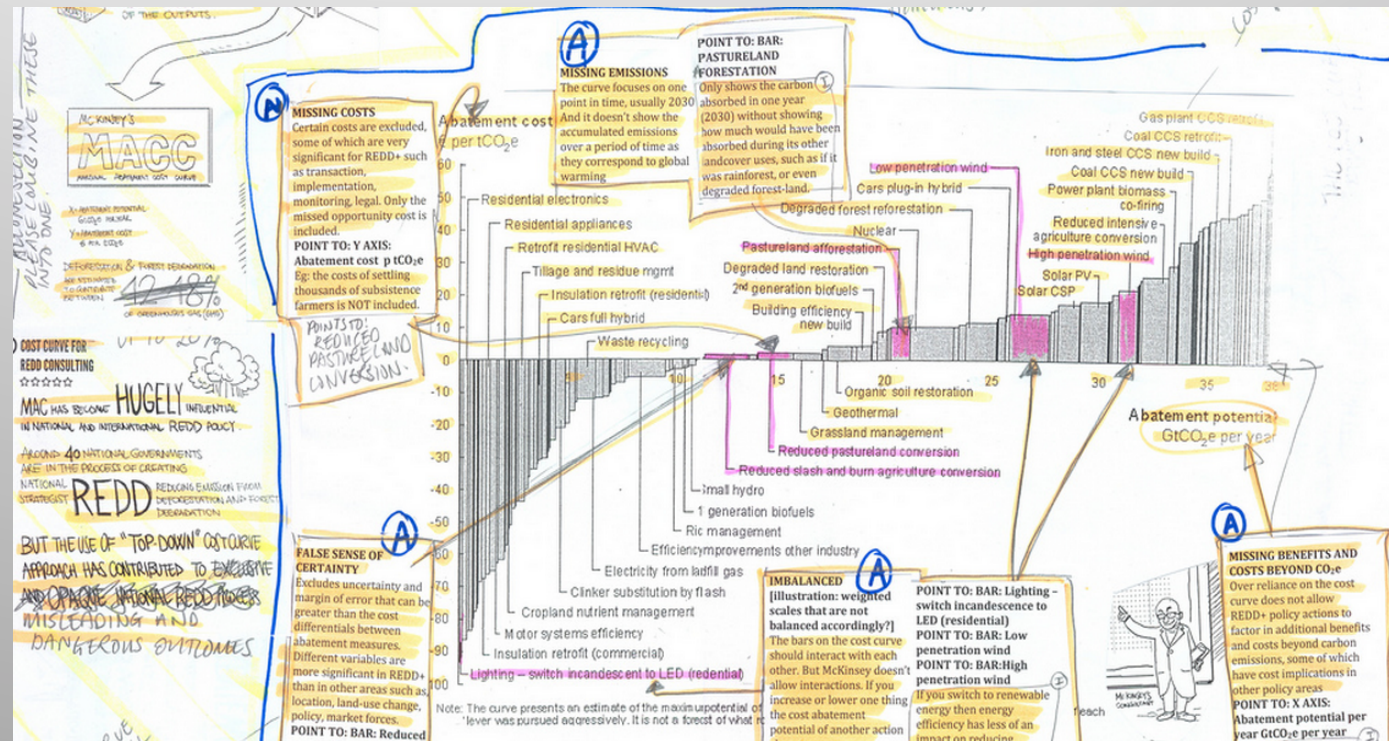


**Not
“consequential”**

**“Levelised”
yearly
economics**

Only two metrics

- 1. Carbon saved**
- 2. Carbon cost**



For the MACC to work ...

.... “Society” is not expected to “change” in response to decarbonisation....

Difficult patterns

Britta Turner (University of Durham)

- The everyday usage of PV electricity is not that straightforward...
- Generation patterns present a poor match to average consumption patterns.

The thrifty 'prosumer'

- “One way of **making the most** of your system is to use more of the electricity it generates at home rather than exporting it back to the grid.
- Financially this makes sense because electricity bought from your electricity supplier...costs more than what you get back through the Feed-in Tariff...
- *You'll need to be careful how you do this, though, as increasing your electricity usage to more than your wind turbine or solar PV panels generate at any given moment can increase your electricity bills and not reduce them”. (Energy Saving Trust 2013)*

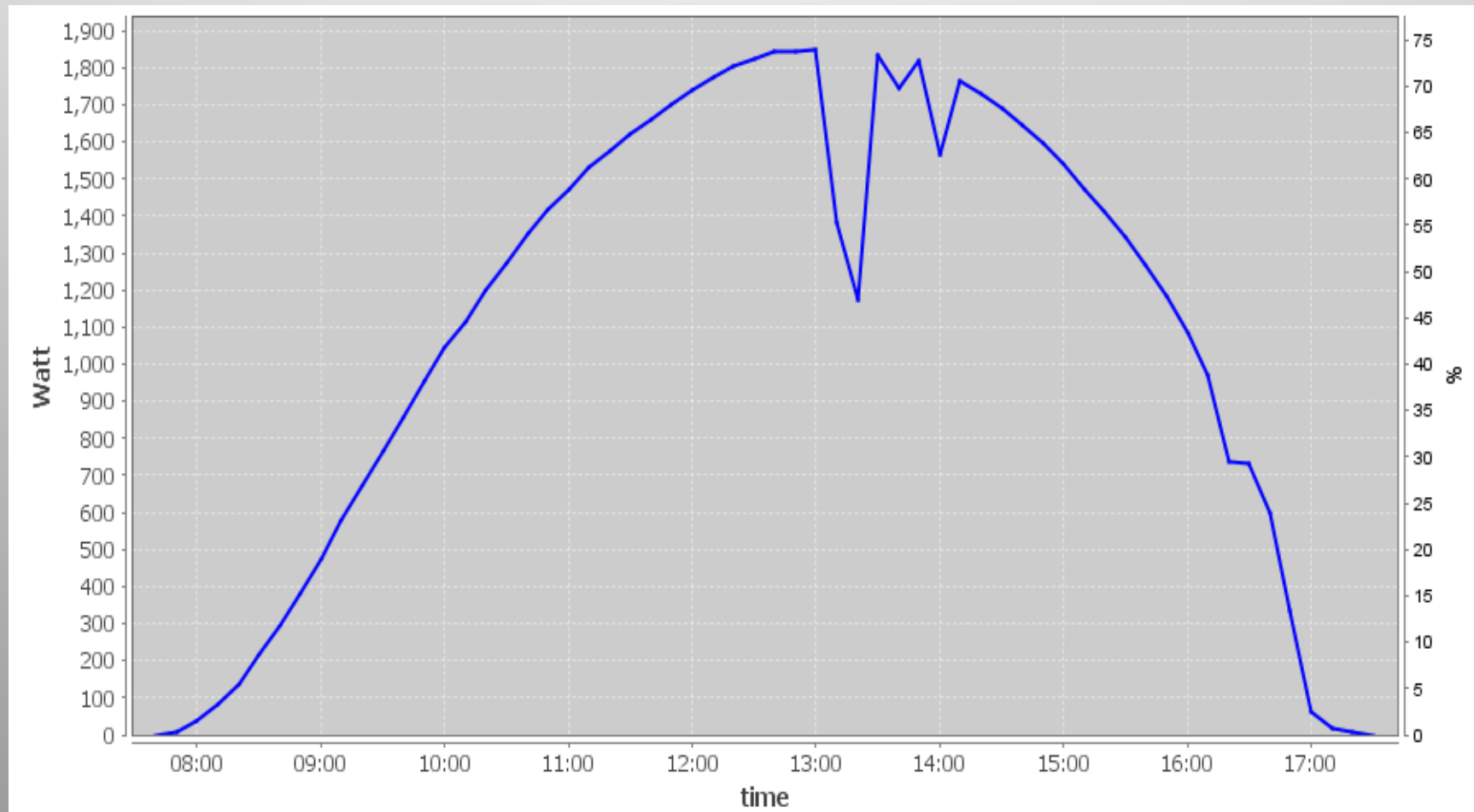
Surplus electricity

- *“I now always try to put my toothbrush on to charge during the day, where before I would charge it overnight. But it’s still difficult getting it completely right, because then I often forget to unplug it when I come home”*
- *“So I look at the weather forecast and see if there is a period around lunchtime or early afternoon where clear skies are forecast. And then I hope the weather does what the forecast said. But at the end of the day this is the weather, you just can’t tell. So then I sit there sometimes at work and look out the window at the time we have set the timer for (laughs), it is pretty ridiculous really...”*

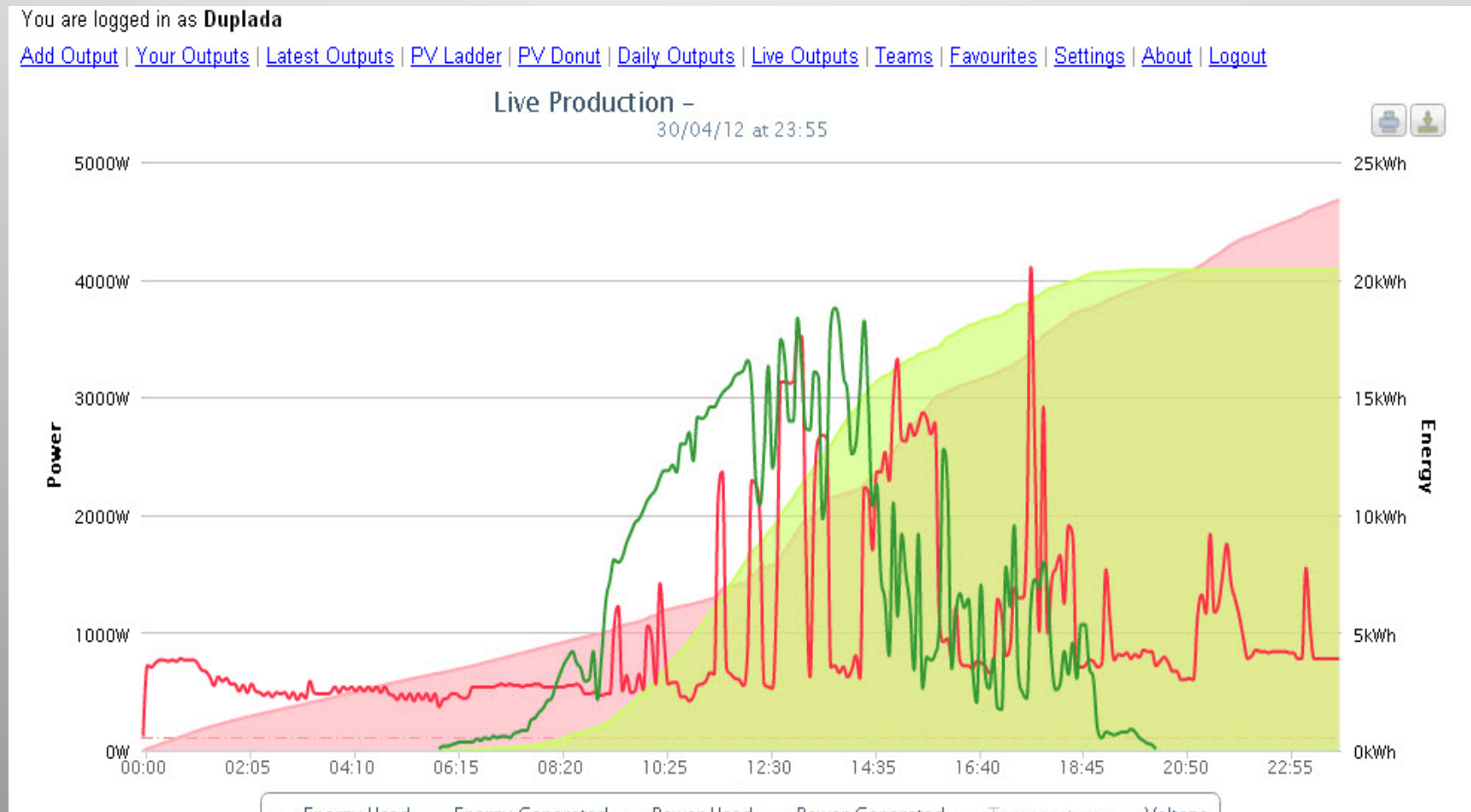
The trouble with lunchtime clouds...

- *Britta: So in the middle of that curve, is that a cloud?*
- *Stan: Yes it is, I've noticed this. Consistently we get sunshine, and that was at about 11.30, and then at lunchtime we get a bit of cloud, and the cloud goes away again! So just when you would like peak power, when we're going to have lunch, there's cloud (we both laugh). It's weird. So actually we're better off putting electrical items on just before lunch and just after lunch, and forgetting all about the lunchtime period. I guess if I looked at August it might be a similar thing. Yes I noticed this myself a few weeks ago, that there is this oddity. (Stan searches for another graph).*
- *Britta: (looking at graph) oh yes, there it is again, not as significant but definitely a lunchtime cloud!*
- *Stan: There is a definite, consistent... just when you think 'we'll put some beans on toast on' or you want to put the toaster or hob on. Ok, all it's done on this one is drop from 1,1 units till 1. We'll be generating more power than what we're using, so that's all right. I've had some great times with these charts! (laughs)*

The lunchtime cloud (19/2 2012)



“[Graph 2](#) shows a good mornings generation with white goods devices being switched on to take account of the good generation, note the two kettle spikes in the evening and a period where my wife had the electric iron in operation”



“[Graph 3](#) is for those of you who have been following the information I gave earlier in this thread concerning using a proportional controller to dump PV export into your hot water cylinder. Note how the two traces very closely match each other as the controller adjusts the immersion power to match the PV generation. The sharp ones amongst you will have noticed that with the proportional controller in operation you can no longer graph the real base house load. Well you can but that is a story for another day”



Energy efficiency or 'dump loads'?

Comments from other Microgen users:

- *“The saving on gas is impressive but do you actually use all that hot water?”*
- *“A proportional controller is only worth the money if you have something you want to use (filling the hot water tank just to "leverage" the system isn't worth it unless it's being used).”*

Devices that use up electricity

- *“it did definitely change the way we use stuff. I guess when we can see the meter spinning backwards like this, we did sort of on those times start using the tumble dryer in the middle of summer and stuff like that, which we wouldn't normally have done, because it's free and not hurting the climate sort of thing. So we'd move stuff into the middle of the day, like the dishwasher and the tumble dryer and what else we've got would tend to go on in the middle of the day if we're around”*
- *“ So we use the tumble dryer more in the summer, although I'm still in the habit of putting it out on the line, which is silly really given that it could be completely free in the tumble drier”*



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The MACC approach...

Only two metrics...

Back in the science lab...

We are trying to make PV cheap....

....to move it left on the MACC

curve



PV becomes “economic” – move left on the MACC curve

High levels of deployment need grid reinforcement – move right



PV electricity needs using and people want to use it
Buy new devices that use electricity – move right



Store it in batteries or curtail is – cost carbon – move right



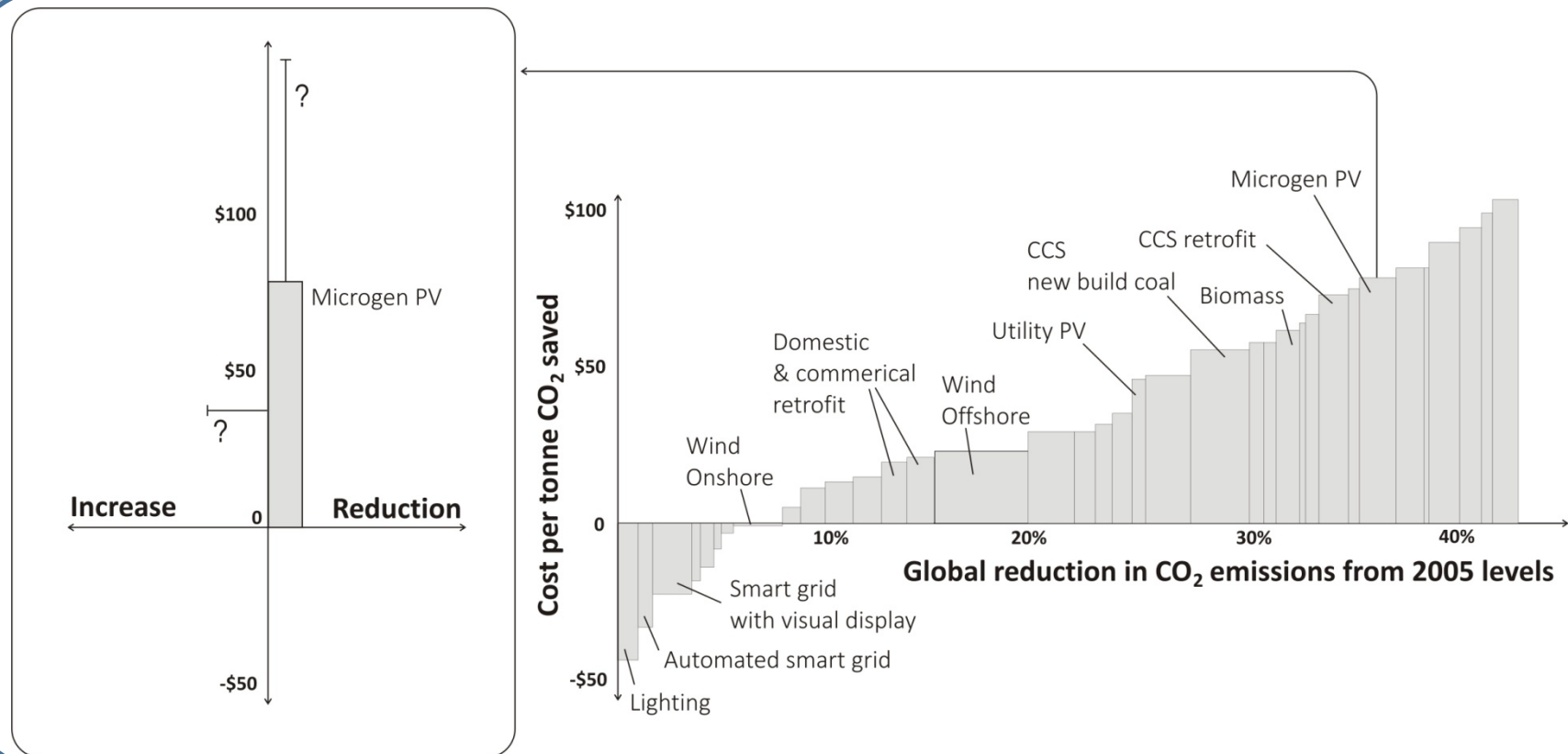
Batteries become “economic” and PV becomes more economic – move left



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Things become very complicated ...
... when global decarbonisation is married
... with local, individual, decision making.

One way of thinking about it is that the Big MACC curve has error bars...





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Thankyou

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Nicky Gregson
Helen Holmes
Huw Birch
Britta Turner
Dave Stone
Martin Foster
David Lidzey
Lisa Clark
Jamie Taylor
Julian Briggs
Giuseppe Colantuono
Mihai Popei
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