

Lithium based energy: A way to a better world

TREM 2011 - Washington DC, March 2011

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Agenda



1. Why Lithium?
2. Lithium Demand
3. Lithium Supply
4. Production capacity vs. lithium demand 2011 – 2025
5. Why we should be concerned about lithium?

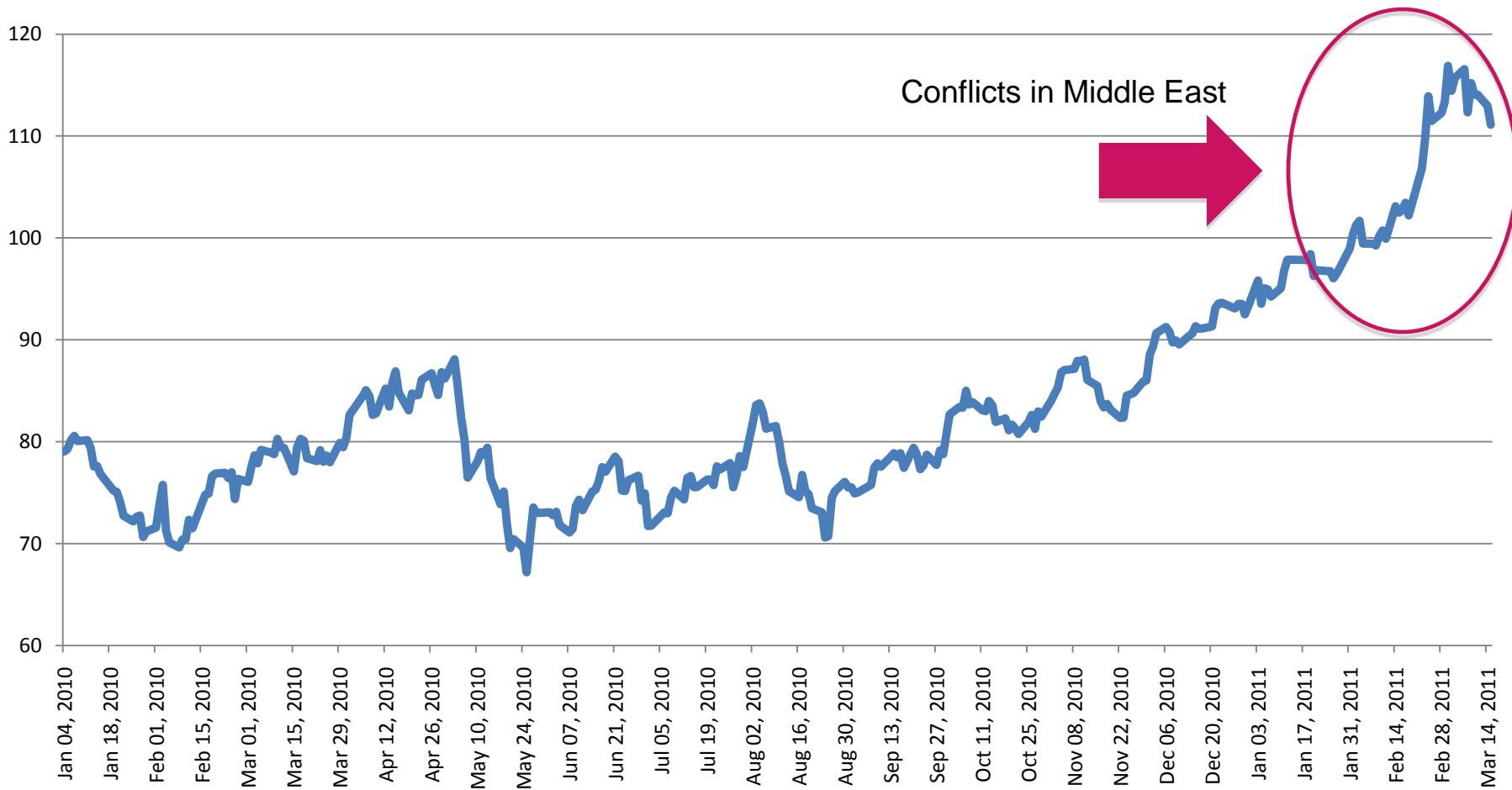




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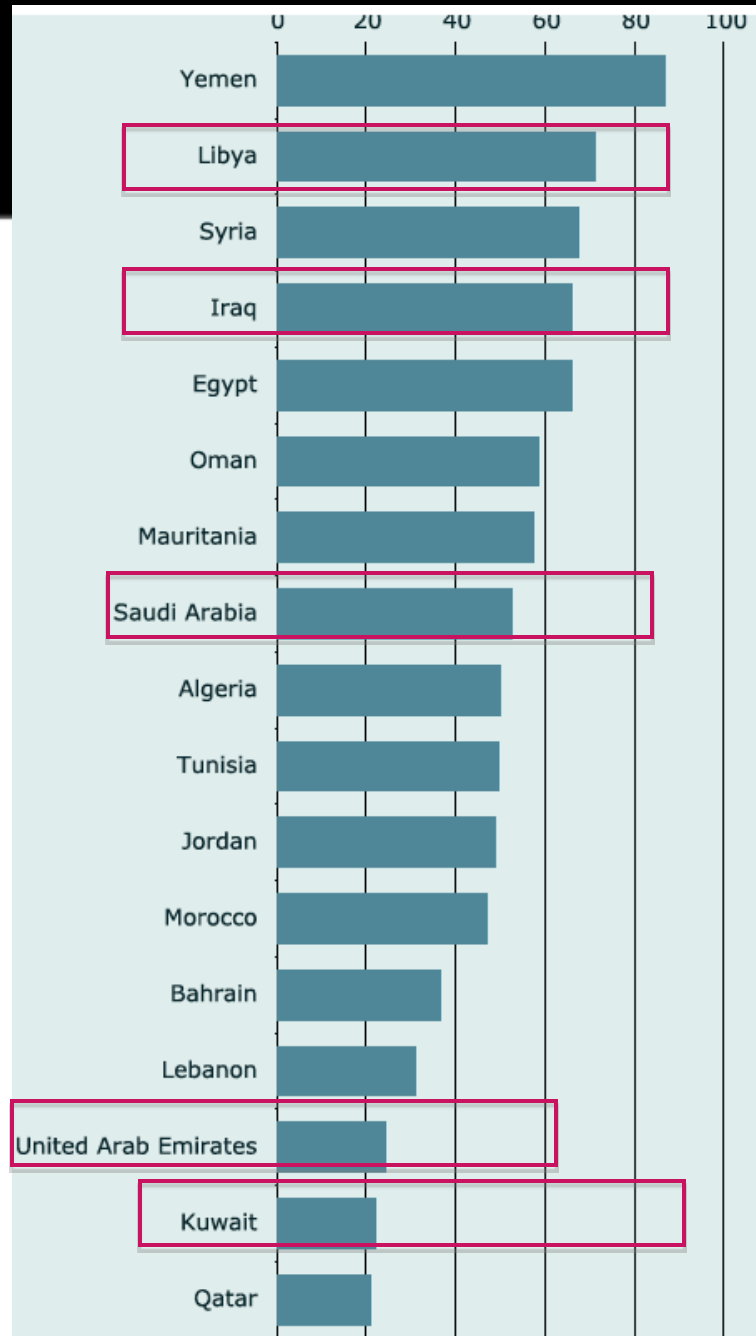


Oil prices have risen about \$15 per barrel since mid-February



The Economist Index of Unrest

EIA: “Over 1/3 of world's liquid fuels are produced in North Africa and Middle East”





Global warming:

- **Transport sector** is responsible for almost **22% of CO2 emissions**.
 - CO2 emissions from transport are dominated by road
- China, US and Russia are the largest countries in terms of CO2 emissions
- IEA - 450 Scenario: A roadmap from 3.5°C to 2°C → further actions are required
 - China and the US: 50% cumulative emission abatement needed
 - Carbon intensity has to fall at twice the rate of 1990 - 2008

A **pure electric** vehicle in the US emits around **115 grams of CO2** per km while an **internal combustion** engine vehicle emits **250 grams of CO2** per km → **Plug in hybrids and electric vehicles will make a big contribution to emissions abatement**

Why lithium?



- Lithium has a **high electrochemical potential**
 - Lithium has a **low atomic mass** (6.941 g/mol)
 - Lithium has a **low density** (around 0.53 g/cm³ at 20°C)
- That is the reason why lithium is widely used as a store energy device
- Hybrid vehicles such as the Toyota Prius and the Honda CIVIC use Nickel-Metal Hydride batteries.
 - These batteries do not meet the requirements in terms of storage capacity in plug-in hybrid electric vehicles and pure electric vehicles.

Given current technology, lithium batteries **are the choice** for energy storage in plug-in hybrid electric vehicles and pure electric vehicles



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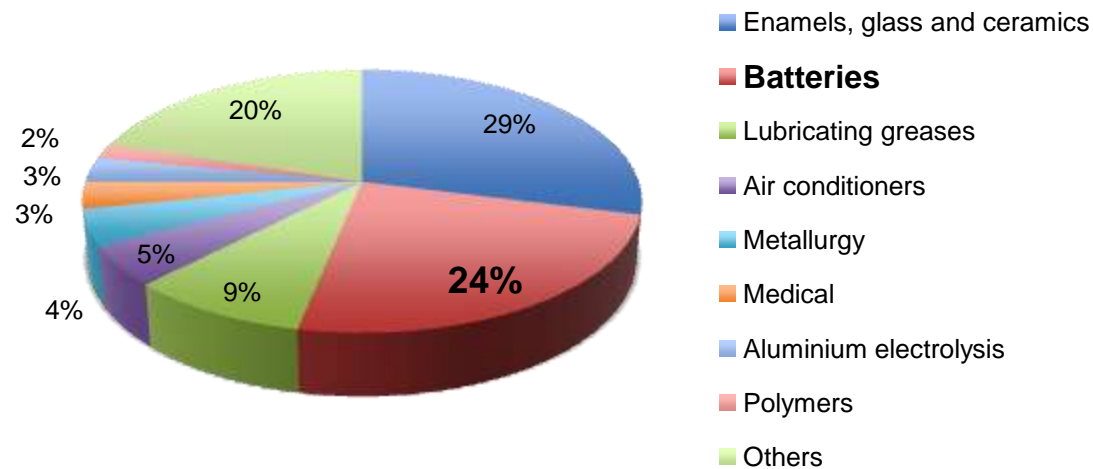
Main uses of lithium: Glass and ceramics (29%) and Batteries (24%)



Lithium used in Batteries: Primary (non rechargeable) and secondary (rechargeable).

- Almost 95% of the batteries used in electronic devices are based in lithium.
- **New use:** hybrid and electric vehicles, electric bicycles, electric scooters, grid storage, among others.

Lithium applications (2011)

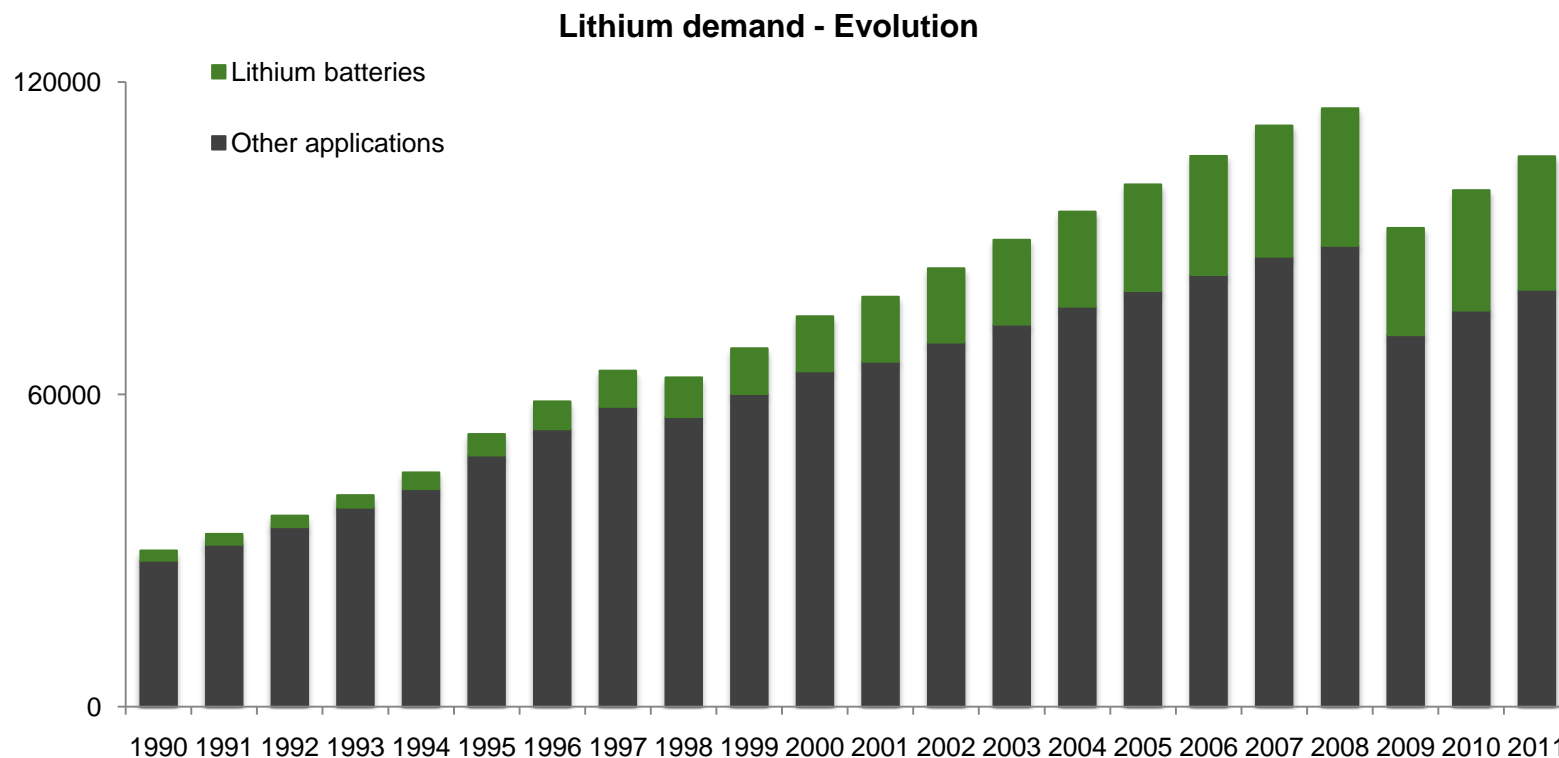


Economic crisis caused an important fall in demand

Lithium demand is expected to rise 6.5% in 2011



- Total lithium demand is expected to reach 105,000 tones as LCE¹ in 2011
- Lithium demand has grown at a CAGR² of 6.5% in the last 20 years



(1) Lithium Carbonate Equivalent
(2) Compound Annual Growth Rate
Source: signumBOX

The amount of lithium in a battery depends on the battery's chemistry, specifications, and the requirement of storage capacity



- In hybrid electric vehicles the amount of lithium varies between 0.8 to 2 Kg
- In plug-in electric vehicles the amount of lithium ranges between 1 to 10 Kg
- In pure electric vehicles the amount of lithium varies from 8 Kg to 40 Kg



Toyota Prius Plug-in Hybrid: 3.6 Kg LCE



Mitsubishi i-MiEV: 10 Kg LCE



Tesla Roadster: 40 Kg LCE

In 2025, 100,000 MT of lithium will be used in batteries for electric vehicles in a conservative scenario

BYD, GM, Toyota and Nissan will be the largest consumers



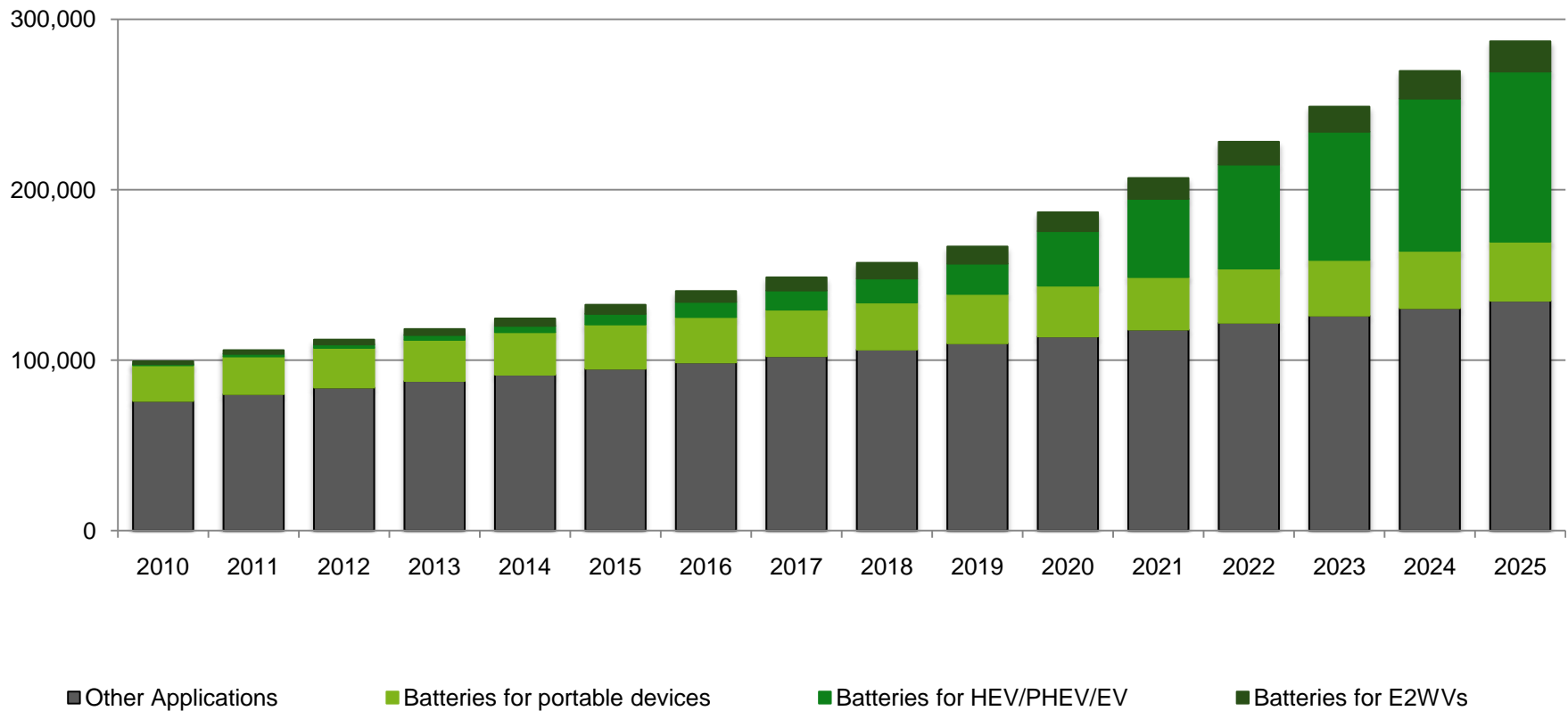
	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
BYD															
F3DM	94	184	274	364	474	583	692	802	911	1093	1275	1457	1639	1822	2004
F6DM	94	184	274	364	474	583	692	802	911	1093	1275	1457	1639	1822	2004
E6	30	50	71	91	437	783	1129	1475	1822	2368	2915	3461	4008	4554	5009
Others	21	2	73	96	272	438	604	843	1237	1940	2581	3375	4047	4718	5198
Total	239	421	692	916	1657	2388	3118	3921	4880	6494	8045	9751	11333	12915	14207
GM															
Volt	331	405	478	552	773	994	1214	1435	1656	2429	3202	3974	4747	5520	6072
Volt MPV5	0	1	4	7	27	48	69	90	110	309	508	707	905	1104	1214
Others	15	25	44	57	151	238	325	451	660	1386	2078	2904	3629	4355	4791
Total	346	431	527	616	951	1280	1608	1976	2426	4123	5788	7584	9282	10979	12077
Toyota															
Prius PHEV	16	22	29	36	100	165	230	294	359	646	933	1220	1507	1794	1973
Short distance EV	6	22	39	55	88	121	155	188	221	729	1236	1744	2252	2760	3036
RAV 4	2	8	14	21	37	54	70	87	104	166	228	290	352	414	455
Others	7	9	14	17	90	161	232	332	495	1455	2390	3484	4464	5444	5989
Total	30	62	96	129	316	501	687	901	1178	2995	4787	6738	8575	10412	11453
Nissan															
Leaf	157	215	273	331	513	696	878	1060	1242	2318	3395	4471	5548	6624	7286
Others	6	10	18	23	67	109	151	210	309	814	1303	1878	2391	2904	3194
Total	164	225	291	354	580	804	1028	1270	1551	3132	4698	6349	7938	9528	10480

	2025		
	Low	Conservative	Optmist
Number of vehicles (Million units)	6,29	8,97	13,88
Lithium consumption (Th. MT LCE)	69,4	99,8	155,5

Total lithium demand to reach 280,000 – 340,000 MT LCE in 2025 depending on P-HEV's and EVs penetration rate



Lithium Demand – Forecast (conservative scenario)





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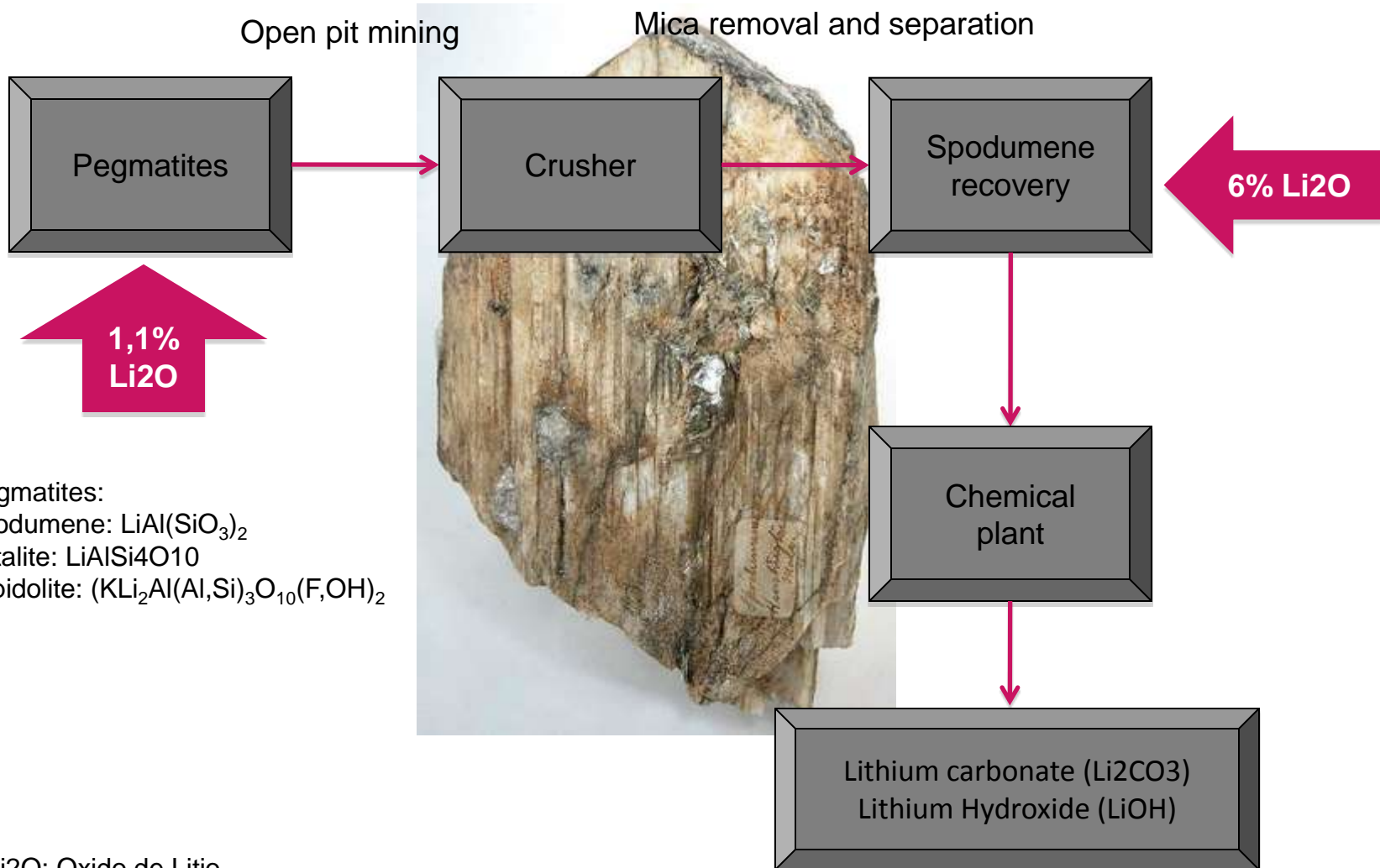
Lithium is abundant
More than 180 million MT as LCE in resources



18 Location of lithium resources/reserves per type of deposit



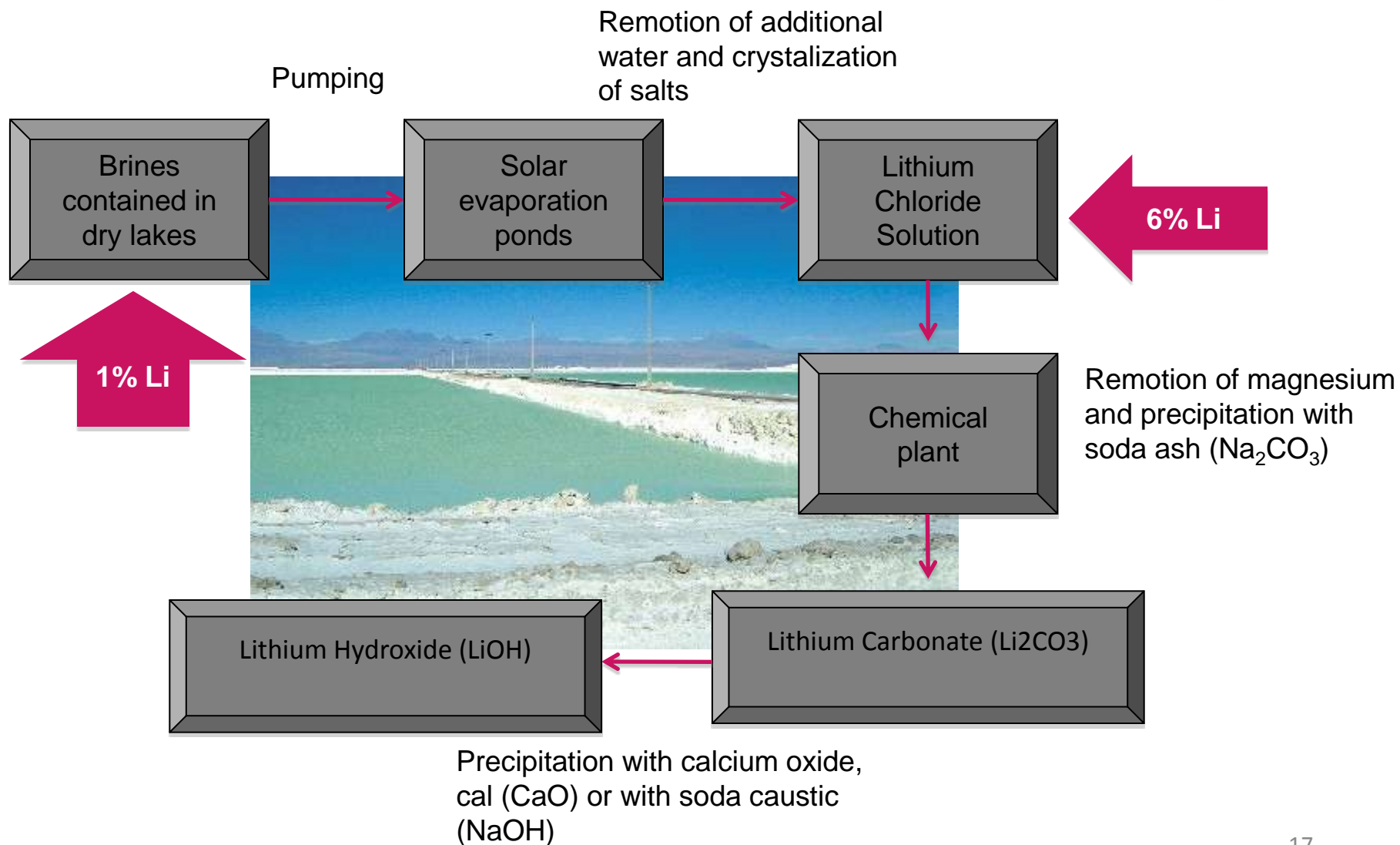
Lithium chemicals produced from hard rock minerals: an energy intensive process



- * Pegmatites:
- Spodumene: $\text{LiAl}(\text{SiO}_3)_2$
- Petalite: $\text{LiAlSi}_4\text{O}_{10}$
- Lepidolite: $(\text{KLi}_2\text{Al}(\text{Al},\text{Si})_3\text{O}_{10}(\text{F},\text{OH})_2)$

Li_2O : Oxido de Litio

Lithium chemicals produced from brines: a greener process

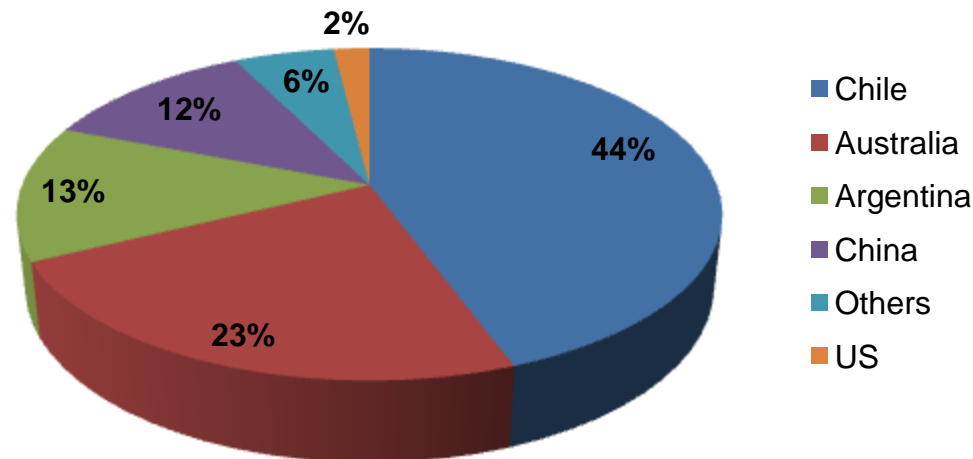


Lithium production is concentrated in Chile, Australia and Argentina



- Lithium chemicals can be produced either from lithium minerals (pegmatites) and from salar-bearing brines
 - **78%** is produced from **Salar**-bearing brines (Chile, Argentina and in the US)
 - **22%** is produced from **Pegmatites** (Australia, China and others)

Lithium Industry: Supply by country (2011)



Lithium Demand is driving exploration activity



- More than 80 exploration projects are currently being studied
- Most of them located in Canada, Argentina and in the US
- 48% correspond to **minerals** deposits; 52% to **salar-brine** deposits

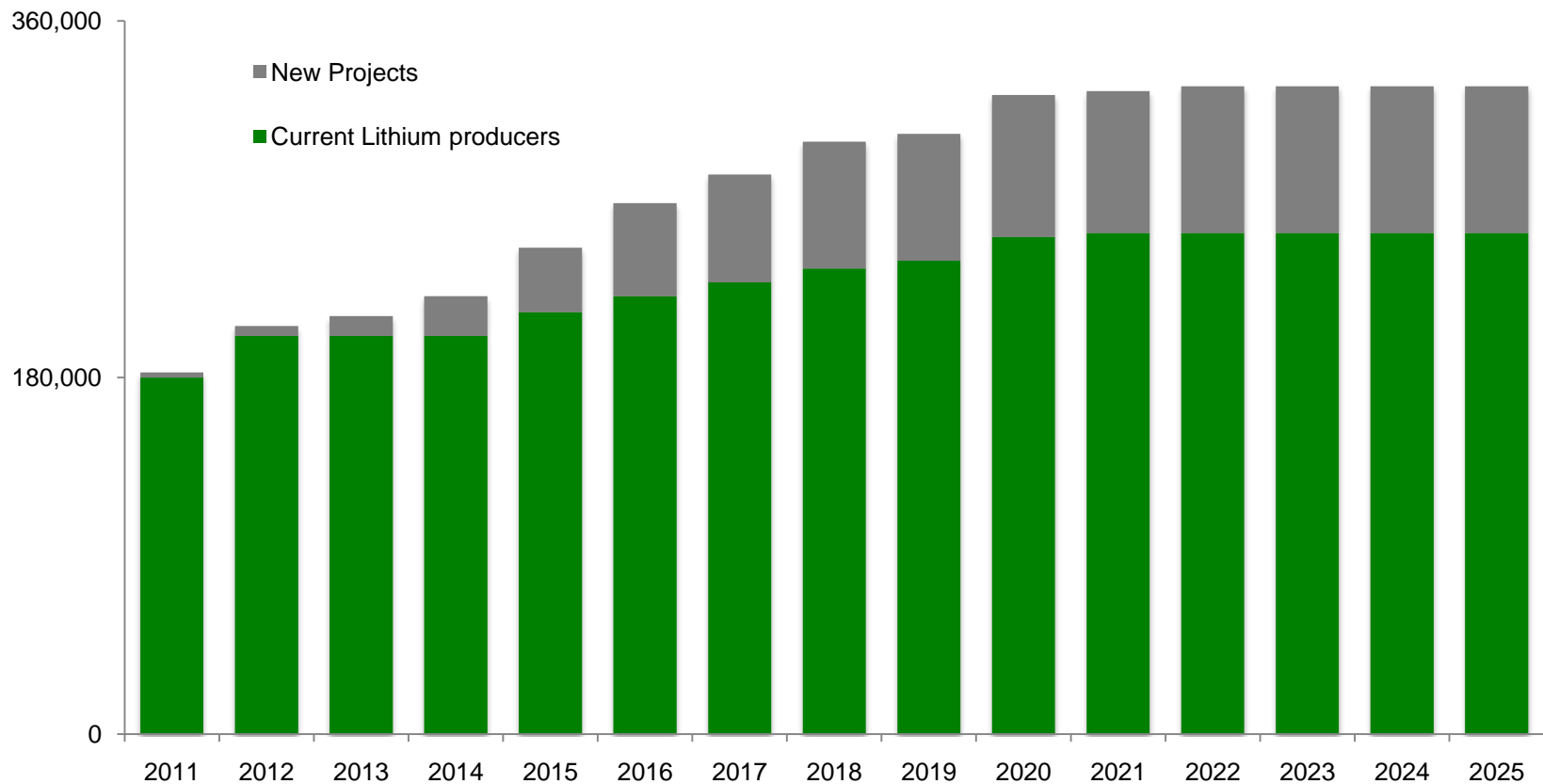


Current production capacity: 180,000 tones LCE

Production capacity in 2025: 340,000 tones LCE



Production capacity (tones LCE)



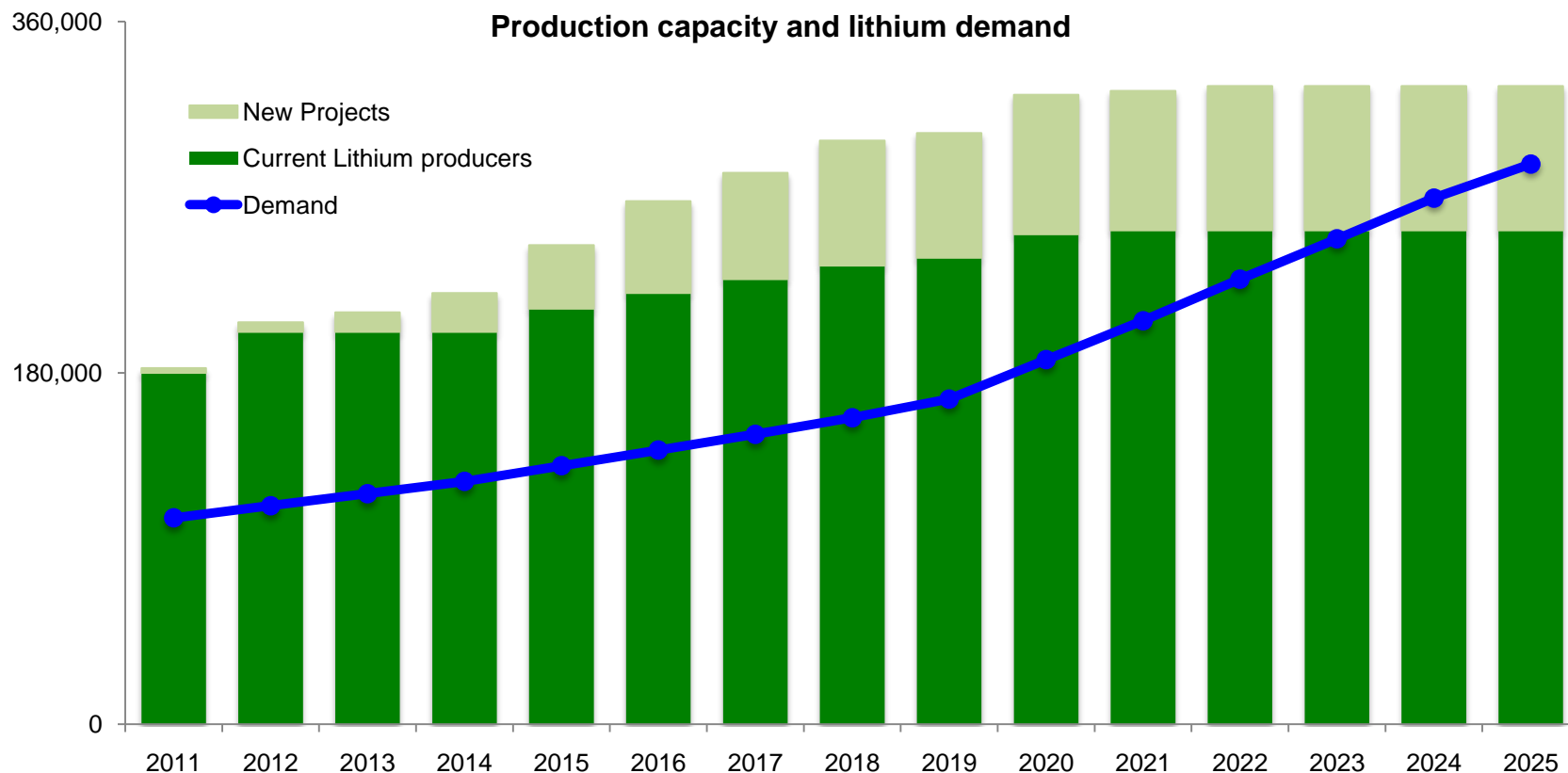


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Further space for new projects after 2020

Prices currently at US \$ 5,000 / MT expressed as LCE





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Why we should be concerned about lithium?



- Lithium is abundant
- There is enough lithium in the world to meet future demand
- Most of the lithium supply is produced in an environmental friendly way
- Lithium reserves are spread over the world
- Lithium is produced in stable countries, with solid economies and governments
- Lithium prices will drop
- Lithium can be recycled from used batteries
- Lithium in a battery is strategic: without lithium, no battery.
- Lithium in a battery is negligible: it represents less than 3% of the battery cost

....BUT



- Electric vehicles are still expensive
- Battery: main component in a car (R&D)
- What about electricity generation?
- What is needed to advance towards a low carbon society and independent from oil?
-a **NUDGE**
 - a **Nudge** to battery manufacturers
 - a **Nudge** to automakers
 - a **Nudge** to consumers
 - a **Nudge** to companies to implement infrastructure, to build charging stations, to develop electricity projects from renewable sources, etc.

