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PROFESSOR: The equivalent cost of manufacturing in China, as best as we can determine, is in the order of \$1, \$1.30, \$1.50-- somewhere in that range with the error bars. So keep those numbers in your head as we dive into price. Because now we're going to be talking about what the market is offering to pay and what that spread is between the cost and the price.

So you have, in your slide deck, a list of different websites. I guess you have web [? e-sites. ?] You have websites, email list serves, blogs, and Twitter feeds-- different sources of information for collecting data from PV. And I should add one more to this list, which wasn't on there, but should be there. PVinsights.com. This is where you can find it pretty up-to-date spot prices for wafers, cells, modules, and so forth.

Does anybody know what a spot price is? What does it mean, a spot price? Spot price means I'm desperate to buy. I need to buy it right now. I pick up a phone and call somebody and say, I'm willing to pay you.

So there's no long term contract involved. It's usually a one-time deal. That's a spot price.

A long term contract, on the other hand, says, no, no, really. I have a factory. It's 100 megawatts. And I need wafer supply for five years. Let's lock ourselves into a price. Maybe we visit it every 2 and 1/2 years, but that's a long term contract.

So these are spot prices and they provide a variety of information. The information for today is free. If you want historical data, you have to sign up, become a member, and pay. But there are other websites like this-- various consulting groups-- that acquire and gather information, [PVinsights](http://PVinsights.com).

So you have a variety of different sites to grab information that could be useful for your class projects. We're going to talk again about the dynamics of price. And that is driven, in large part, by-- well, we agreed to call it different things. Support mechanisms, tax breaks, incentives-- but in reality, they're support for PV.

Recognizing that with \$1.30, \$1.10 cost, and then you add on top of that the profit margin, even if you assume a very meager margin of 15%, you're-- and then the balances systems, and then the installation costs on top of that-- you're not reaching grid parity in the majority of markets. Not with that sort of cost structure today. With innovation and moving forward into the future and scale-- we'll get there, I'm fairly confident-- but today, we don't have the cost structure necessary to match, say, a subsidized coal-fired power plant.

So there are a variety of different support mechanisms, a variety of different subsidies in different countries, and different states within the United States. And you can think about these as the carrot, the stick, and the hybrid. The carrot meaning the margin enhancement, the stick being the penalty if you produce too much carbon, for instance, and some variety of mixtures between the two.

So in terms of margin enhancement-- the carrot-- what mechanisms exist? Let me break it down very simply into-- we'll look in two different categories. We'll look at what the United States has mostly done, which are tax relief and grants and soft loans. So let's describe what that means.

When I bought the panels on top of the house in 2007, we paid out of the box somewhere in the order of \$7 to \$8 per watt peak. And after tax rebate coming from the federal government, and some additional support from the state of Massachusetts, the final price tag wound up being from say \$18,000 plus down to about \$12,000 to \$14,000. And then there's revenue coming in from offsets and so forth.

So this is a one-time deal. I could have installed those panels in my basement and still gotten the tax break, right? Because it's per watt peak, not per kilowatt hour produced.

The rebates based on carbon emissions is based on the amount of energy it produces. That gives you an incentive to maximize the efficiency of the installation. But just a one-time tax rebate doesn't.

However, what the one-time tax rebate allows you to do is decrease the upfront sticker price. So if I'm trying to sell you system on your house, US installers are convinced that it's a lot easier to sell you the system if the price tag is lower. If I can say, well this is the real cost, but wait, wait, there's more. We'll give you this tax rebate, this tax rebate, draw a line. The final amount you pay is this lower amount right here.

The other mechanism of margin enhancement, if you will, is what's called a feed-in tariff. Now, a feed-in tariff works as follows. A feed-in tariff says, OK, if you're paying-- let's say, in the state of Massachusetts, we don't have one. We don't have a feed-in tariff here in Massachusetts. But imagine if we did.

You, as a residential customer, are paying \$0.18 per kilowatt hour for your electricity. But if you have solar panels on your roof, the utility, if you will-- the state of Massachusetts-- is willing to pay you \$0.30 per kilowatt hour for that PV electricity. Recognizing the additional value that that PV is adding to the state. Reducing the need for additional transmission lines, reducing the amount of investment in new coal-fired power plants, reducing the health detriment to the local communities around the coal plants, and so forth.

So a feed-in tariff is meant to give an incentive-- a market pull incentive, if you will-- to install PV on your house. Or in a field. And this is the mechanism that has been in use in Germany. And because it's a market-driven mechanism, it rewards the most efficient systems that are out there. If you install that system in your basement, you're not going to be producing kilowatt hours, and hence you're not going to benefit from the feed-in tariff.

Now it's a tricky business to decide where exactly to fit that feed-in tariff. Right? If you go too low, people aren't going to move. They're going to say, eh, no, not

enough. Not enough to make me want to install solar.

If the feed-in tariff is too high, you're going to get this massive onrush of people coming to install solar. And now you're going to have to finance it, right? And the money has to come from somewhere.

In Germany, the money comes from the rate payers, not from the state. Which means that if you install solar panels on your house, all of us have to help pay for the electricity that you sell back to the grid. So our rate goes up from \$0.18 per kilowatt hour to, say, 18.2 cents per kilowatt hour.

In the beginning, we don't notice it at all. But then if Joe starts putting solar panels up, as well, and then, let's say, 50% of us put solar panels up, now obviously we're paying a lot more. And it gives more of an incentive for more people to put the solar panels up on the roof. And of course, the price goes up.

So the feed-in tariff is a very-- it is a market-driven incentive. And hence, it is very skillful at rewarding the most efficient installations. But from a government point of view, it requires very structured, rigorous, and deaf-to-manipulation of the feed-in tariff rate-- the decline of the rate versus time-- to ensure that A, the installers aren't reaping an enormous profit, and B, that the system doesn't become unsustainable over time. That the burden on the rate payers is not so great that they're shouldered in for 20 years paying these excessively high rates.

So it rewards first adopters, it allows the market to predict, versus rate of growth, what the reward rate will be. And it allows you to glide into grid parity. So we're at a situation today where we're not at grid parity. In 10, 20 years, we're likely to be there. And so the declining rate of the feed-in tariff allows you to glide back in.

In the United States, the tax rebate, unfortunately-- because of the way our political system works-- it tends to get renewed in a very frequent rate. Every two years, it seems, it's going up for debate and discussion. Should we continue it? Should we not continue it? It becomes a big political struggle just to get it passed.

And as a result, everybody uses up their energy trying to pass this thing and renew

it, as opposed to saying, gee, what's the best way to decrease this over time so that we can kind of glide into grid parity? So we have some issues in the US, more related to how our political system doesn't work. But there are examples of this throughout the world, in terms of what are states and countries doing to enhance the margins to create market-pull incentives to allow solar to be installed on the grid?

And the panels that are installed could come from anywhere. They could be produced in Guam and they could qualify for the feed-in tariff. So it doesn't discriminate against particular regions of the world.

Another thing to add here is that this is just the support from the state, from the public sector. From the private sector, what is possible? Well what is possible is what's called a power purchase agreement. And this was alluded to during our tour. What is a power purchase agreement?

A power purchase agreement is-- instead of you buying a system and putting it up on your roof and having to pay all that money up front, what you do is you enter an agreement with the installer. They will put the panels up on your roof for free because they're getting the financing, say, from Morgan Stanley, from the Bank of Joe.

So the Bank of Joe is financing the panels on your roof. So the panels went up on your roof. You didn't pay a penny. But you inked an agreement with me, the installer, because I just borrowed money from Joe at a certain interest rate. And you inked an agreement with me that you'll pay a certain amount for your electricity over the next 10, 15, 20 years, however long it is-- usually 12.

And that rate may be a little bit higher than what it is today, but it's certainly going to be lower if current price inflation continues for the price of electricity. It will certainly be lower than what the price of electricity will be in 12 years. And so you'll make money.

I'll make money because there's a spread between the rate at which I'm borrowing

the money from the bank and what you're paying me for those panels-- for renting the panels on the roof, if you will. For buying the electricity from those panels. So everybody's making money. And the bank's making money, obviously, because they're charging an interest rate on the loan.

And so with those financing schemes, where it's called a power purchase agreement, bank loans the money to the installer, the installer loans the panels on the roof of the customer, and the customer pays a fixed price for the electricity. That allows everybody to make money from day one, as long as there's capital in play. It requires capital to be in play, meaning it requires the Bank of Joe to be willing to lend money to me, the installer. If the Bank of Joe doesn't want to lend, then that isn't an option.

And so you see many of these very large deals being forged with the investment banks between large installers-- say, SunPower, SunEdison, and so forth-- in New York City. It's becoming an increasingly popular form of financing solar panels. You may stand to make more money as an individual by buying the panels up front because then you reap the entire benefit of your investment.

You're not sharing the investment benefit with the installer. You're not sharing the investment benefit with the bank. But that requires, again, access to capital. And not everybody has a spare \$14,000, \$15,000 lying around to put solar on the roof.
Question.

AUDIENCE: What's the incentive of the, I guess, whoever's installing the panels on to buy the electricity from you. Why would you buy it from you, [INAUDIBLE]?

PROFESSOR: Yeah. So over the past 10 years-- say, from 2000 to 2009-- in the state of Massachusetts, the price of electricity increased by 15%. So if you compare what did it take per kilowatt hour at the beginning and the end-- normalize for inflation, 15% inflation-- in the price of electricity. And there are a variety of reasons for that.

We're at the end of a natural gas pipeline, so even if the price of natural gas goes down, it takes a lot to get it to us. Sometimes shipments go in by boat. Other times,

up the actual pipeline itself. And then, other forms of fossil fuel-- oil, especially-- has experienced a rise in prices of the last few years.

And so for a variety of reasons, including those and including a difficulty in transmission, and including limited new power plants coming online, the price has gone up. And as a result, if you project forward, you could say, OK, let's hedge our bets here. We can estimate that the price is going to go up another 15% between now and the next decade.

So what I'm going to do is to say, this is the price today, this is the price tomorrow-- in 10 years, right? I'm going to sell you electricity here. And so it's almost like the deal-- I don't know if anybody signs up for the natural gas lock-in price during winter with NStar. You probably see the envelope in the mail, or maybe your landlord does.

But NStar-- the utility company around this area-- will allow you to lock in a price for natural gas per therm-- per unit of natural gas-- over the winter, that is slightly above the market rate in the fall. With the understanding that prices tend to spike during winter, and you're able to hedge, you're able to reduce risk.

And so really what it is is a risk mitigation strategy. And it's good enough for most people. I know two people on our street alone have entered power purchase agreements as means of financing their solar installations.

So let's discriminate once again between the private sector that's trying to sell you the panels-- I say, Omar, you have to buy my panels. Let me sweeten the deal here. You don't have to pay a penny upfront. We'll introduce a power purchase agreement.

Versus what the state is doing, right? Whether that's the national government or the state level is doing to try to get the installers and other industries growing within their organization. And as well, several of the EU states meeting their Kyoto Protocol obligations to reduce carbon emissions by a certain amount by 2020.

So we're going to do a deep dive into the German case, just because it is so

interesting and so exemplary, in terms of increasing the amount of PV on the grid. And one thing to note, just upfront, this is the insulation map of Europe. Insulation being the solar radiance, the total solar resource available, shown in this barely distinguishable little legend down here. Blue being low, red being high.

And Germany is right here, as they would say, from herzen Europas, from the heart of Europe right there. Right in the middle. And this is the insulation comparison, again, between Germany the United States. Same scale over here. A lot less solar resource in Germany, even than in the Northeastern part of the United States.

Yet there was about half of all solar panels installed here last year. Why? Well first off, it's high electricity prices. Secondly, there is a feed-in tariff that gives an incentive for solar to be installed on a grid. So what I'm going to do is go over several slides coming from the ministry in Germany, describing the growth of solar and the growth of other renewables on the grid, in response to this feed-in tariff.

So the renewable energy resources, if you will, as a share of the total energy supply in Germany-- the goal by 2020 is this white bar right here. And if we look at the share of renewable sources in total gross electricity consumption, you can see that it's getting there, right? 17% versus a minimum of 35%. So working toward those targets pretty well. And climbing from 2000 to 2010-- more than doubling, almost tripling.

This is the electricity, heat supply, and fuel supply breakdown. If we just look at the electricity component right here, since that's where PV falls and contributes, you can see it's growing. What you have to keep in mind is this 17% of electricity consumption coming from renewables-- this 17% is this amount here, the yellow bar. And we're looking at something in the range of 103 terawatt hours over the course of a year in 2010.

And out of those 103 terawatt hours, breaking it out into PV, biomass, hydro, and wind, you can see that PV has accounted for a relatively small fraction of that total. The largest, by far, has been wind. Wind has reached lower prices of electricity faster than solar has. Differences between the technology, so we say.

And as a result, the grid penetration of wind has preceded that of solar. But solar is growing quite a bit. And this is averaged over the entire country. And as I mentioned before, there are certain regions within Germany, as you might guess-- down here, for instance-- that have experienced larger grid penetration of solar than others. Just because they have a larger solar resource available to them.

So this is the little fraction here-- growing-- of solar electricity. These here are the different legislations that are being passed, regulating the feed-in tariff. Now, the feed-in tariff is scheduled to reduce gradually for each year.

Let me show you how that works. We'll go back to this German energy blog by two of our energy law experts in Germany. And this describes for you the German feed-in tariffs as of 2010.

The Renewable Energy Sources act-- essentially, one of those legislations that have passed-- and it just shows you what you can expect over a variety of different sectors. Hydro, landfill, gas. And you can see, it's broken into very specific details. Different sizes of installations, different types of plants and so forth. This is bio, geothermal, onshore wind, offshore wind, solar radiation, roof-mounted facilities, electricity used within the building facility, freestanding facilities, and digression.

Digression means, how much does it go down per year? This is based on their best estimate for the growth of grid penetration of PV. They're trying to guess in the future, how much PV is going to come onto the grid by a certain date? And hence, what the price will be, as well. And thus, reduce their feed-in tariff accordingly.

And since it's impossible to look into a crystal ball and nail it-- especially since this is a nonlinear system-- the price depends on the feed-in tariff, the feed-in tariff depends on the price, right? So there's a little bit of that interaction going on. They have to reassess, from time to time, what the new rates are going to be. And that's why you have these various-- well, aside from the initial-- you have these various reevaluations from time to time, looking at the feed-in tariff.

Now, what has happened more recently-- there was a reevaluation in January 2009.

Another mid-2010 that decreased it even further. So more recently-- this, unfortunately, only goes to 2010-- but more recently, there have been more significant, stronger cuts to the feed-in tariff in Germany in response to a few things.

So let me go over this real quick. I'll get back to that in a second. First off, this is the payment of fees in millions of \$ versus time that the rate payers are paying in total. So that winds up being something in the order of 135 \$ per head in Germany.

That's not spread equally amongst everybody-- per year-- that's not spread equally amongst everybody. That's, as well, their industry bears more, obviously than the residential customer would. But it's a line item of a few \$ on your utility bill per month as a customer. And that begins to add up.

So Germany has begun putting on the brakes on the incentives. And further, if they look at how much they've installed versus other countries-- again, this is the same chart we showed last class-- their portion of all new installations is very large. And so they began looking around to the rest of the world, saying, hey folks, we don't have a lot of sun here. Why aren't you doing your part to put solar on your grids? Compounded by the fact that now they have a growing percentage of manufacturing that's not in Germany.

The percentage of German manufacturing of the PV modules themselves has stayed more or less flat. And so Germany's sitting here thinking, OK, we're in a financial crisis right now. Something has to give. Let's put a damper on this feed-in tariff for a little bit until the situation straightens itself out and until there's more growth in other markets besides just Germany.

Let's try to reduce the incentive that we give to put PV on our grid and maybe increase the share of PV going onto US, China, and so forth-- other big markets around the world. So that we're not bearing the sole burden of trying to reduce the cost of PV to grid parity.

As a result of this-- the decline in the feed-in tariff in Germany-- and as a result of a massive amount of new production capacity coming online in China and Taiwan,

we're now in an oversupply condition. What means an oversupply condition? What it means is that there are more PV modules available today than there are customers to buy them at the given prices that are available. And the price is dictated, in part, by the feed-in tariff.

And so what you've seen is-- sorry, I'm just going to drive through these slides right over here till I get to that one. So what you see is that chart that Secretary Chu presented yesterday during his talk. This was in first quarter of 2008.

This was when the market began softening. Right around here, the German feed-in tariffs really started going down tremendously. Chinese manufacturing and Taiwanese manufacturing really started ramping up around here, 2007, 2008.

And so what happened? This here is price, not cost. Price. So this is being driven by market dynamics, not solely by the costs of manufacturing. So we have what people are willing to pay for their hours of watt.

So if the feed-in tariff is going down in Germany, which is acquiring 50% of the modules in the market, that means that the price has to come down, as well. If you're going to be able to sell your modules, you're going to have to sell them at a lower price because the feed-in tariff is now lower. At the same time, you have now more supply on the market and you have companies competing against each other to get their modules on the market. And so prices are going to come down by that, as well.

So what this chart is telling you-- let's look at the blues, for instance. Let's start here. These are estimates made in 2008.

And this blue line extending forward is the estimated price-- not cost-- the estimated price of what a PV module would sell for, projected forward to the end of 2010. Then, we enter 2009-- the reds here. And the real prices continue to drop precipitously.

Again, here we have the analysts' estimates for what the price is going to be, moving forward to end of 2011. And you can see that the analysts' estimates are

always above the actual prices over the last three years. Which means that the actual prices have fallen faster than anybody-- or the analysts-- expected to. Maybe there were some smart people in the actual industry who saw this coming in quite the same way.

But what this means is the prices have come down a lot faster than what people expected. I don't think people expected that Germany would cut the feed-in tariff rate quite as large as it did in '09 and in '10. And some people, who haven't been paying attention to the market, might not have expected as much supply to be available from China as there is today. Those people should have been paying better attention.

But that combination of factors resulted in a much faster price decline than what people saw coming. And as a result, companies that were formed in, say, 2007, 2008, and got venture capital-- and saw one of these lines right here and said, oh, we're going to be able to intersect them in 2010-- are now looking at these sorts of prices here. And saying, oh, gee, we're not to be able to intersect them in 2010, it's going to be more like 2015 before we get our production costs low enough to compete at those prices.

And so the venture catalysts are now sitting back thinking, so let me get this straight. You came to us three years ago and told us that you'd be cost competitive by 2010. But now the story is you're going to be cost competitive by 2015. This kind of smells fishy.

I don't know if I want to lend you an additional round here, especially if I have to wait another five years before you're profitable. Let me just cut my losses and pick up shop and leave. And your company will go under.

So that's happened a few times. That's happened in a high profile way, which we all know about-- Solyndra. It's also happened to a few other companies-- SpectraWatt. Even earlier ones at the beginning of the financial crisis-- OPTI-Solar and others.

So the companies that are surviving right now-- there are still more than 100 startup

companies in the United States. Dozens and dozens of startup companies in solar. Those smart ones that are surviving are usually in pre-production stage. They don't have big manufacturing lines, hundreds, thousands of people to pay, supply chains to pay for, and customers evaporating, so they're not caught in that situation.

That was Solyndra. They had a big production line. They had 1,100 people employed in that line.

And they had customers lined up. They had suppliers shipping in materials that they were converting into product. And some of the customers disappearing were not willing to pay as high prices anymore.

And that leads to a very difficult situation. You don't have a cash cushion, you don't have any reserves in the bank, you have to sell your product. And you're not able to compete at these prices. It's a recipe for disaster if you're a mid-size company.

So small companies can survive in what I call spore mode. They're like a spore. They don't have that big manufacturing line to pay for. They can survive off grants, they can survive off venture capital. And their cash burn rate is very low, they're developing technologies.

The big companies have cash cushions already, they have cash reserves. They might even be able to access low interest rate loans from banks that borrow money at ridiculously low rates from the treasury right now. They may even have financial branches within their own company, like GE Finance, that can do that sort of thing. So big companies are, so far, surviving, the really tiny companies are, so far, surviving, but the market dynamic is really hitting those mid-size companies that already have a manufacturing line.

And so you hear about layoffs, you hear about job losses. These are often the mid-size companies just trying to go back to spore mode so they can survive this difficult period until prices equilibrate.

And when we look at price is equilibrating-- let's look at the price now. We're headed towards Q4 2011. Let's put a data point right here for Q4 2011. Let's do it right now.

So I'll go back here and-- sorry about that. That was me registering a website. That's for the project that Doug was working on.

We'll go to PVinsights. And we're going to add the latest data point here. So solar wafer-- this is silicon, this is wafer, this is cell, and this is module. All right. This is our low, this is our high.

These are all prices in dollars per watt peak. Prices. Our low and our high and our average for-- I guess, last update was yesterday.

The low-- I can tell you this particular low number right here came from a tier three manufacturer in China. What is tier one, tier two, tier three? So tier one are brand names. Yingli-- they advertised during the World Cup. Suntech, mentioned in Secretary Chu's presentation yesterday. Trina Solar, LDK, and so forth. These are tier one manufacturers, the big dogs.

Tier three are companies you've never heard of but are employing thousands of people and manufacturing modules in the hundreds of megawatts range. Perhaps even reaching a gigawatt scale. And because banks have never heard of them either-- maybe that's an overstatement, but I'm making a point here.

They're not as well known, they're not as reliable from the bank's perspective. Maybe they haven't been around as long and it's questionable whether they're going to survive this difficult economic climate. They have difficulty to sell their product. The installers don't want to take their product. And so they have to undercut the competition. They have to leave money on the table. And selling at prices at \$0.75 per watt.

Now, what Doug's calculations are indicating-- as you saw from the very beginning-- the cost of manufacturing in the US is around \$1.30. The cost of manufacturing in China is around \$1.00. And then you have to ship it over to the US.

So if somebody is willing to sell you a module at 0.75 dollars per watt, that means that the price is below the cost. That means that that company is desperate to get

rid of inventory. They must have modules stacking up in their shipment yard. They're unable to move them.

And so the chief financial officer walks over and says, we got to get rid of this stuff. It's costing us money. It costs us money to keep this product on the books. Sell it for whatever you have to sell it for to get rid of it.

And as a consequence, they sell below cost, put it out into the market. And then you have SolarWorld, or a US company, coming to the Department of Commerce saying, they're dumping product. It's an unfair competition. According to the World Trade Organization, you can't sell at a price below your cost in order to squeeze out and gain market share.

So it's a complex situation right now. I've described for you, in as much detail as I can, my impression of what's happening in the world today. This low price right here, of 0.75 from a Chinese tier three manufacturer. And the high price here coming from, most likely, a German supplier or US supplier.

Selling what is known to be a very high quality, reputable, product, has been selling for the last 10 years. Very reliable, very few incidences of consumers returning the product. And banks like that product.

So they're able to extract a premium for their product. They're able to sell and move those modules at a higher price because they're more bankable. This average right here is more representative of what Chinese tier one manufacturers are currently selling for, and what many of the US and European average module makers are having to compete against with costs on the order of \$1.30. That's the constriction right now.

So if we add that one data point onto this chart right here, where we have Q4 2011-- we're solidly in Q4 right now-- and we're at 0.98 with an error bar somewhere around here. So we're at 0.98. You see the prices are still coming down. And will likely come down for maybe another quarter before they start to stabilize.

And as companies fail-- as more companies leave the market-- you'll have

consolidation of market share, you'll have the few remaining companies that had the large cash cushion, that had the lowest cost structure, survive. And increase their market share and reduce the number of players out on the market. And probably, prices will come back up afterwards. Because you can't continue selling below cost for very long before everybody goes out of business. I saw a hand going up over there.

AUDIENCE: I guess, those prices-- a transaction happened at that price, or that was just the asked price of the the manufacturer?

PROFESSOR: So these right here-- I know that the 0.75, that was an offer price.

AUDIENCE: Oh.

PROFESSOR: Yeah. So it was 0.85 during Solar Power International in Texas about a month ago. And it made a big splash and everybody was really awed by it. The 0.75 is news to me. It probably came up over the last week or so.

And in response, most likely, to that company selling at 0.85-- unable to move their product-- going even lower in a desperate attempt just to get rid of their inventory.

AUDIENCE: But these are offered prices? The transaction hasn't happened at that price as of yet?

PROFESSOR: So these prices, most likely, are coming from a few different routes. So you, as an individual, can send an email or fax over a request for a quote from any one of 100 module manufacturers around the world. And you will get a quote back or an offer sheet back.

And most likely, what PVinsights is doing is some combination of that-- a guerrilla tactic, let's gather information. And as well, information gleaned from their installer base. So they have contacts to various installer companies. They keep the finger on the pulse over there, talking to their friends saying, how much are they offering you the modulus for?

AUDIENCE: It's not like the stock market, where the price sold at is subjective?

PROFESSOR: Yeah. The sell and the buy price are a little different. No-- or currency exchange markets. No. These are individual companies trying to assess what the market is willing to pay for their product.

In the case on the low end, these are desperate producers trying to move product. And on the high end, these are companies with high cost structures, typically, in the west-- typically US and Germany-- that have a reputation. And they are clinging for as long as they can on to the high prices.

For as long as they can do it, before the market finally says, you know what? I'm sorry. We've been good friends. We've worked together for the last 10 years.

But honestly, I'm not going to buy it \$1.45. Not when Suntech is offering me a module at \$1.05 and it's comparable in quality. They've proven themselves.

The days when all Chinese modules were inferior are over. Now we have several tier one Chinese manufacturers that have proven their modules out in the open market. There hasn't been a large number of recalls. So I'm willing to take the risk with them.

And at that point, you'll start to see the higher priced US and European products begin to soften. Yeah.

AUDIENCE: If the oversupply condition doesn't get resolved in enough time, does it have the potential to, basically, stall the entire industry? And if so, how long would that take?

PROFESSOR: Well, keep in mind that this is just the module. There's a whole other dynamic happening on the installation side. And the reason I'm not getting into that in too much detail is because it varies so much from country to country. Although I will say a few comments before the end of class.

If the oversupply condition continues and if the feed-in tariffs continue to be low, what you'll see is a continued softening of the module price into the point where almost all manufacturers are selling below manufacturing costs. They're all

desperately trying to reduce manufacturing costs, reduce overhead. It's forcing them to innovate-- at least in manufacturing innovation-- faster. Not on product innovation, not on, how do we design this cell differently?

But more on the process innovation on the line of saying, gee, how do we mix the silver with the cheaper metal like aluminum in a ratio so that we eek out half a cent per watt peak? Because any small fraction counts at this point. We're desperate.

And you can think of this oversupply condition as a bunch of horses running nose to nose. And which ones will begin falling out? In the beginning, you could point to easy candidates. Those that have already begun to go by the wayside.

But now, companies are burning through the cash cushion, reporting negative profits. You see right and left, even the Chinese tier one manufacturers are reporting negative earnings this last quarter. So that's a reflection not only of the oversupply condition, but also the fact that they're continuing to expand, despite the oversupply condition. The idea being, well, we can withstand one, two, three, four quarters of losses as long as we consolidate market share.

Once we emerge from this oversupply condition, we'll be able to increase prices a bit more. And then return to a more sustainable market. But we'll be the big dogs and everyone else will be out.

So I think all companies right now are trying to play that game of survive. Survive this oversupply condition, make it through. Some are able to continue growing and other ones are just stagnant.

So the stagnant ones are going to become niche players. They won't be the major players in the market. The ones who continue growing will be 80%, 90% of the market.

AUDIENCE: Has there been talk of increasing feed-in tariffs to try to keep the American companies alive?

PROFESSOR: So US doesn't do many feed-in tariffs. This goes back to the US case right here. So

due to lack of leadership at the national level, there are a variety of state level incentives put forth.

So these are the policies-- we kind of talked about this last class, but to dive into a bit more detail. The rebate programs for the renewables-- these are state programs plus the utility and/or nonprofit programs. Utility, local, and/or nonprofit programs only and state programs only.

So you see, for example, in the state of Massachusetts, we have what used to be the Massachusetts Technology Collaborative. There was a bit of a power struggle within Mass State and it got incorporated into a more centralized organization downtown. So that used to be in a nonprofit organization, which is now more affiliated with the state.

The state also has a rebate. We have a very different set of ways of doing things than, say, California, which has a clean energy commission that rates each module and gives you a rebate depending on what they rate the module as performing in California. So every state has its own way of doing things and it becomes very complicated very quickly.

To enact a national incentive, beyond the tax rebate that is already offered today, is challenging, in this political climate especially. Because anything that you would do to raise the cost of something, which most likely would come from some federal program-- right now, the Republican Party is demanding that there be an offset, a reduction of spending elsewhere within the government. Many of the places that are easy to cut have already been cut.

And so you've gone through the fat. You're now hitting muscle, and pretty soon you're going to be hitting bone. So it's difficult to enact something that the government would pay for.

It is even more difficult to enact something that the utilities and rate payers would pay for at a national level because, oftentimes, those powers are delegated to the states. And you would enter a federal versus state fight over that, which would go to

the courts, most likely, and be held up there for several years. There are about 18,000 different independent jurisdictions within the United States governing how solar is added to the grid.

And so what the Department of Energy has done, which I think is the wisest thing to do-- given this situation that we have-- is to say, OK, we're not going to force anybody to change, but we're going to give an incentive for people to change. And like they had in the Department of Education-- the race to the top, where states competed against each other to implement best practices in education-- they're having a similar program on the installation side of solar, trying to get various states to adopt a best practices. To streamline the permitting process to get solar onto the grid in the most efficient way possible, and hopefully reduce the installation costs associated with that.

So let's turn our attention, quickly, to installations, since I want to give some time to have people ask questions about their class projects. Since time is running very short, if you're hitting up against a roadblock, I want to make sure that we resolve that. I'll say a couple of words about the installation.

So a funny thing happened on Tuesday night. I met with a colleague from Wisconsin. And he said, well, I met the editor of-- I think it was an editor from one of the big journals. We'll protect the innocent. And this was a very high-impact scientific journal.

And he said, well, the majority of the cost right now is in the installation side, not in the module, in solar. So I'm not going to be interested in any papers to my journal that describe new concepts for PV modules. I'm interested in the installation side because that's where the majority of the cost is.

And I went, oh my goodness, here's another one who can't distinguish between cost and price. So the installation cost right now-- let's focus on cost first and then we'll get to price. So the installation cost in the United States is partially reflective of the fact that we have those 18,000 different ways of doing it here, versus in Germany, there is one way to do it nationally. The federal government said, we are going to

demand that everybody in Germany install in this protocol.

And the paperwork is very, very brief. It's a couple of pages to get it installed. And the inspection is one.

And so Germany has a much more efficient system. And they've installed roughly six to seven times more solar than we have. And if we remember experience learning curves, when you have the reduction of cost the more you do it, that means you have three doublings.

Germany has three doublings over us. And even if you assume a very leisurely 20% reduction for each doubling, that means Germany is about the half of the cost as we are, because they've done more. They know how to do it more efficiently than we do.

OK. So that's on the cost side. On the price side, if you look around the US, you have some states like New Jersey, which had an amazing incentive program for a while. And California's as well, quite generous.

So there are certain states where it's almost like a gold mine. And so there's no incentive for the installer to reduce their price. Their costs can be going down, but their price can be maintained high.

And usually-- this isn't always the case, but in most industries-- when prices are high, the industry becomes lazy. Now this isn't always the case, but is often the case. It is not atypical that when the prices are high, the industry says, oh, prices are high, that's pretty good. I'm enjoying myself right now. I'm not going to be focused on cost reduction.

It seems that, at least, the lower level managers suddenly become fixated on cost reduction when it's too late. When margins have already begun shrinking, when prices are collapsing, and when it's do or die for the company. Then, all of sudden, cost becomes imperative.

So there are very few companies. The ones that usually become leaders are the

ones who recognize, gee, prices can't remain high forever. We have to reduce our costs now.

And hey, it'll be even to our benefit, because our margins will be greater. We'll be able to take advantage of this right now and build up some cash, so that when the prices do collapse, we have some buffer. And we can survive the oversupply condition.

So installers, right now, I have to say I'm disappointed in our installers in the United States for not doing more amongst themselves to reduce the amount of paperwork. For not taking a leadership role in reducing the paperwork burden. And the true cost of installing PV on the balances system, [INAUDIBLE] installation side. I think that's a very resolvable problem.

You look to Germany and you have residential systems going in for below three euros per watt peak price taking advantage of the low module prices right now. And the fact that the installation costs in Germany are low, as well. Because they've learned how to do it well, they've learned how to do it efficiently. And they've reduced their cost structure.

So I personally-- I think there is innovation to be done on the installation side. I think there's a lot that can be done with pre-fabrication. Maybe moving a robot out there that can assemble things in a big rack and then a crane that puts it on the roof. As opposed to having 10 people going out to a house and spending a couple days putting panels on the roof.

It's not that bad. Maybe it's more like a day. But it's still a very labor-intensive industry right now in the US. So more innovation can be done.

But the lion's share of the installation price right now is driven by what I would call inefficiencies in the way installation is done and inefficiencies in the way the permitting process is done, the paperwork is done. So that's my soapbox speech on installation. By all means, there is innovation to be done.

So don't give up on that side either. It's important. It's where the rubber hits the

road.

But I think you can't just look at the price of modules today and the price of installing the system today in the United States-- and realize that 80% of the price right now is wrapped up in the installation-- and say, oh, well, there isn't any more innovation to be done on the module side. You have to look at cost. And you have to recognize that the module cost is driven by the efficiency of the module.

And the installation cost, as well, will be driven by the efficiency the module. And so the module being the engine of the system is still very, very, very important. And so the work that folks are doing-- on new PV materials, especially-- is important.