

# Next Generation Solar

Using Cipher for Competitive Intelligence and  
Technology Trends Analysis

[Link to Landscape reports](#)

# Classifier Scopes

## Crystalline Silicon Photovoltaics

Crystalline silicon cells belong to the first generation of solar cell technologies and are the most commonly used cell types in commercial solar applications. This classifier captures both monocrystalline and polycrystalline silicon cells. Amorphous silicon cells are captured in the thin film classifier.

1<sup>st</sup> Generation Technology

## Thin Film Photovoltaics

Thin film photovoltaics belong to the second generation of solar cell technologies. These cells are made by depositing thin layers of photovoltaic materials onto a substrate (typically plastic, metal or glass), using physical vapor deposition or chemical vapor deposition techniques. This classifier captures all thin film technologies, including amorphous silicon, CIGS, CdTe, GaAs and dye-sensitized solar cells.

2<sup>nd</sup> Generation Technology

## Organic Photovoltaics

Organic photovoltaics belong to the third generation of solar cell technologies. Organic cells are solar cells where the absorbing layer is formed from an organic semiconductor material (OSC). This classifier captures both small-molecule OPV cells and polymer-based OPV cells.

3<sup>rd</sup> Generation, Emerging Technologies

## Perovskite Photovoltaics

Perovskite photovoltaics belong to the third generation of solar cell technologies. Perovskite solar cells include a perovskite-structured compound in the active layer (general formula  $ABX_3$ , where A and B are cations, and X is an anion).



# Competitive Intelligence

Analysing technology landscapes to compare your competitors – both known and unknown

# Competitive Intelligence – Identifying Key Players

	LG Electronics	Chinese Academy of Science-	Panasonic	Shin Etsu Chemical	Jinko Solar	Sharp	Canadian Solar	Mitsubishi Electric	Kaneka	Kyocera	Hitachi	SUMCO	Fuji Film	Samsung Electronics	Merck	TOTAL
Crystalline Silicon Photovoltaics	921	550	672	708	561	283	396	298	260	288	394	419	17	88	13	5,868
Thin Film Photovoltaics	557	297	264	67	90	240	98	109	172	156	34	0	135	26	22	2,267
Organic Photovoltaics	96	322	42	17	0	5	0	55	4	4	5	0	212	278	320	1,360
Perovskite Photovoltaics	39	200	40	0	2	7	2	9	15	2	0	0	41	4	12	373
<b>TOTAL</b>	<b>1,613</b>	<b>1,369</b>	<b>1,018</b>	<b>792</b>	<b>653</b>	<b>535</b>	<b>496</b>	<b>471</b>	<b>451</b>	<b>450</b>	<b>433</b>	<b>419</b>	<b>405</b>	<b>396</b>	<b>367</b>	<b>9,868</b>

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## PORTFOLIO SIZE - Active families, by organisation and technology

Who are the top patent owners?

How many active patents are there in each technology?

How do these organisations compare in each technology?

LG Electronics holds the most patents in total across the four technologies, with 1613.

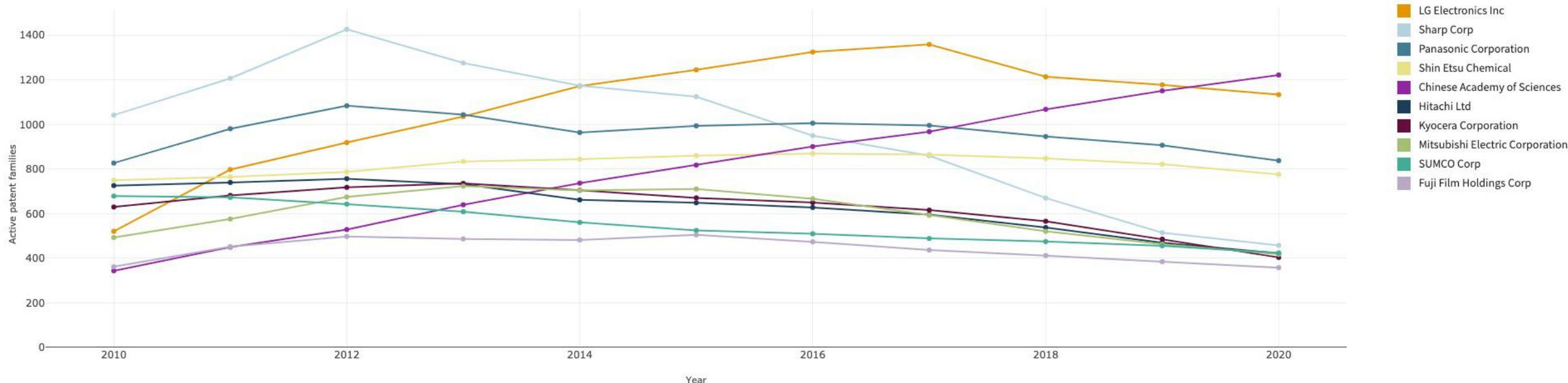
We can identify organisations that are more focused on a single technology (e.g., Jinko Solar, SUMCO, Merck).

Crystalline silicon is the technology with the most active families.

# Competitive Intelligence – Identifying Key Players



2010 to 2020



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## PORTFOLIO TRENDS - Active families, by organisation and year

How have the top patent owners changed their filings over time?  
Are my competitors increasing or decreasing their filing?

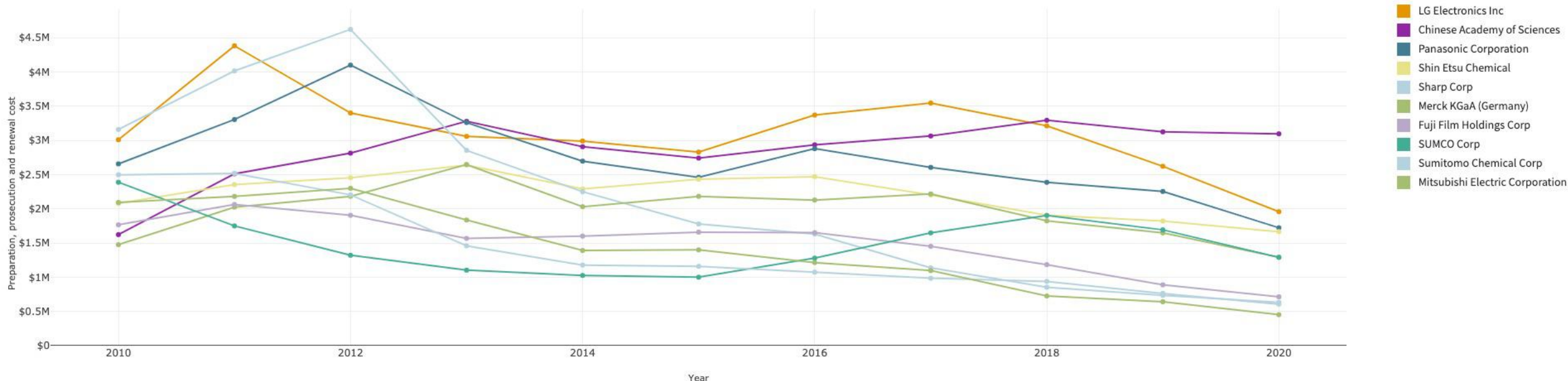
The Chinese Academy of Sciences has been steadily increasing its number of active families over the past 10 years.

Sharp Corp's number of active families reached a peak in 2012 and has since fallen.

# Competitive Intelligence – Identifying Key Players



2010 to 2020



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**COST** - Spend, by organisation and year

How much are organisations spending on preparation, prosecution and renewals across all technologies?

LG Electronics has decreased spend on this part of the portfolio since 2012.

Sharp Corp's spending has also fallen significantly since 2012.

# Competitive Intelligence – Universities

	South China	Korea U	Univ Zhejiang	Huazhong University of Science and Technology	Peking U	Tsinghua U	XI'AN Jiaotong U	Sungkyunkwan U	Korea Advanced Institute of Science and Technology	Harbin Institute of Technology	Shanghai Jiao Tong U	Pohang University of Science and Technology	Dalian University of Technology	University of California	Yonsei U	TOTAL
Organic Photovoltaics	178	38	45	35	46	38	17	16	35	11	20	38	14	38	24	593
Crystalline Silicon Photovoltaics	34	48	69	29	35	63	41	28	24	48	25	9	25	15	10	503
Thin Film Photovoltaics	42	63	38	35	25	40	12	42	23	24	21	12	17	5	22	421
Perovskite Photovoltaics	21	30	18	69	56	19	48	24	10	6	18	12	10	7	9	357
TOTAL	275	179	170	168	162	160	118	110	92	89	84	71	66	65	65	1,874

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## PORTFOLIO SIZE - Active families, by organisation and technology

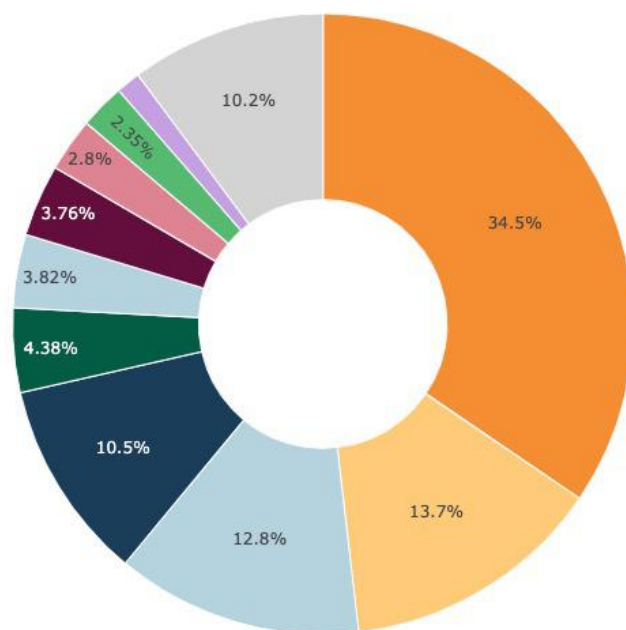
Which universities are most actively patenting in these technologies?  
How do these universities compare in each technology?

The technology with the largest number of active families when looking exclusively at universities is organic photovoltaics.

Perovskite photovoltaics also has a high number of active families, when compared to the more established crystalline and thin film cells.

This indicates that there is academic interest in these emerging technologies.

# Competitive Intelligence – Geographical Analysis



China	25,307
Japan	9,765
United States	9,217
Korea, Republic of	7,634
Germany	3,140
Taiwan	2,748
EPO	2,685
France	2,020
United Kingdom	1,683
Italy	912
Next 63	7,316
<b>TOTAL</b>	<b>72,427</b>

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## GEOGRAPHY - Granted patents, by country

How many patents have been granted in each country?  
In which territories are the most filings being made?

China has by far the most granted patents in this technology space.

Japan and the United States have a similar number of granted patents.

# Competitive Intelligence – Geographical Analysis

	Panasonic	LG Electronics	Shin Etsu Chemical	Merck	SUMCO	Chinese Academy of Science-	Fuji Film	Sumitomo Chemical	Samsung Electronics	LG Chem	TOTAL
Japan	762	158	719	283	362	10	335	223	126	113	3,091
China	233	159	194	249	133	1,194	93	122	106	140	2,623
Korea	52	1,055	230	253	168	4	95	104	318	260	2,539
USA	453	317	255	309	267	24	192	168	322	155	2,462
Other	380	108	291	322	180	33	234	196	6	143	1,893
Europe	217	260	203	304	127	8	120	137	120	107	1,603
Rest of World	39	4	152	176	159	4	117	83	15	63	812
TOTAL	2,136	2,061	2,044	1,896	1,396	1,277	1,186	1,033	1,013	981	15,023

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GEOGRAPHY - Active families, by organisation and region

Where are the top patent owners filing?

LG Electronics and Chinese Academy file heavily in Korea and China respectively.

Other organisations, such as Merck, SUMCO, or Fuji Film hold active families across a broad range of regions.

Where an organisation does not usually file outside of a certain region, those patents that have been filed internationally are good candidates for review.

# Competitive Intelligence – Entrance Year

	Chinese Academy of Science-	Kaneka	LG Electronics	Kyocera	Mitsubishi Electric	Sharp	Panasonic	Jinko Solar	Canadian Solar	Shin Etsu Chemical	Hitachi
Thin Film Photovoltaics	1996	1985	1985	1985	1985	1985	1985	2011	2009	1995	1985
Crystalline Silicon Photovoltaics	1987	1985	1985	1985	1985	1985	1985	2010	2008	1985	1985
Perovskite Photovoltaics	2013	2014	2014	2015	2015	1997	2000	2020	2018	n/a	n/a
Organic Photovoltaics	2003	2008	2004	1992	1985	1998	1988	n/a	n/a	2003	1999

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## PATENTING ACTIVITY - Entrance year, by organisation and technology

When did the top organisations first file in these technologies?  
Are these organisations early or late adopters?

The more established players are easily identified, with entrance years between 1985 and 2000. Entrance years into perovskites are much later, showing that this is an emerging technology.

Jinko Solar and Canadian Solar can be identified as relatively recent entrants to perovskite photovoltaics (in 2020 and 2018 respectively).

# Competitive Intelligence – Identifying New Entrants

	HUANENG RENEWABLES	Taizhou Zhong	LONGJI GREEN	SUZHOU TALESUN	TONGWEI SOLAR	Longji Green	Beijing Hongtai	Changshu Inst Tech	Univ Science & Technology	TONGWEI SOLAR
Organic Photovoltaics	2020	2020	2020	2020	2020	2020	2019	2020	2019	2020
Perovskite Photovoltaics	2020	2020	2020	2020	2019	2020	2019	2019	2019	2019
Thin Film Photovoltaics	2020	2020	2020	2020	2019	2019	2019	2019	2019	2019
Crystalline Silicon Photovoltaics	2020	2019	2018	2018	2019	2017	2019	2018	2019	2017

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PATENTING ACTIVITY - Entrance year, by organisation and technology

Who are the most recent entrants to these technologies?

This view shows the most recent entrants across all four technologies.

This is a shortcut to finding the organisations filing for the first time in the technologies important to you.

# Competitive Intelligence – Litigation Activity

	Solannex	Kaneka	Hitachi	Compagnie De	SunEdison	SOLAR PASTE	Jiangsu Zhongneng	Fuji Electric	Showa Denko	Semiconductor Energy	TOTAL
Crystalline Silicon Photovoltaics	2	2	1	1	2	2	2	0	1	0	13
Thin Film Photovoltaics	7	1	1	1	0	0	0	1	0	0	11
Organic Photovoltaics	0	0	0	0	0	0	0	0	0	1	1
TOTAL	9	3	2	2	2	2	2	1	1	1	25

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## DISPUTES - Litigated families, by organisation and technology

Count of litigated patent families, split by technology and current organisation.

This dataset shows how many patent families have been involved in disputes that are currently owned by any organisation. These disputed families can be quickly accessed for review.

Litigation is higher in the more established technologies of crystalline silicon and thin film.

The Cipher litigation export reports can also be used to formulate a picture of litigation risk amongst a set of peers.



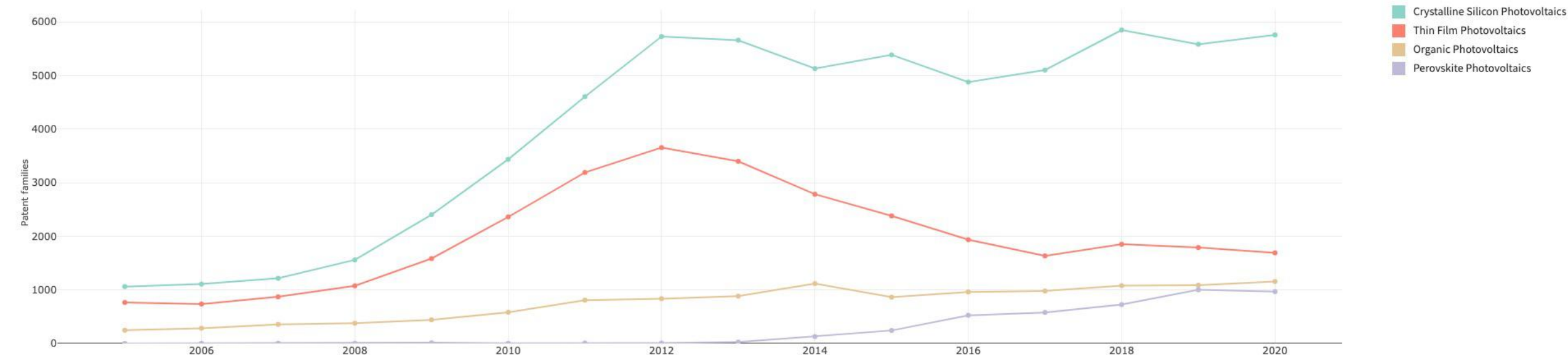
# Technology Trends

Dig into specific technologies using Cipher classifiers

# Technology Trends – Comparing Solar technologies



2005 to 2020



[Click here to access this CIPHER chart](#)

**PATENTING ACTIVITY** – Number of Families published each year, by technology and publication year

How are filing trends in these technologies changing over time?  
Are there technologies of interest for further analysis?

As the most established technology, crystalline silicon shows the highest number of filings each year with a lead over the other technologies.

Filings in thin film cells have fallen from a peak in 2012. This indicates that the pace of invention has slowed in this technology.

# Technology Trends – Comparing Solar technologies



2005 to 2020

Crystalline Silicon Photovoltaics  
Thin Film Photovoltaics  
Organic Photovoltaics  
Perovskite Photovoltaics



[Click here to access this Cipher chart](#)

## PORTFOLIO TRENDS – Number of Active families, by technology and year

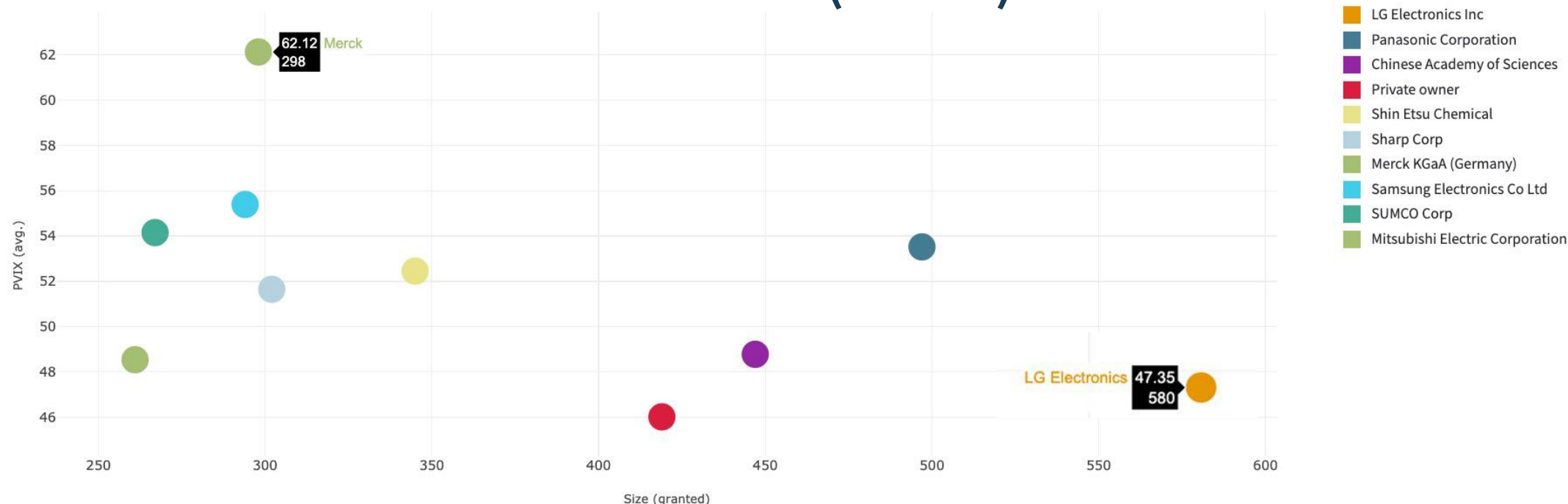
How is the total number of families in these technologies changing year on year?

Are there technologies that are increasing, and of interest for further analysis?

As the most established technology, crystalline silicon holds the highest number of active families with a lead over the other technologies. Thin film has fallen from its peak of active families in 2012.

Both organic and perovskite technologies show a steady growth in active families.

# Technology Trends – Comparing Patent Strength metrics (PVIX)



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PORTFOLIO VALUE INDEX (PVIX) - Average PVIX score, by organisation and size

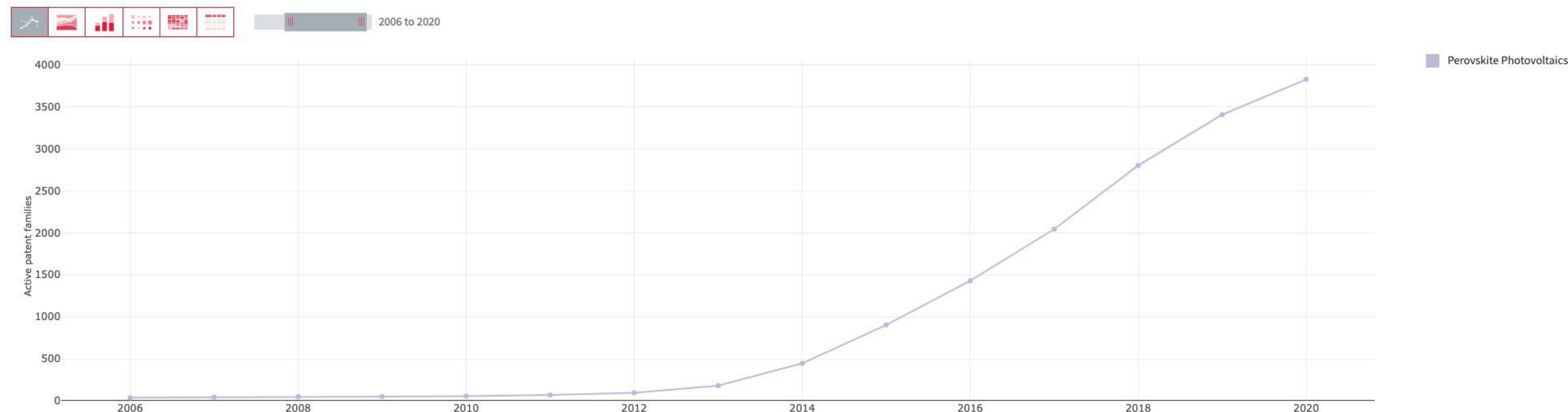
How strong the are portfolios (PVIX score) whilst also taking size into the equation?

The PVIX datasets are ideal if you wish to review or compare portfolios and evaluate portfolio strength via an industry recognised score. An organisation appearing in the upper right quadrant of this chart would indicate both a large and high-quality portfolio.

Merck has a smaller portfolio, but the highest mean PVIX of the top ten organisations.

LG Electronics has the largest portfolio, but a lower mean PVIX score, indicating lower quality.

# Technology Trends – Perovskites global analysis



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**PORTFOLIO TRENDS** – Number of Active families, by technology and year (globally)

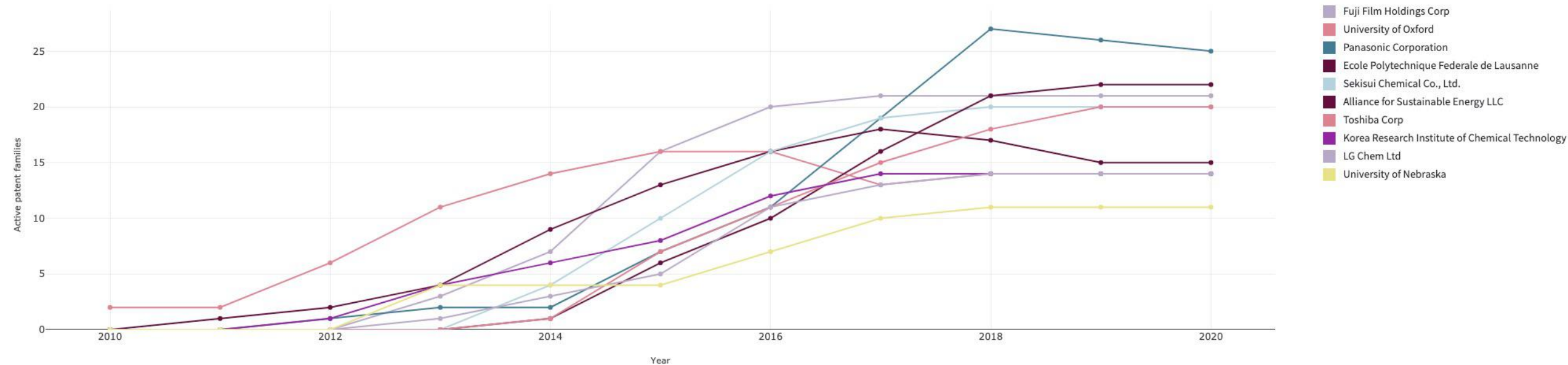
How is the number of active families changing over time for these technologies?

Is this technology area growing or reducing in size?

The trend in number of active families can be isolated for a single technology, in this case perovskites.

We can see here that the number of active families (pending and granted) has increased significantly since 2012.

# Technology Trends - Perovskites US & European analysis



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**PORTFOLIO TRENDS** – Number of Active families, by organisation and year (US & Europe)

How have the top patent owners changed their portfolio over time?  
Has the size of their portfolio in this tech area increased or decreased?

Panasonic has pulled ahead in terms of active families in perovskites, with a clear increase since 2014.

The University of Oxford held active families before the other organisations (2010-2015) .

# Technology Trends – Perovskites US & European analysis

	University of Oxford	Ecole Polytechnique	Korea Research	Alliance for Sustainable	BASF	Fujifilm	Private owner	University of Nebraska	Fujitsu	Weizmann Institute of Science	Merck	National Cheng	Panasonic	Samsung SDI	Sony	TOTAL
Perovskite Photovoltaics	922	695	231	178	165	131	113	110	106	102	85	78	75	70	65	3,126
TOTAL	922	695	231	178	165	131	113	110	106	102	85	78	75	70	65	3,126

[Click here to access this Cipher chart](#)

**PORTFOLIO STATS** - Forward citations, by organisation and technology (US & Europe)

Which organisations have received the most citations?

The University of Oxford and the Ecole Polytechnique have a clear lead in number of forward citations. This metric can be used as a proxy when considering the technological influence of a portfolio.



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