Hybrid Electric Vehicles

Contents

Objective

This wiki is a demo which provides overall IP insights related to Hybrid Electric Vehicles. The wiki focuses on technological and IP related insights based on a set of selected patents.

Hybrid electric vehicles

Introduction

A hybrid electric vehicle (HEV) is a type of hybrid vehicle and electric vehicle which combines a conventional internal combustion engine (ICE) propulsion system with an electric propulsion system. The presence of the electric powertrain is intended to achieve either better fuel economy than a conventional vehicle or better performance. There are a variety of HEV types, and the degree to which they function as EVs varies as well. The most common form of HEV is the hybrid electric car, although hybrid electric trucks (pickups and tractors) and buses also exist. Modern HEVs make use of efficiency-improving technologies such as regenerative braking, which converts the vehicle's kinetic energy into electric energy to charge the battery, rather than wasting it as heat energy as conventional brakes do. Some varieties of HEVs use their internal combustion engine to generate electricity by spinning an electrical generator (this combination is known as a motor-generator), to either recharge their batteries or to directly power the electric drive motors. Many HEVs reduce idle emissions by shutting down the ICE when idle and restarting it when needed; this is known as a start-stop system. A hybrid-electric produces less emissions from its ICE than a comparably-sized gasoline car, since an HEV's gasoline engine is usually smaller than a comparably-sized pure gasoline-burning vehicle (natural gas and propane fuels produce lower emissions) and if not used to directly drive the car, can be geared to run at maximum efficiency, further improving fuel economy.Source HEV Wikipedia

Transportation accounts for 41% of the sources of global warming. Electric vehicles can help dramatically reduce the production of greenhouse gases. A hybrid electric vehicle combines the internal combustion engine with an electric propulsion system which helps it achieve better fuel economy than a conventional fuel engine based vehicle. Initially hybrid vehicles were considered unnecessary but with increase in the price of petroleum, automobile manufacturers started to release more hybrids. Now hybrid vehicles are expected to form a core segment of the automotive market in future. Over 6.8 million hybrid electric vehicles have been sold worldwide - with United States being the world's largest hybrid market followed by Japan. The most iconic hybrid vehicle brand has been **Toyota Prius** which also makes Toyota the market leader in hybrid vehicles followed by Honda.

Toyota Prius Source

Search

Methodology

- The search was run in Thomson innovation database.
- There was a narrow search and the keywords were restricted to Title,Abstract and Claims.
- A broad search in full text field and with broad classes, was also executed.
- The broad class search was restricted with keyword search.
- The search timeline is from 01st Jan 2010-31st Dec 2014.
- Relevant US, IPC, CPC and JP-F term classifications are used for searching patents.

Concept table

Hybrid electric vehicles	Vehicle	Electric Motor
HEV	Automotive	Electric motor
Hybrid Vehicles	Automobile	Electric-motor
Hybrid electric vehicles	Vehicle	Electric driven
hybridelectric	Motor-car	Electrically driven
Plug-In hybrid vehicles	Motor-vehicle	-
Charge-in hybrid vehicles	Motorcar	-
PHEV	Motorvehicle	-

Classification

CPC/IPC Classes

CPC/IPC Class	Definition
B60K0001*	Vehicles in general ----- Arrangement or mounting of propulsion units or of transmissions in vehicles; Arrangement or mounting of plural diverse prime-movers; Auxiliary drives; instrumentation or dashboards for vehicles; Arrangements in connection with cooling, air intake, gas exhaust, or fuel supply, of propulsion units, in vehicles ----- Arrangement or mounting of electrical propulsion units
B60K2001*	Vehicles in general ----- Arrangement or mounting of propulsion units or of transmissions in vehicles; Arrangement or mounting of plural diverse prime-movers; Auxiliary drives; instrumentation or dashboards for vehicles; Arrangements in connection with cooling, air intake, gas exhaust, or fuel supply, of propulsion units, in vehicles ----- Arrangement or mounting of electrical propulsion units ----- {one motor mounted on a propulsion axle for rotating right and left wheels of this axle}
B60K00062*	Vehicles in general ----- Arrangement or mounting of propulsion units or of transmissions in vehicles; Arrangement or mounting of plural diverse prime-movers; Auxiliary drives; Instrumentation or dashboards for vehicles; Arrangements in connection with cooling, air intake, gas exhaust, or fuel supply, of propulsion units, in vehicle ----- Arrangement or mounting of plural diverse prime-movers for mutual or common propulsion, e.g. hybrid propulsion systems comprising electric motors and internal

	combustion engines ----- the prime-movers consisting of electric motors and internal combustion engines, e.g. HEVs
B60K2006262	Vehicles in general ----- Arrangement or mounting of propulsion units or of transmissions in vehicles; Arrangement or mounting of plural diverse prime-movers; Auxiliary drives; Instrumentation or dashboards for vehicles; Arrangements in connection with cooling, air intake, gas exhaust, or fuel supply, of propulsion units, in vehicle ----- Arrangement or mounting of plural diverse prime-movers for mutual or common propulsion, e.g. hybrid propulsion systems comprising electric motors and internal combustion engines ----- the prime-movers consisting of electric motors and internal combustion engines, e.g. HEVs ----- characterised by apparatus, components or means specially adapted for HEVs ----- characterised by the motors or the generators ----- {the motor or generator are used as clutch, e.g. between engine and driveshaft}
B60K2006264	Vehicles in general ----- Arrangement or mounting of propulsion units or of transmissions in vehicles; Arrangement or mounting of plural diverse prime-movers; Auxiliary drives; Instrumentation or dashboards for vehicles; Arrangements in connection with cooling, air intake, gas exhaust, or fuel supply, of propulsion units, in vehicle ----- Arrangement or mounting of plural diverse prime-movers for mutual or common propulsion, e.g. hybrid propulsion systems comprising electric motors and internal combustion engines ----- the prime-movers consisting of electric motors and internal combustion engines, e.g. HEVs ----- characterised by apparatus, components or means specially adapted for HEVs ----- characterised by the motors or the generators ----- {with outer rotor and inner stator}
B60K2006266	Vehicles in general ----- Arrangement or mounting of propulsion units or of transmissions in vehicles; Arrangement or mounting of plural diverse prime-movers; Auxiliary drives; Instrumentation or dashboards for vehicles; Arrangements in connection with cooling, air intake, gas exhaust, or fuel supply, of propulsion units, in vehicle ----- Arrangement or mounting of plural diverse prime-movers for mutual or common propulsion, e.g. hybrid propulsion systems comprising electric motors and internal combustion engines ----- the prime-movers consisting of electric motors and internal combustion engines, e.g. HEVs ----- characterised by apparatus, components or means specially adapted for HEVs ----- characterised by the motors or the generators ----- {with two coaxial motors or generators}
B60K2006268	Vehicles in general ----- Arrangement or mounting of propulsion units or of transmissions in vehicles; Arrangement or mounting of plural diverse prime-movers; Auxiliary drives; Instrumentation or dashboards for vehicles; Arrangements in connection with cooling, air intake, gas exhaust, or fuel supply, of propulsion units, in vehicle ----- Arrangement or mounting of plural diverse prime-movers for mutual or common propulsion, e.g. hybrid propulsion systems comprising electric motors and internal combustion engines ----- the prime-movers consisting of electric motors and internal combustion engines, e.g. HEVs ----- characterised by apparatus, components or means specially adapted for HEVs ----- characterised by the motors or the generators ----- {Electric drive motor starts the engine, i.e. used as starter motor}
B60K00063*	Vehicles in general ----- Arrangement or mounting of propulsion units or of transmissions in vehicles; Arrangement or mounting of plural diverse prime-movers; Auxiliary drives; Instrumentation or dashboards for vehicles; Arrangements in connection with cooling, air intake, gas exhaust, or fuel supply, of propulsion units, in vehicle ----- Arrangement or mounting of plural diverse prime-movers for mutual or common propulsion, e.g. hybrid propulsion systems comprising electric motors and internal combustion engines ----- the prime-movers consisting of electric motors and internal combustion engines, e.g. HEVs ----- characterised by apparatus, components or means specially adapted for HEVs ----- characterized by chargeable mechanical accumulators, e.g. flywheels
B60K2006381	Vehicles in general ----- Arrangement or mounting of propulsion units or of transmissions in vehicles; Arrangement or mounting of plural diverse prime-movers; Auxiliary drives; Instrumentation or dashboards for vehicles; Arrangements in connection with cooling, air intake, gas exhaust, or fuel supply, of propulsion units, in vehicle ----- Arrangement or mounting of plural diverse prime-movers for mutual or common propulsion, e.g. hybrid propulsion systems comprising electric motors and internal combustion engines ----- the prime-movers consisting of electric motors and internal combustion engines, e.g. HEVs ----- characterised by apparatus, components or means specially adapted for HEVs ----- characterised by the driveline clutches ----- {characterized by driveline brakes}
B60K00064*	Vehicles in general ----- Arrangement or mounting of propulsion units or of transmissions in vehicles; Arrangement or mounting of plural diverse prime-movers; Auxiliary drives; Instrumentation or dashboards for vehicles; Arrangements in connection with cooling, air intake, gas exhaust, or fuel supply, of propulsion units, in vehicle ----- Arrangement or mounting of plural diverse prime-movers for mutual or common propulsion, e.g. hybrid propulsion systems comprising electric motors and internal combustion engines ----- the prime-movers consisting of electric motors and internal combustion engines, e.g. HEVs ----- characterised by the architecture of the hybrid electric vehicle
B60K20064808*	Vehicles in general ----- Arrangement or mounting of propulsion units or of transmissions in vehicles; Arrangement or mounting of plural diverse prime-movers; Auxiliary drives; Instrumentation or dashboards for vehicles; Arrangements in connection with cooling, air intake, gas exhaust, or fuel supply, of propulsion units, in vehicle ----- Arrangement or mounting of plural diverse prime-movers for mutual or common propulsion, e.g. hybrid propulsion systems comprising electric motors and internal combustion engines ----- the prime-movers consisting of electric motors and internal combustion engines, e.g. HEVs ----- characterised by the architecture of the hybrid electric vehicle ----- Parallel type ----- {Electric machine connected or connectable to gearbox output shaft}
B60K20064816	Vehicles in general ----- Arrangement or mounting of propulsion units or of transmissions in vehicles; Arrangement or mounting of plural diverse prime-movers; Auxiliary drives; Instrumentation or dashboards for vehicles; Arrangements in connection with cooling, air intake, gas exhaust, or fuel supply, of propulsion units, in vehicle ----- Arrangement or mounting of plural diverse prime-movers for mutual or common propulsion, e.g. hybrid propulsion systems comprising electric motors and internal combustion engines ----- the prime-movers consisting of electric motors and internal combustion engines, e.g. HEVs ----- characterised by the architecture of the hybrid electric vehicle ----- Parallel type ----- {Electric machine connected or connectable to gearbox internal shaft}
B60K20064825	Vehicles in general ----- Arrangement or mounting of propulsion units or of transmissions in vehicles; Arrangement or mounting of plural diverse prime-movers; Auxiliary drives; Instrumentation or dashboards for vehicles; Arrangements in connection with cooling, air intake, gas exhaust, or fuel supply, of propulsion units, in vehicle ----- Arrangement or mounting of plural diverse prime-movers for mutual or common propulsion, e.g. hybrid propulsion systems comprising electric motors and internal combustion engines ----- the prime-movers consisting of electric motors and internal combustion engines, e.g. HEVs ----- characterised by the architecture of the hybrid electric vehicle ----- Parallel type ----- {Electric machine connected or connectable to gearbox input shaft}
B60K20064833	Vehicles in general ----- Arrangement or mounting of propulsion units or of transmissions in vehicles; Arrangement or mounting of plural diverse prime-movers; Auxiliary drives; Instrumentation or dashboards for vehicles; Arrangements in connection with cooling, air intake, gas exhaust, or fuel supply, of propulsion units, in vehicle ----- Arrangement or mounting of plural diverse prime-movers for mutual or common propulsion, e.g. hybrid propulsion systems comprising electric motors and internal combustion engines ----- the prime-movers consisting of electric motors and internal combustion engines, e.g. HEVs ----- characterised by the architecture of the hybrid electric vehicle ----- Parallel type ----- {Step up or reduction gearing driving generator, e.g. to operate generator in most efficient speed range}

B60K20064841	Vehicles in general ----- Arrangement or mounting of propulsion units or of transmissions in vehicles; Arrangement or mounting of plural diverse prime-movers; Auxiliary drives; Instrumentation or dashboards for vehicles; Arrangements in connection with cooling, air intake, gas exhaust, or fuel supply, of propulsion units, in vehicle ----- Arrangement or mounting of plural diverse prime-movers for mutual or common propulsion, e.g. hybrid propulsion systems comprising electric motors and internal combustion engines ----- the prime-movers consisting of electric motors and internal combustion engines, e.g. HEVs ----- characterised by the architecture of the hybrid electric vehicle ----- Parallel type ----- {Step up or reduction gearing driving generator, e.g. to operate generator in most efficient speed range} ----- {the gear provides shifting between multiple ratios}
B60K00065*	Vehicles in general ----- Arrangement or mounting of propulsion units or of transmissions in vehicles; Arrangement or mounting of plural diverse prime-movers; Auxiliary drives; Instrumentation or dashboards for vehicles; Arrangements in connection with cooling, air intake, gas exhaust, or fuel supply, of propulsion units, in vehicle ----- Arrangement or mounting of plural diverse prime-movers for mutual or common propulsion, e.g. hybrid propulsion systems comprising electric motors and internal combustion engines ----- the prime-movers consisting of electric motors and internal combustion engines, e.g. HEVs ----- Architecture of the driveline characterised by arrangement or kind of transmission units
B60K2006541	Vehicles in general ----- Arrangement or mounting of propulsion units or of transmissions in vehicles; Arrangement or mounting of plural diverse prime-movers; Auxiliary drives; Instrumentation or dashboards for vehicles; Arrangements in connection with cooling, air intake, gas exhaust, or fuel supply, of propulsion units, in vehicle ----- Arrangement or mounting of plural diverse prime-movers for mutual or common propulsion, e.g. hybrid propulsion systems comprising electric motors and internal combustion engines ----- the prime-movers consisting of electric motors and internal combustion engines, e.g. HEVs ----- Architecture of the driveline characterised by arrangement or kind of transmission units ----- Transmission for changing ratio ----- {without reverse ratio using instead electric reversing}
B60K2006542	Vehicles in general ----- Arrangement or mounting of propulsion units or of transmissions in vehicles; Arrangement or mounting of plural diverse prime-movers; Auxiliary drives; Instrumentation or dashboards for vehicles; Arrangements in connection with cooling, air intake, gas exhaust, or fuel supply, of propulsion units, in vehicle ----- Arrangement or mounting of plural diverse prime-movers for mutual or common propulsion, e.g. hybrid propulsion systems comprising electric motors and internal combustion engines ----- the prime-movers consisting of electric motors and internal combustion engines, e.g. HEVs ----- Architecture of the driveline characterised by arrangement or kind of transmission units ----- Transmission for changing ratio ----- {with overdrive ratio}
B60L0008*	Vehicles in general ----- Electric equipment or propulsion of electrically-propelled vehicles; Magnetic suspension or levitation for vehicles; Electro-dynamic brake systems for vehicles, in general ----- Electric propulsion with power supply from force of nature, e.g. sun, wind
B60L0011*	Vehicles in general ----- Electric equipment or propulsion of electrically-propelled vehicles; Magnetic suspension or levitation for vehicles; Electro-dynamic brake systems for vehicles, in general ----- Electric propulsion with power supplied within the vehicle
B60L0011123	Vehicles in general ----- Electric equipment or propulsion of electrically-propelled vehicles; Magnetic suspension or levitation for vehicles; Electrodynamic brake systems for vehicles, in general ----- Electric propulsion with power supplied within the vehicle ----- using engine-driven generators ----- with additional electric power supply, e.g. accumulator ----- {using range extenders, e. g. series hybrid vehicles}
B62M002302	Land vehicles for travelling otherwise than on rails ----- Rider propulsion of wheeled vehicles or sledges; powered propulsion of sledges or cycles; Transmissions specially adapted for such vehicles ----- Transmissions characterised by use of other elements; other transmissions ----- characterised by the use of two or more dissimilar sources of power, e.g. transmissions for hybrid motorcycles
B60W001006	Vehicles in general ----- Conjoint control of vehicle sub-units of different type or different function; Control systems specially adapted for hybrid vehicles; Road vehicle drive control systems for purposes not related to the control of a particular sub-unit ----- Conjoint control of vehicle sub-units of different type or different function ----- Including control of propulsion units ----- including control of combustion engines
B60W001008	Vehicles in general ----- Conjoint control of vehicle sub-units of different type or different function; Control systems specially adapted for hybrid vehicles; Road vehicle drive control systems for purposes not related to the control of a particular sub-unit ----- Conjoint control of vehicle sub-units of different type or different function ----- Including control of propulsion units ----- including control of electric propulsion units, e.g. motors or generators
B60W0020*	Vehicles in general ----- Conjoint control of vehicle sub-units of different type or different function; Control systems specially adapted for hybrid vehicles; Road vehicle drive control systems for purposes not related to the control of a particular sub-unit ----- Control systems specially adapted for hybrid vehicles, i.e. vehicles having two or more prime movers of more than one type, e.g. electrical and internal combustion motors, all used for propulsion of the vehicle
Y10S0903*	Hybrid electric vehicles, HEVS
Y02T001062*	Climate change mitigation technologies related to transportation ----- Road transport of goods or passengers ----- Other road transportation technologies with climate change mitigation effect (not used, see subgroups) ----- Hybrid vehicles

US Classes

US Class	Definition
18006521	MOTOR VEHICLES ----- POWER ----- Electric ----- Hybrid vehicle
903	HYBRID ELECTRIC VEHICLES (HEVS)

F-Term

F-Term	Definition
3D202	HYBRID ELECTRIC VEHICLES
3D235CC32	ARRANGEMENT OR MOUNTING OF PROPULSION UNITS FOR VEHICLES ----- Internal combustion engines and electric motors

3D301BA20	VEHICLE BODY SUSPENSIONS --- Electrical vehicle, e.g. EV, HEV or FCEV
5H601BB20	IRON CORE OF ROTATING ELECTRIC MACHINES --- for EV drive including HEV and FCV

Search Query

- **Database**: Thomson Innovation
- **Timeline**: 1836/01/01 - 2014/12/31
- **Coverage**: US Grant, AU Innov, CA App, US App, AU Grant, FR App, EP Grant, AU App, DE Util, EP App, GB App, DE Grant, WO App, CA Grant, DE App, CN Util, ID Simple, KR Util , SG App, CN Grant, ID App, KR Grant, TH Grant, CN App, JP Util, KR App, VN Grant, IN Grant, JP Grant, MY Grant, VN App, IN App, JP App, SG Grant, Others

S. No.	Search Concept	Class codes	Keywords	Hits
1	**Direct class codes of hybrid electric vehicles + keywords in full text**	Y10S0903* OR B60K2006542 OR B60K2006541 OR B60K00065* OR B60K20064841 OR B60K20064833 OR B60K20064825 OR B60K20064816 OR B60K20064808 OR B60K00064* OR B60K2006381 OR B60K00063* OR B60K2006268 OR B60K2006266 OR B60K2006264 OR B60K2006262 OR B60K00062* OR 903* OR 1800652* OR 3D202* OR 3D235CC32	**Full Text=** ((((hybrid NEAR2 electric) OR hybridelectric OR electrichybrid) ADJ3 (vehicle* OR motorcar OR motorvehicle OR (motor ADJ1 (car OR vehicle)) OR automo*)) OR (HEV*2 OR PHEV*2) OR (((plug adj2 in) OR plugin OR charge-in) ADJ2 (hybridvehicle OR (hybrid ADJ2 (automo* OR vehicle* OR motorcar OR motorvehicle OR (motor ADJ1 (car OR vehicle))))))) **OR** ((hybrid ADJ2 (vehicle* OR motorcar OR motorvehicle OR (motor ADJ (car OR vehicle)) OR automo*)) AND ((electric*6 ADJ2 (machine*1 OR motor*1 OR drive*)) OR electricmotor OR electricdrive OR electricmachine))	45197
2	**Electric propelled vehicles class codes + hybrid vehicles keywords**	B60W001008 OR B60L0011* OR B60L0008* OR B60K2001* OR B60K0001*	**Claims, Title, Abstract=** (hybrid NEAR2 (vehicle* OR motorcar OR motorvehicle OR (motor ADJ1 (car OR vehicle)) OR automo*));	70390
3	**Broad class codes of hybrid vehicles + Electric drive keywords**	B62M002302 OR B60W0020* OR Y02T001062*	**Claims, Title, Abstract=** ((electric*6 ADJ2 (machine*1 OR motor*1 OR drive*)) OR electricmotor OR electricdrive OR electricmachine);	39689
4	**Miscellaneous (Controls of hybrid vehicles) class codes + HEV keywords**	B60W001006 OR B60L0011123 OR 3D301BA20 OR 5H601BB20	**Claims, Title, Abstract=** ((((hybrid NEAR2 electric) OR hybridelectric OR electrichybrid) ADJ3 (vehicle* OR motorcar OR motorvehicle OR (motor ADJ1 (car OR vehicle)) OR automo*)) OR (HEV*2 OR PHEV*2) OR (((plug adj2 in) OR plugin OR charge-in) ADJ2 (hybridvehicle OR (hybrid ADJ2 (automo* OR vehicle* OR motorcar OR motorvehicle OR (motor ADJ1 (car OR vehicle)))))));	7560
5	**Only Hybrid Electric vehicle Keywords**	--	**Claims, Title, Abstract=** ((((hybrid NEAR2 electric) OR hybridelectric OR electrichybrid) ADJ3 (vehicle* OR motorcar OR motorvehicle OR (motor ADJ1 (car OR vehicle)) OR automo*)) OR (HEV*2 OR PHEV*2) OR (((plug adj2 in) OR plugin OR charge-in) ADJ2 (hybridvehicle OR (hybrid ADJ2 (automo* OR vehicle* OR motorcar OR motorvehicle OR (motor ADJ1 (car OR vehicle)))))));	74080
6	**Combined query**	**1 OR 2 OR 3 OR 4 OR 5**		**144885**
7	**Combined query for last 5 years**	**6 AND (DP>=(20100101) AND DP<=(20141231))**		**87121 (36788 Unique INPADOC families)**

German Language Search

S. No.	Search Concept	Class codes	German keyword Search	Hits
1	**Direct class codes of hybrid electric vehicles + keywords in full text**	Y10S0903* OR B60K2006542 OR B60K2006541 OR B60K00065* OR B60K20064841 OR B60K20064833 OR B60K20064825 OR B60K20064816 OR B60K20064808 OR B60K00064* OR B60K2006381 OR B60K00063* OR B60K2006268 OR B60K2006266 OR B60K2006264 OR B60K2006262 OR B60K00062* OR 903* OR 1800652* OR 3D202* OR	**Full Text=** (((hybrid NEAR2 elektrisch) OR ("Hybrid-Elektro") OR ("Elektro-Hybrid")) ADJ3 (Fahrzeug OR Fahrzeuge OR Automobil OR Motorwagen OR kraftfahrzeug OR KFZ OR Kraftwagen OR automotive OR Automoteur OR Kraftfahrzeugen OR (voiture ADJ1 motor))) OR (HEV*2 OR PHEV*2) OR (((plug ADJ2 in) OR plugin OR charge-in) ADJ2 (hybridvehicle OR (hybrid ADJ2 (Fahrzeug OR Fahrzeuge OR Automobil OR Motorwagen OR kraftfahrzeug OR KFZ OR Kraftwagen OR automotive OR Automoteur OR Kraftfahrzeugen OR (voiture ADJ1 motor))))) OR (((hybrid ADJ2 (Fahrzeug OR Fahrzeuge OR Automobil OR Motorwagen OR kraftfahrzeug OR KFZ OR Kraftwagen OR automotive OR Automoteur OR Kraftfahrzeugen OR (voiture ADJ1 motor))) OR (Hybridfahrzeugs OR Hybridfahrzeug OR "Hybrid-Kraftfahrzeug" OR "Hybrid-Fahrzeuge")) AND ((elektrisch ADJ2 (Maschine OR antrieb OR Laufwerk)) OR (Elektrische ADJ1 Drehmaschine) OR ElecktroAntriebsstrang OR Elektroantrieb OR Elektromotor OR (Elektrische ADJ1 Maschine))) OR HYBRIDANTRIEBSSTRANG OR (Hybrid ADJ1 Antriebsstrang) OR Hybridantriebes OR (Hybrid ADJ1 antriebes) OR ((Hybridsystem NEAR2 (Brennstoffzelle)) OR "FuelCELL-Hybrid" OR "Plug-In-Hybridtechnologie" OR Elektrohybridfahrzeuge OR	11445

		3D235CC32	"Hybrid-Elektrofahrzeuge" OR "Hybrid-Elektrokraftfahrzeugs" OR "Hybrid-Elektrofahrzeug" OR Elektrohybridfahrzeugs OR Elektrohybridfahrzeug)	
2	**Electric propelled vehicles class codes + hybrid vehicles keywords**	B60W001008 OR B60L0011* OR B60L0008* OR B60K2001* OR B60K0001*	**Claims, Title, Abstract**= ((hybrid ADJ2 (Fahrzeug OR Fahrzeuge OR Automobil OR Motorwagen OR kraftfahrzeug OR KFZ OR Kraftwagen OR automotive OR Automoteur OR Kraftfahrzeugen OR (voiture ADJ1 motor))) OR (Hybridfahrzeugs OR Hybridfahrzeug OR "Hybrid-Kraftfahrzeug" OR "Hybrid-Fahrzeuge")) OR (HYBRIDANTRIEBSSTRANG OR (Hybrid ADJ1 Antriebsstrang) OR Hybridantriebes OR (Hybrid ADJ1 antriebes))	4653
3	**Broad class codes of hybrid vehicles + Electric drive keywords**	B62M002302 OR B60W0020* OR Y02T001062*	**Claims, Title, Abstract=** ((Elektrische ADJ1 Drehmaschine) OR ElecktroAntriebsstrang OR Elektroantrieb OR Elektromotor OR (Elektrische ADJ1 Maschine))	5978
4	**Miscellaneous (Controls of hybrid vehicles) class codes + HEV keywords**	B60W001006 OR B60L0011123 OR 3D301BA20 OR 5H601BB20	**Claims, Title, Abstract**=(((hybrid NEAR2 elektrisch) OR ("Hybrid-Elektro") OR ("Elektro-Hybrid")) ADJ3 (Fahrzeug OR Fahrzeuge OR Automobil OR Motorwagen OR kraftfahrzeug OR KFZ OR Kraftwagen OR automotive OR Automoteur OR Kraftfahrzeugen OR (voiture ADJ1 motor))) OR (HEV*2 OR PHEV*2) OR (((plug ADJ2 in) OR plugin OR charge-in) ADJ2 (hybridvehicle OR (hybrid ADJ2 (Fahrzeug OR Fahrzeuge OR Automobil OR Motorwagen OR kraftfahrzeug OR KFZ OR Kraftwagen OR automotive OR Automoteur OR Kraftfahrzeugen OR (voiture ADJ1 motor))))) OR (((hybrid ADJ2 (Fahrzeug OR Fahrzeuge OR Automobil OR Motorwagen OR kraftfahrzeug OR KFZ OR Kraftwagen OR automotive OR Automoteur OR Kraftfahrzeugen OR (voiture ADJ1 motor))) OR (Hybridfahrzeugs OR Hybridfahrzeug OR "Hybrid-Kraftfahrzeug" OR "Hybrid-Fahrzeuge")) AND ((elektrisch ADJ2 (Maschine OR antrieb OR Laufwerk)) OR (Elektrische ADJ Drehmaschine) OR ElecktroAntriebsstrang OR Elektroantrieb OR Elektromotor OR (Elektrische ADJ1 Maschine)))	2041
5	**Only Hybrid Electric vehicle Keywords**	--	**Claims, Title, Abstract=** (((hybrid NEAR2 elektrisch) OR ("Hybrid-Elektro") OR ("Elektro-Hybrid")) ADJ3 (Fahrzeug OR Fahrzeuge OR Automobil OR Motorwagen OR kraftfahrzeug OR KFZ OR Kraftwagen OR automotive OR Automoteur OR Kraftfahrzeugen OR (voiture ADJ1 motor))) OR (HEV*2 OR PHEV*2) OR (((plug ADJ2 in) OR plugin OR charge-in) ADJ2 (hybridvehicle OR (hybrid ADJ2 (Fahrzeug OR Fahrzeuge OR Automobil OR Motorwagen OR kraftfahrzeug OR KFZ OR Kraftwagen OR automotive OR Automoteur OR Kraftfahrzeugen OR (voiture ADJ1 motor))))) OR (((hybrid ADJ2 (Fahrzeug OR Fahrzeuge OR Automobil OR Motorwagen OR kraftfahrzeug OR KFZ OR Kraftwagen OR automotive OR Automoteur OR Kraftfahrzeugen OR (voiture ADJ1 motor))) OR (Hybridfahrzeugs OR Hybridfahrzeug OR "Hybrid-Kraftfahrzeug" OR "Hybrid-Fahrzeuge")) AND ((elektrisch ADJ2 (Maschine OR antrieb OR Laufwerk)) OR (Elektrische ADJ1 Drehmaschine) OR ElecktroAntriebsstrang OR Elektroantrieb OR Elektromotor OR (Elektrische ADJ1 Maschine))) OR HYBRIDANTRIEBSSTRANG OR (Hybrid ADJ1 Antriebsstrang) OR Hybridantriebes OR (Hybrid ADJ1 antriebes) OR ((Hybridsystem NEAR2 (Brennstoffzelle)) OR "FuelCELL-Hybrid" OR "Plug-In-Hybridtechnologie" OR Elektrohybridfahrzeuge OR "Hybrid-Elektrofahrzeuge" OR "Hybrid-Elektrokraftfahrzeugs" OR "Hybrid-Elektrofahrzeug" OR Elektrohybridfahrzeugs OR Elektrohybridfahrzeug)	17313
6	**Combined query**	**1 OR 2 OR 3 OR 4 OR 5**		**30648**
7	**Combined query for last 5 years**	**6 AND (DP>=(20100101) AND DP<=(20141231))**		**17073**

French Language Search

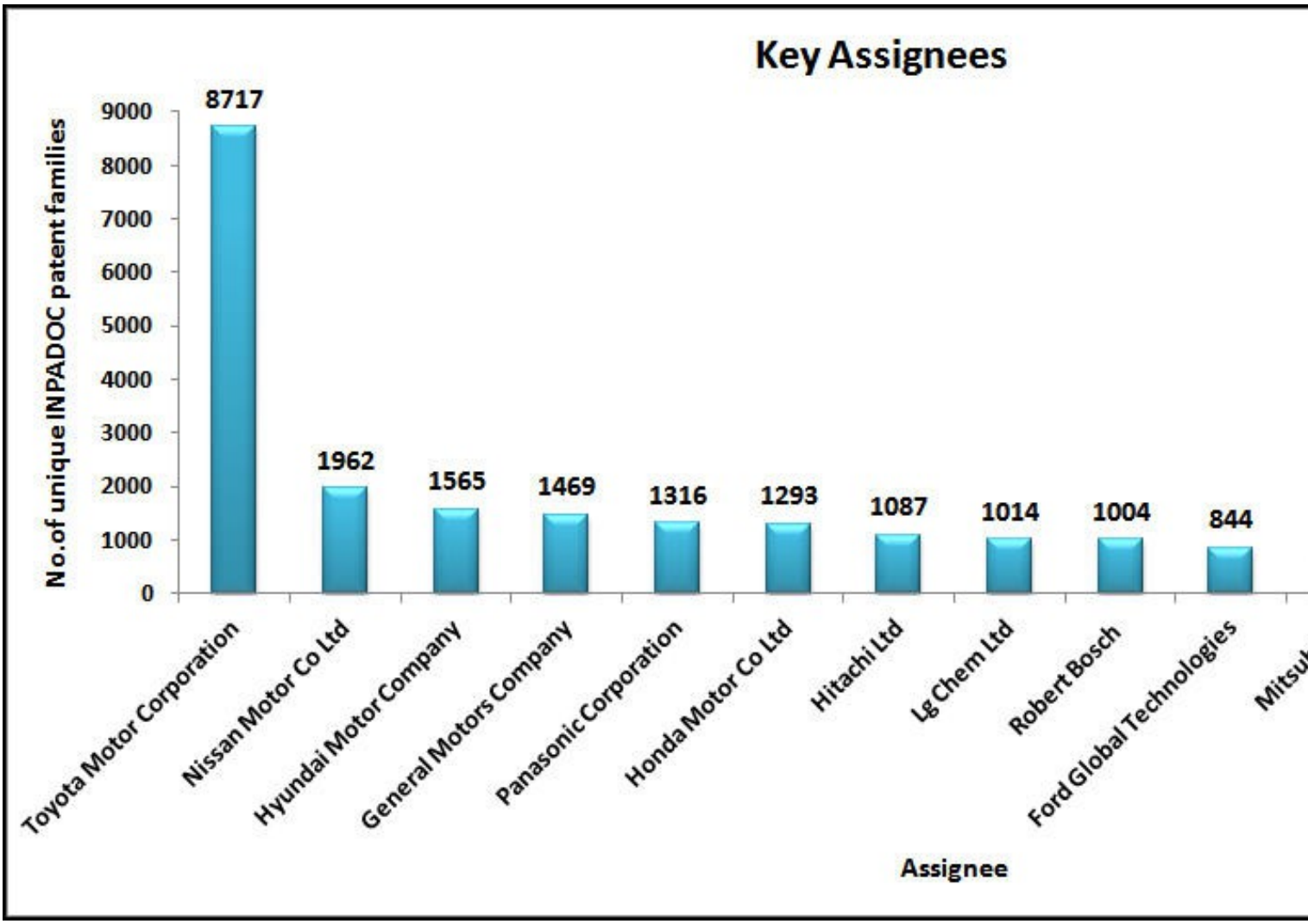
S. No.	Search Concept	Class codes	French Keyword Search	Hits
1	**Direct class codes of hybrid electric vehicles + keywords in full text**	Y10S0903* OR B60K2006542 OR B60K2006541 OR B60K00065* OR B60K20064841 OR B60K20064833 OR B60K20064825 OR B60K20064816 OR B60K20064808 OR B60K00064* OR B60K2006381 OR B60K00063* OR B60K2006268 OR B60K2006266 OR B60K2006264 OR B60K2006262 OR B60K00062* OR 903* OR 1800652* OR 3D202* OR 3D235CC32	**Full Text=** (((hybride NEAR2 ELECTRIQUE) OR ("ELECTRIQUE HYBRIDE") OR ("ELECTRIQUE HYBRIDES")) ADJ3 (AUTOMOBILE OR VEHICULES OR véhicule OR véhicules OR VEHICULE OR (Véhicule NEAR1 automobile) OR Automoteur OR (voiture ADJ motor))) OR (HEV*2 OR PHEV*2) OR (((plug adj2 in) OR plugin) ADJ2 ("véhicule hybride" OR (hybride ADJ2 (AUTOMOBILE OR VEHICULES OR véhicule OR véhicules OR VEHICULE OR (Véhicule NEAR1 automobile) OR Automoteur OR (voiture ADJ motor))))) OR (((hybrid ADJ2 (AUTOMOBILE OR VEHICULES OR véhicule OR véhicules OR VEHICULE OR (Véhicule NEAR1 automobile) OR Automoteur OR (voiture ADJ motor))) OR ("Système d?entraînement hybride" OR "Traction Hybride" OR "Propulsion Hybride" OR "GROUPE MOTOPROPULSEUR HYBRIDE" OR "Entraînement hybride")) AND ((ELECTRIQUE NEAR2 (Machine OR moteur OR (UN ADJ1 MOTEUR) OR (DE ADJ1 TRACTION) OR (entraînement) OR ("chaîne de traction"))) OR "entraînement électrique" OR "chaîne de traction électrique" OR "groupe motopropulseur électrique")) OR ("Pile à combustible HYBRIDE") OR ("Pile à combustible HYBRIDES") OR ("FuelCELL-hybride") OR (hybride ADJ2 rechargeable) OR ("HYBRIDEs ELECTRIQUE VEHICULES") OR ("HYBRIDE ELECTRIQUE véhicules") OR ("HYBRIDE ELECTRIQUE VEHICULES")	8863
2	**Electric propelled vehicles class**	B60W001008 OR B60L0011* OR B60L0008* OR B60K2001* OR B60K0001*	**Claims, Title, Abstract**= ((hybrid ADJ2 (AUTOMOBILE OR VEHICULES OR véhicule OR véhicules OR VEHICULE OR (Véhicule NEAR1 automobile) OR Automoteur OR (voiture ADJ motor))) OR ("Système d?entraînement hybride"	3618

	codes + hybrid vehicles keywords		OR "Traction Hybride" OR "Propulsion Hybride" OR "GROUPE MOTOPROPULSEUR HYBRIDE" OR "Entraînement hybride"))	
3	**Broad class codes of hybrid vehicles + Electric drive keywords**	B62M002302 OR B60W0020* OR Y02T001062*	**Claims, Title, Abstract=** (((ELECTRIQUE OR électrique) NEAR2 (Machine OR moteur OR (UN ADJ1 MOTEUR) OR (DE ADJ1 TRACTION) OR (entraînement) OR ("chaîne de traction"))) OR "entraînement électrique" OR "chaîne de traction électrique" OR "groupe motopropulseur électrique")	9451
4	**Miscellaneous (Controls of hybrid vehicles) class codes + HEV keywords**	B60W001006 OR B60L0011123 OR 3D301BA20 OR 5H601BB20	**Claims, Title, Abstract**=(((hybride NEAR2 ELECTRIQUE) OR ("ELECTRIQUE HYBRIDE") OR ("ELECTRIQUE HYBRIDES")) ADJ3 (AUTOMOBILE OR VEHICULES OR véhicule OR véhicules OR VEHICULE OR (Véhicule NEAR1 automobile) OR Automoteur OR (voiture ADJ motor))) OR (HEV*2 OR PHEV*2) OR (((plug adj2 in) OR plugin) ADJ2 ("véhicule hybride" OR (hybride ADJ2 (AUTOMOBILE OR VEHICULES OR véhicule OR véhicules OR VEHICULE OR (Véhicule NEAR1 automobile) OR Automoteur OR (voiture ADJ motor))))) OR (((hybrid ADJ2 (AUTOMOBILE OR VEHICULES OR véhicule OR véhicules OR VEHICULE OR (Véhicule NEAR1 automobile) OR Automoteur OR (voiture ADJ motor))) OR ("Système d?entraînement hybride" OR "Traction Hybride" OR "Propulsion Hybride" OR "GROUPE MOTOPROPULSEUR HYBRIDE" OR "Entraînement hybride")) AND ((ELECTRIQUE NEAR2 (Machine OR moteur OR (UN ADJ1 MOTEUR) OR (DE ADJ1 TRACTION) OR (entraînement) OR ("chaîne de traction"))) OR "entraînement électrique" OR "chaîne de traction électrique" OR "groupe motopropulseur électrique")) OR ("Pile à combustible HYBRIDE") OR ("Pile à combustible HYBRIDES") OR ("FuelCELL-hybride") OR (hybride ADJ2 rechargeable) OR ("HYBRIDEs ELECTRIQUE VEHICULES") OR ("HYBRIDE ELECTRIQUE véhicules") OR ("HYBRIDE ELECTRIQUE VEHICULES")	2153
5	**Only Hybrid Electric vehicle Keywords**	--	**Claims, Title, Abstract=** (((hybride NEAR2 ELECTRIQUE) OR ("ELECTRIQUE HYBRIDE") OR ("ELECTRIQUE HYBRIDES")) ADJ3 (AUTOMOBILE OR VEHICULES OR véhicule OR véhicules OR VEHICULE OR (Véhicule NEAR1 automobile) OR Automoteur OR (voiture ADJ motor))) OR (HEV*2 OR PHEV*2) OR (((plug adj2 in) OR plugin) ADJ2 ("véhicule hybride" OR (hybride ADJ2 (AUTOMOBILE OR VEHICULES OR véhicule OR véhicules OR VEHICULE OR (Véhicule NEAR1 automobile) OR Automoteur OR (voiture ADJ motor))))) OR (((hybrid ADJ2 (AUTOMOBILE OR VEHICULES OR véhicule OR véhicules OR VEHICULE OR (Véhicule NEAR1 automobile) OR Automoteur OR (voiture ADJ motor))) OR ("Système d?entraînement hybride" OR "Traction Hybride" OR "Propulsion Hybride" OR "GROUPE MOTOPROPULSEUR HYBRIDE" OR "Entraînement hybride")) AND ((ELECTRIQUE NEAR2 (Machine OR moteur OR (UN ADJ1 MOTEUR) OR (DE ADJ1 TRACTION) OR (entraînement) OR ("chaîne de traction"))) OR "entraînement électrique" OR "chaîne de traction électrique" OR "groupe motopropulseur électrique")) OR ("Pile à combustible HYBRIDE") OR ("Pile à combustible HYBRIDES") OR ("FuelCELL-hybride") OR (hybride ADJ2 rechargeable) OR ("HYBRIDEs ELECTRIQUE VEHICULES") OR ("HYBRIDE ELECTRIQUE véhicules") OR ("HYBRIDE ELECTRIQUE VEHICULES")	16858
6	**Combined query**	**1 OR 2 OR 3 OR 4 OR 5**		**32686**
7	**Combined query for last 5 years**	**6 AND (DP>=(20100101) AND DP<=(20141231))**		**18912**

Insights on Complete Search Hits

- Following are the insights obtained from the search results(taking unique INPADOC patent families) when restricted to the last 5 years (2010-2014).

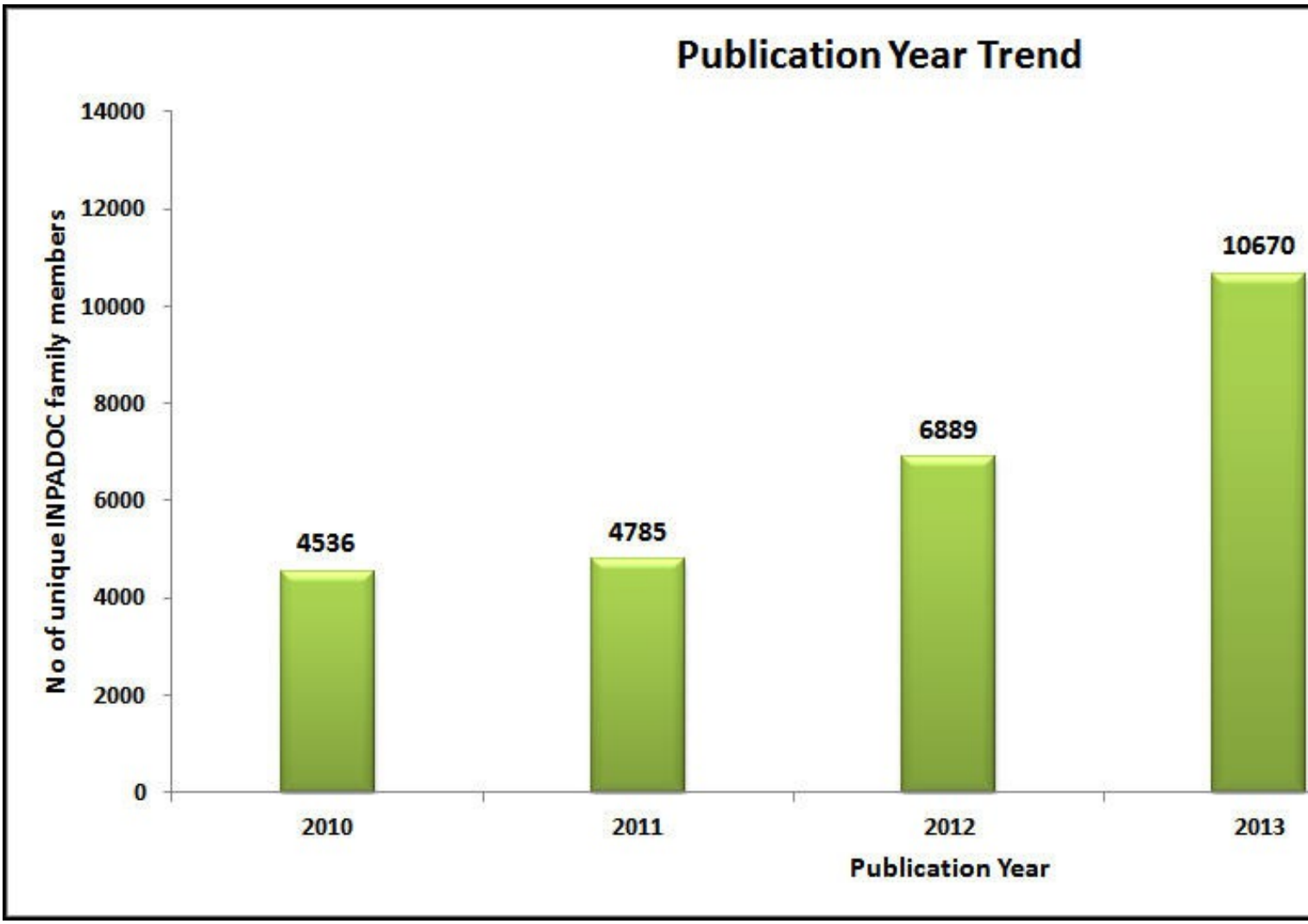
Key Assignees



"Key Assignees in Hybrid Electric Vehicles"

- Toyota Motors has the highest number of published patents - with 8717 unique patent families, followed by Nissan Motors(1962), Hyundai Motors(1565) and General Motors(1469) respectively.
- There is a significant difference in patent publications between Toyota Motors and other assignees.

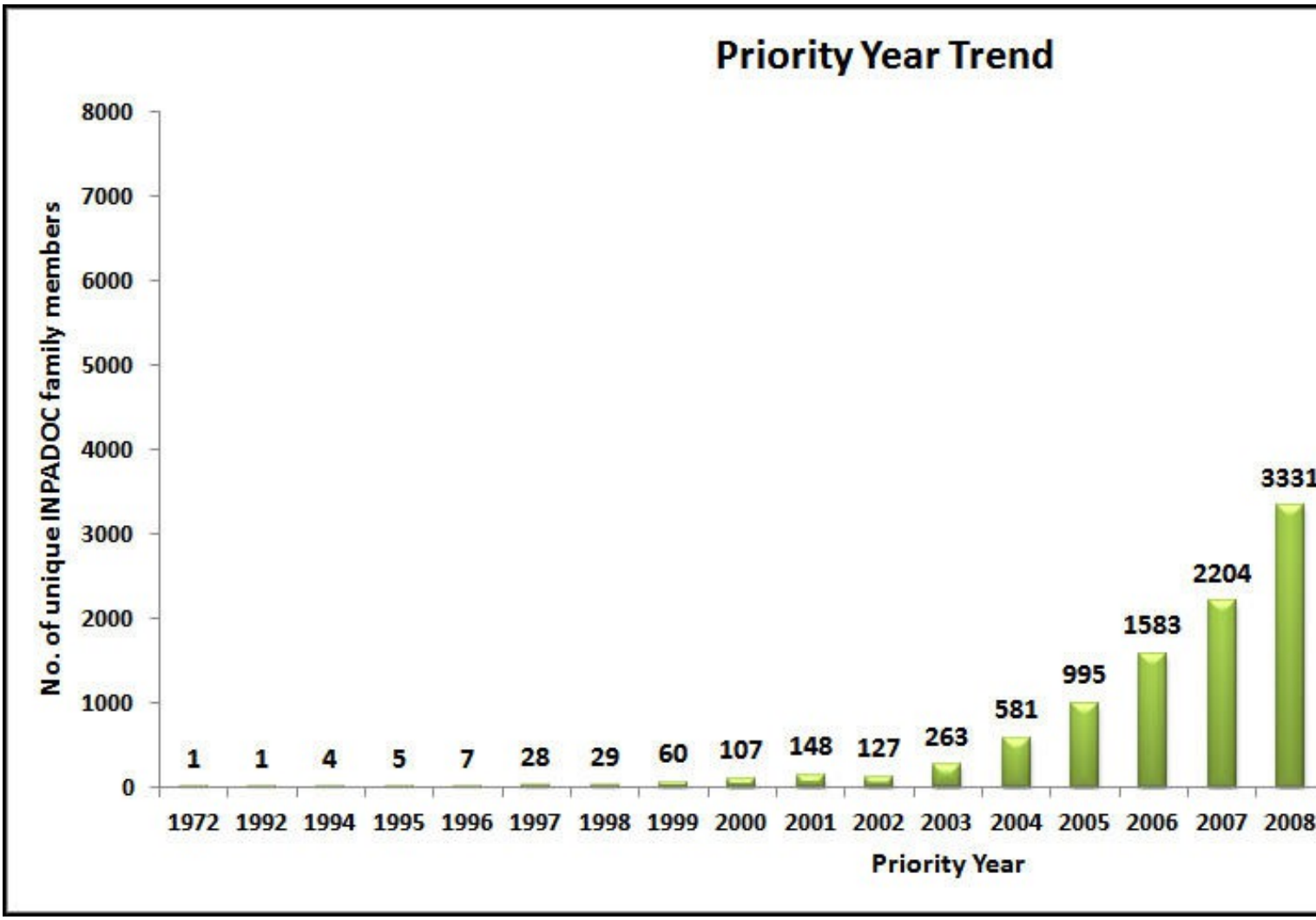
Publication Year Trend



"Overall Publication year trend"

- There has been an increase in patent publication activity over the last 5 years.
- Major increase in patent publication activity is observed in the year 2013.

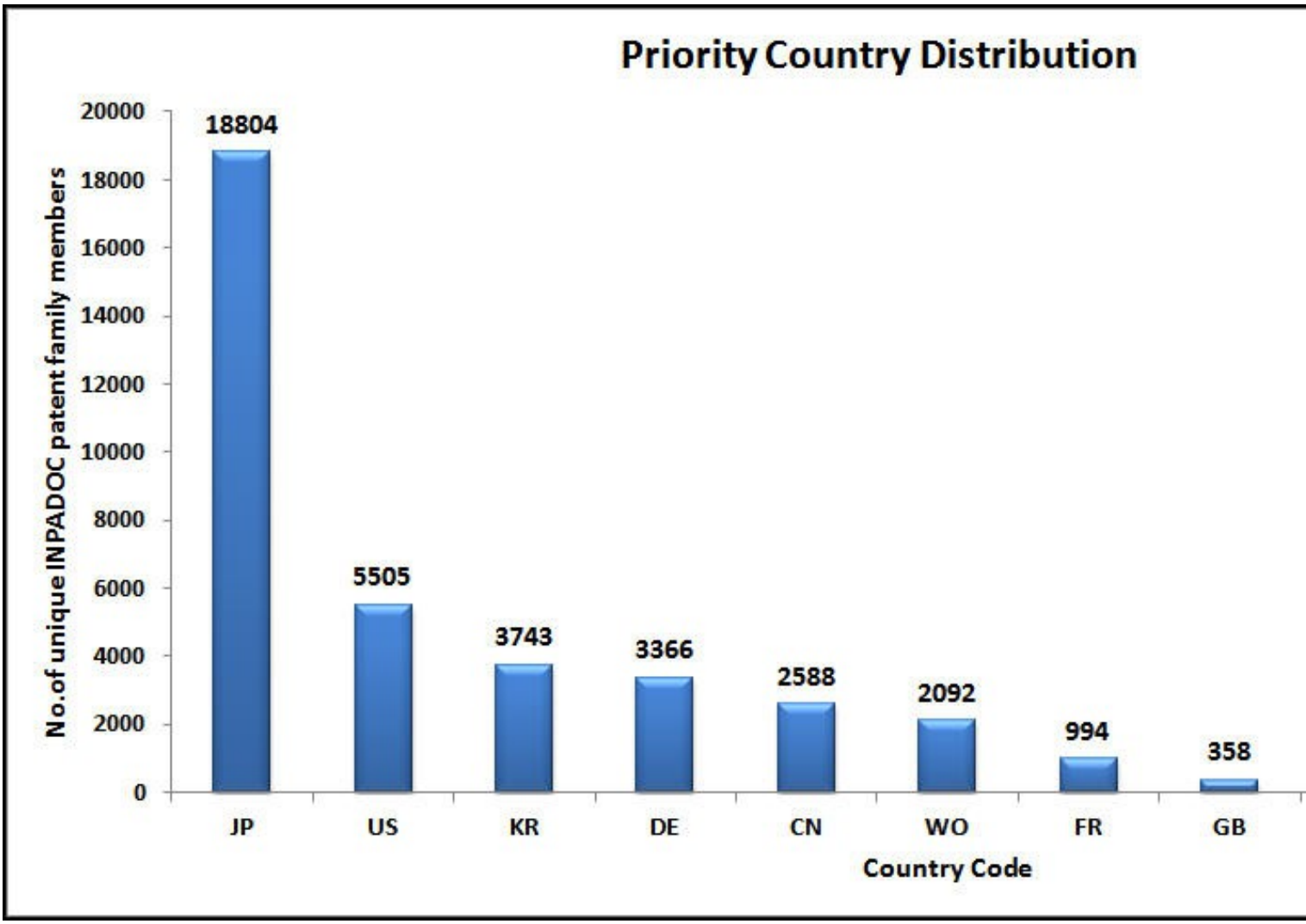
Priority Year Trend



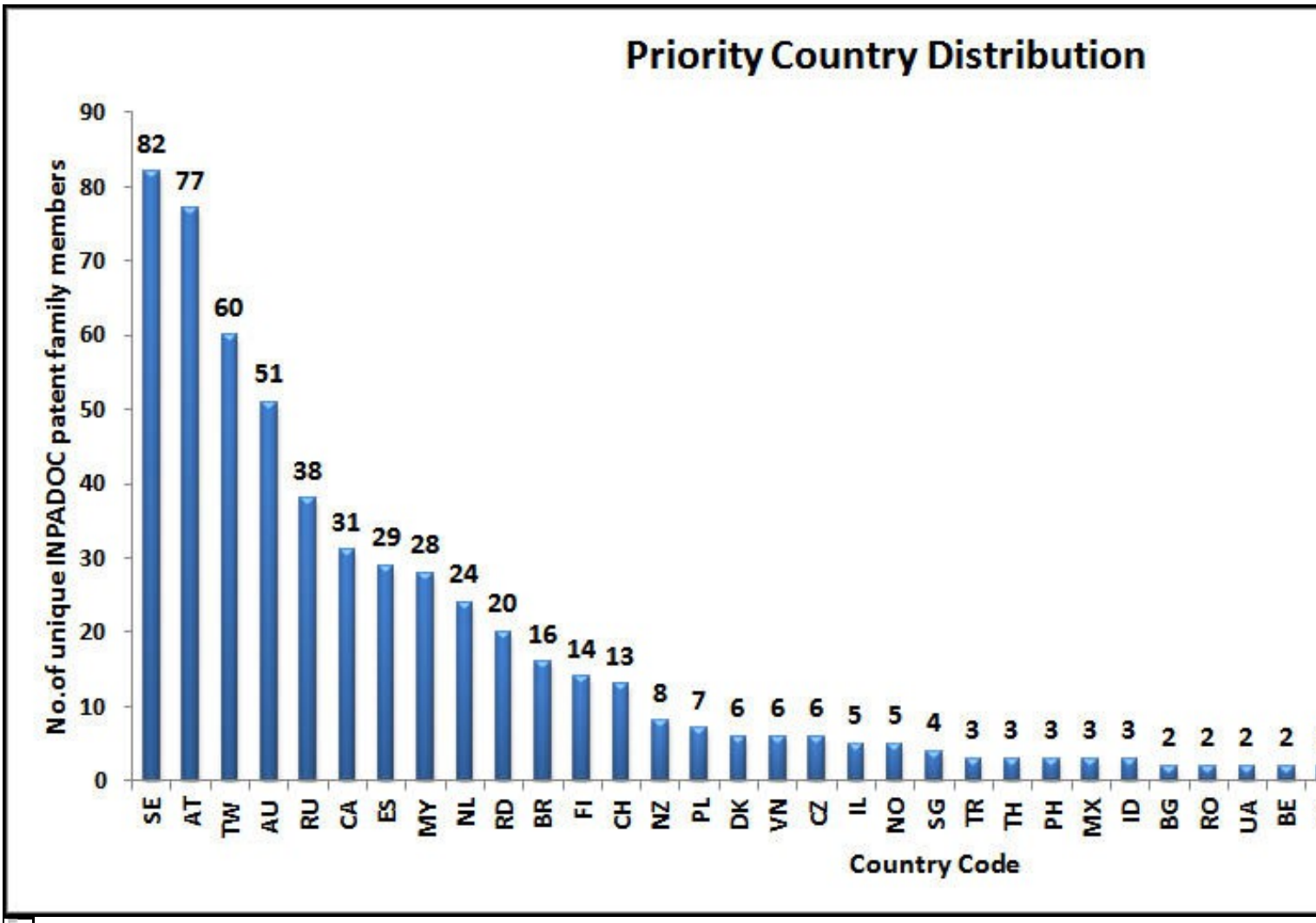
"Overall Priority year trend"

- The priority year wise graph shows an exponential growth in patent filings from 2002 to 2011.

Priority Country



"Priority Country"

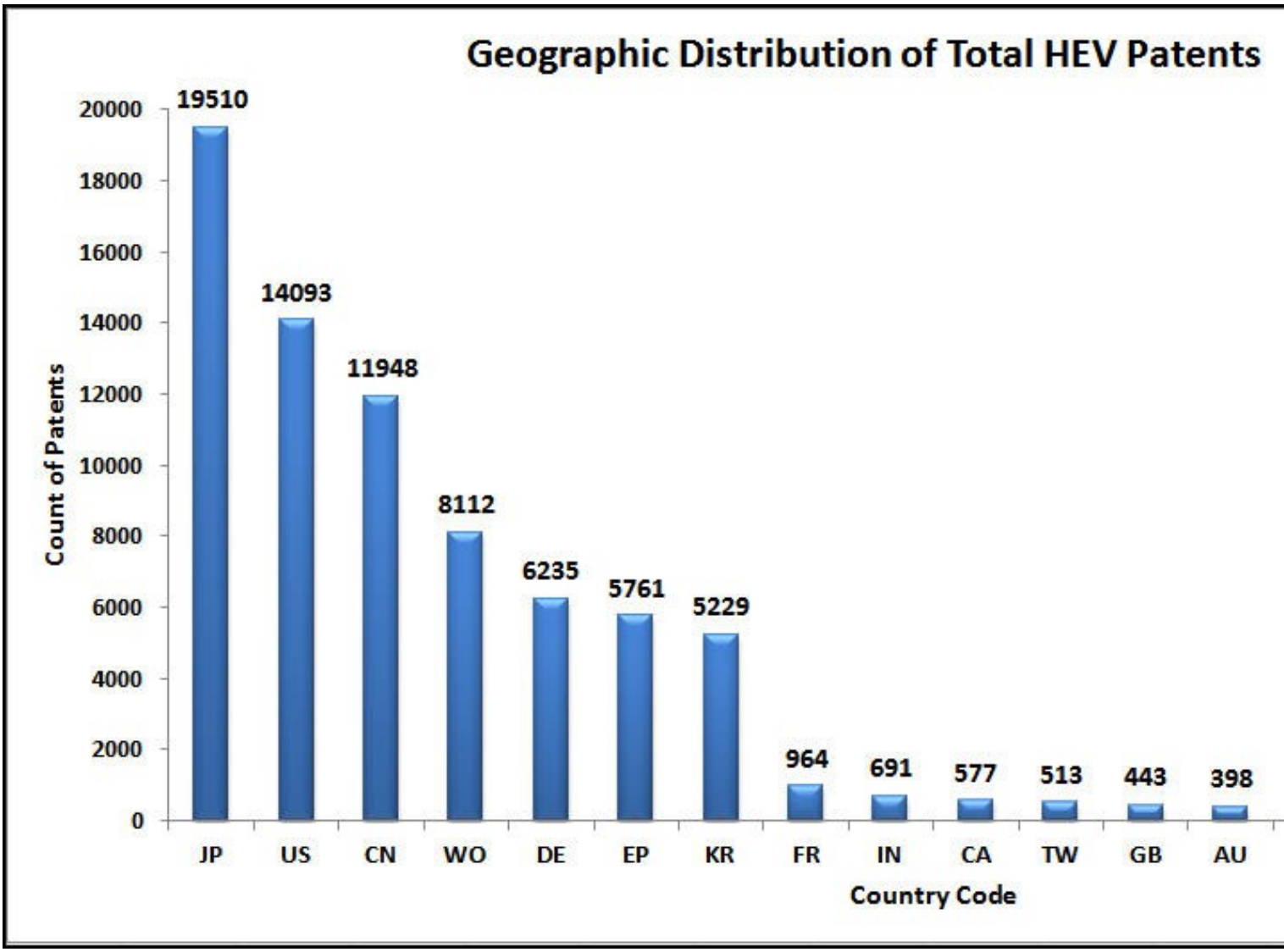


"Priority Country-contd"

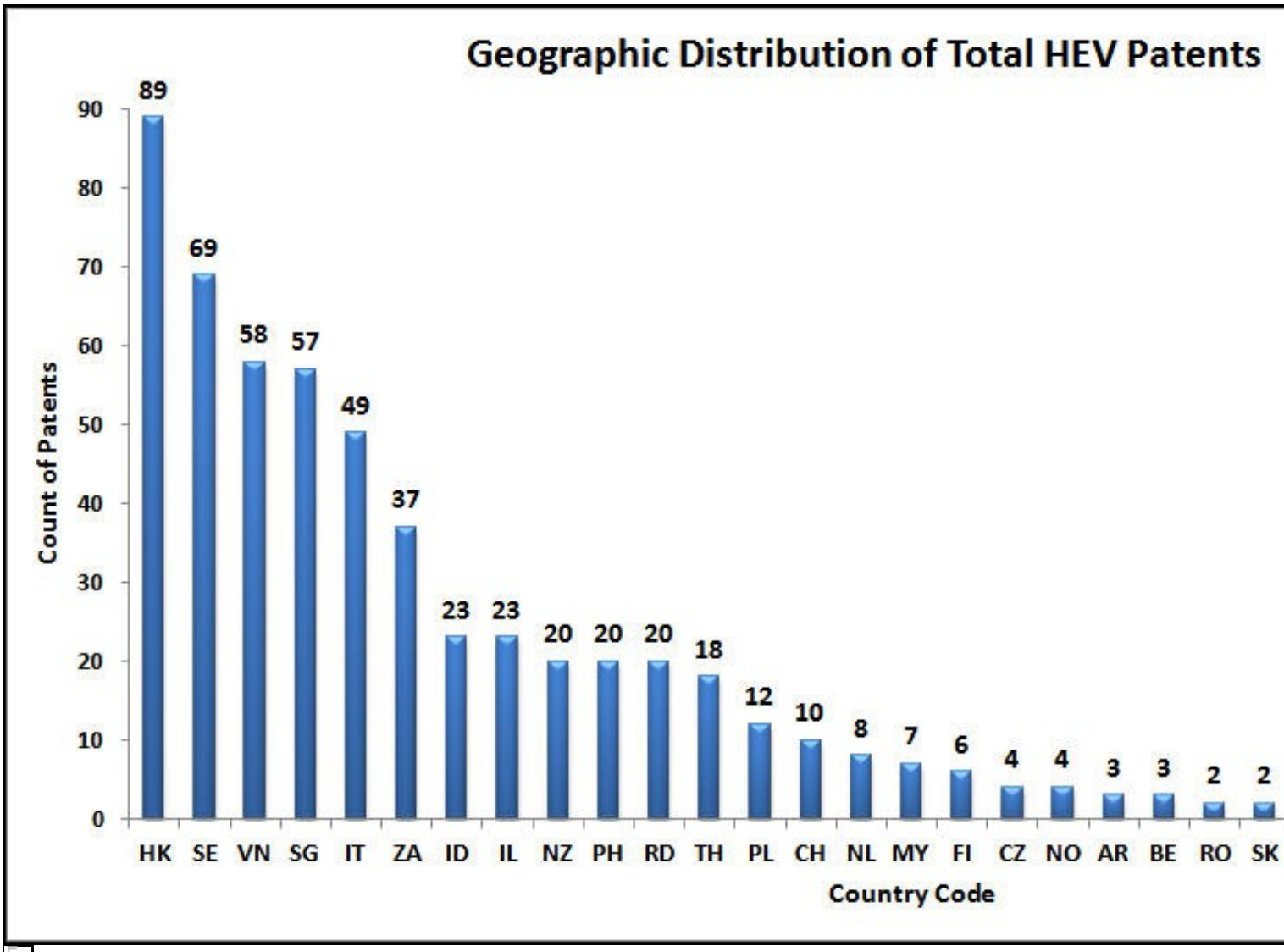
- The priority country with the highest number of first patent filings in the area of hybrid electric vehicles(HEV) is Japan.
- United States(5505), South Korea(3743), Germany(3366) and China(2588) follow Japan, but with a huge difference in first patent filings compared to Japan.

Geographical Distribution

Note: While making the geographic distribution of patents, only the granted patents are considered and their publication is removed, thus eliminating the duplicates.



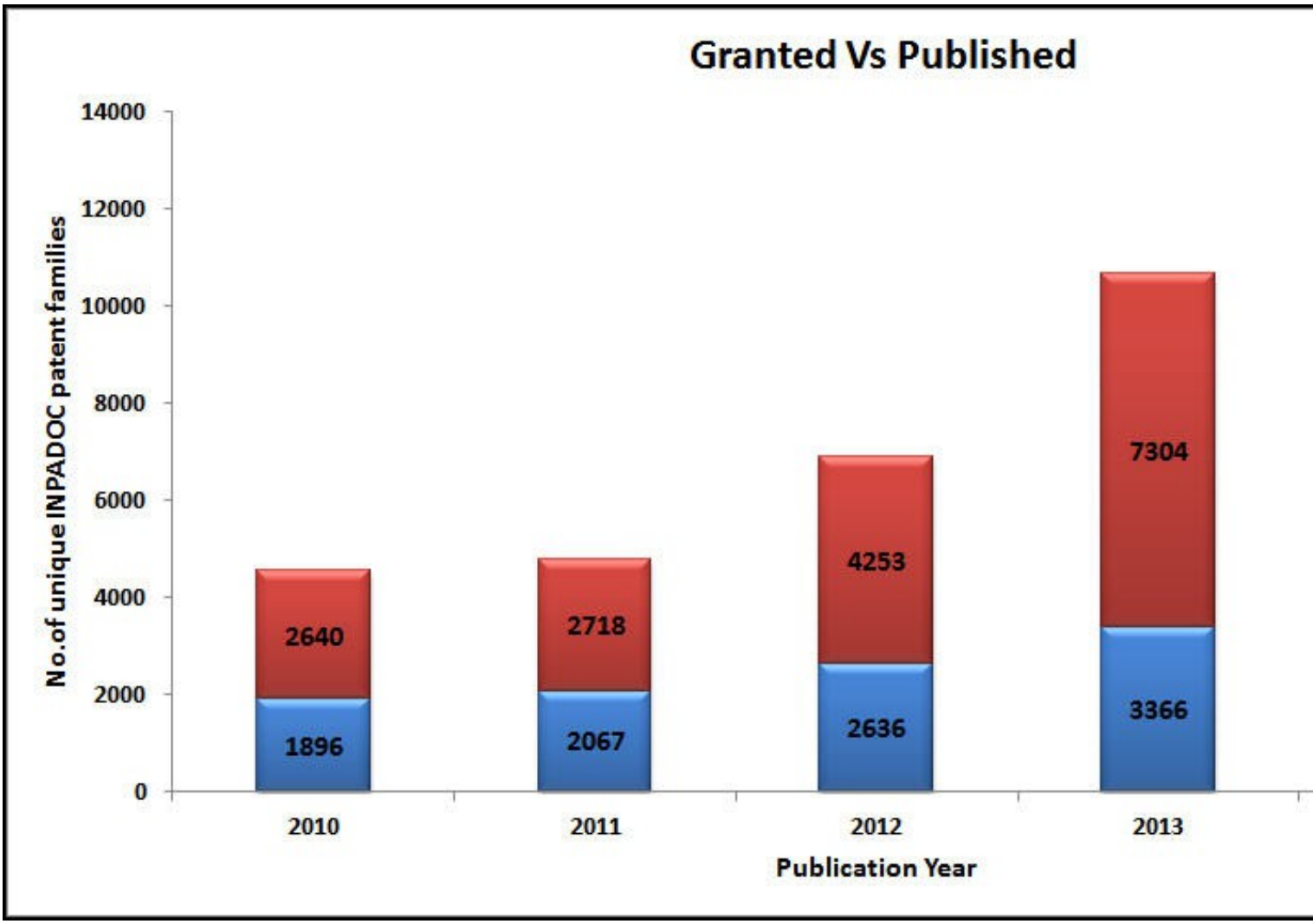
"Geographic Distribution"



"Geographic Distribution-contd"

- Majority of total number of INPADOC families spread in Japan, United States, China, Germany, Korea and WIPO,EP patent organizations.

Patent Status - Publication Year Wise



"Patent status publication year wise"

- The year 2014 has the highest number of published and granted patents.
- The published to granted patents ratio has grown from 1.4 to 2 from 2010 to 2014.

Geographic Distribution - Publication Year Wise

Country/Year	2010	2011	2012	2013	2014	Grand Total
Argentina	1	1	1			3
Austria	14	38	44	14	11	121
Australia	60	57	92	115	74	398
Belgium		1	1	1		3
Brazil	13	32	23	33	35	136
Canada	107	135	133	141	61	577
Switzerland	1	3	3	1	2	10
China	1320	1829	2712	3100	2987	11948
Czech Republic			1	1	2	4
Germany	930	971	1249	1573	1512	6235
Denmark					1	1
Egypt				1		1
Europe	806	923	1141	1415	1476	5761
Spain	21	34	39	40	28	162
Finland		4			2	6
France	126	200	211	232	195	964
Great Britain	51	81	81	99	131	443
Gulf Cooperation Council	1					1
Greece			1			1
Hongkong		11	26	28	24	89
Indonesia	5	1	5	12		23
IL	3		5	12	3	23
India	113	67	119	173	219	691
Italy	16	3	7	10	13	49
Japan	3336	3299	4031	4993	3851	19510
Korea (South)	604	871	820	1480	1454	5229

"Geographic distribution publication year wise"

Country/Year	2010	2011	2012	2013	2014	Grand Total
Latvia					1	1
Mexico	19	28	43	49	40	179
Malaysia		1	5		1	7
Netherlands	1	3	2	1	1	8
Norway		1		1	2	4
New Zealand	1	2	5	5	7	20
Philippines		2	2	5	11	20
Poland		6	3	2	1	12
Portugal		1				1
Research Disclosure	1	3	8	5	3	20
Romania			1		1	2
Russia	48	53	46	88	77	312
Sweden	5	15	16	20	13	69
Singapore	14	7	11	14	11	57
Slovenia		1				1
Slovakia			1	1		2
Thailand	5	6	5		2	18
Taiwan	56	76	120	139	122	513
Ukraine			1	1		2
United States	1961	2536	2981	3359	3256	14093
Vietnam	10	2	7	17	22	58
WIPO	989	1284	1764	2149	1926	8112
South Africa	5	9	6	10	7	37

"Geographic distribution publication year wise"

- In China, Germany, Europe, Great Britain and India an increase in publication activity is observed from 2010 to 2014.
- Major countries like Japan and US have seen a dip in patent publications from 2013 to 2014.
- Countries like Argentina, Belgium, Czech republic, Denmark, Egypt, Greece etc have very few filings.

Insights on Detailed Analysis for a Specific Set of Patent Documents

- A set of 8721 patents out of the total search hits are selected. These patents are selected based on the primary CPC classification that exclusively talk about hybrid electric vehicles(HEVs). The patents are categorized into different technological areas of HEVs.
- The patent analysis is carried out using Dolcera's Proprietary ***automatic categorization tool***.
- The categorization of patents is carried out considering "***Title Abstract Claims***" Only.

Interactive Taxonomy

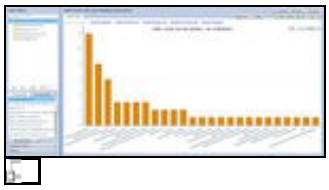
- *Use the mouse(click and drag/scroll up or down/click on nodes) to explore nodes in the detailed taxonomy*
- Click here to see the **Taxonomy node definition spreadsheet**

Taxonomy Node Definitions

Node	Definition
Travel mode control (EV-HEV)	The patents under this node include those which have a control system that switches the travelling mode from Pure Electric (EV) to Hybrid Electric (HEV)
Start-Stop control	The patents in this node talk about control system employed to control the start and stop of vehicle under different conditions.
Speed control	The patents under this node talk about control system provided to control the speed of the vehicle such as cruise control, acceleration control,etc.

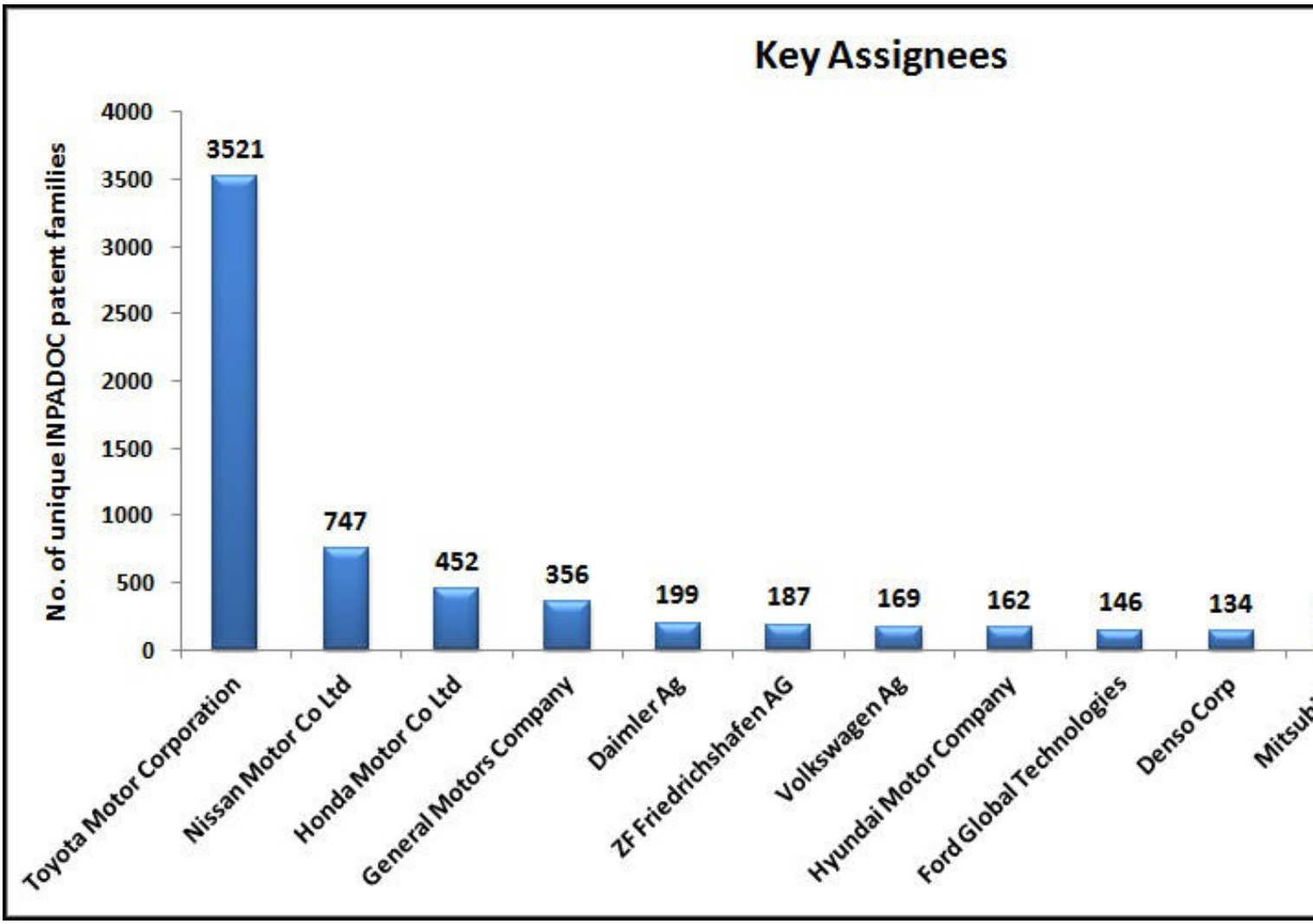
Braking control	The patents in this category talk about control of braking the vehicle and brake fluid supply control.
Regenerative braking control	Patents under this node talk about regenerative braking energy recovery control.
Radiator cooling control	It is about control systems provided to control the temperature of radiator of the vehicle
Power distribution between power sources	Patents under this node talk about control system to switch or distribute the power from one power source to the other ICE and Motor)
Motor control	Motor control related patents include control techniques for motor torque, motor speed, rotor, generator, motor vibration, damping, motor cooling, motor components,etc.
Engine control	Engine control related patents include control techniques for engine speed, valve timing, EGR, exhaust gas refinement, engine torque, fuel injection, engine cooling, combustion control, catalytic converter, engine vibrations reduction, etc .
Transmission control	Transmission control related patents include control techniques for drive train and its components.
Automatic transmission	This node categorizes patents on automatic transmission such as torque converters, hydraulic transmission, CVT, etc.
Mechanical transmission	Mechanical transmission node include patents on transmission that have dual clutches, planetary gear train, sequential, infinitely variable, etc.
Multi Stage transmission	Patents under this node specifically talk about multi step or multi stage type transmission.
Differential gear distribution type	Patents under this node specifically talk about differential gear distribution type transmission.
Charge discharge control	This node include patents with techniques to control charging and discharging of various power sources.
Power output control	This node include patents with techniques to control power supplied from energy storage devices.
Thermal	Patents under this node include thermal management such as heating or cooling of energy storage devices on board.
Electrical	Patents under this node include protective measures employed to ensure safety of electrical energy storage devices from high voltage, high current, etc.
Structural	Structural protection patents include provisions to safeguard electrical energy storage devices during vehicle collision events.
Fuel Cells	Patents under this node include those which have fuel cell as one of the power source.
Capacitors	Patents with capacitor as energy storage device are categorized under this node.
Electrical power converters	Patents talking about electrical power converters such as AC-DC, DC-DC, etc. are categorized under this node.

Dolcera Dashboard for Patent Analysis

Dashboard for patents: Hybrid Electric Vehicles Landscape	

The dashboard contains patents categorized according to the taxonomy provided.

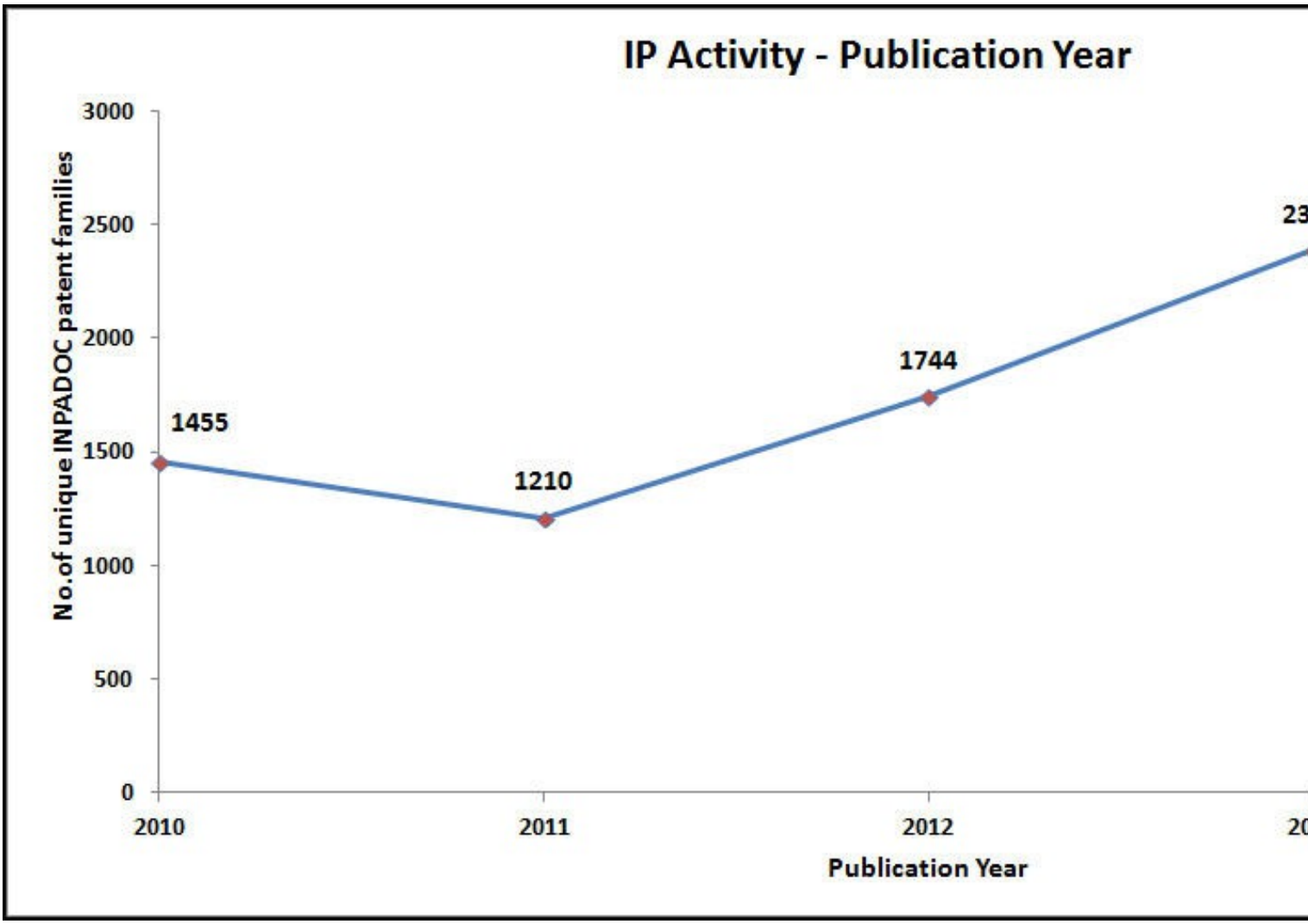
Key Assignees (Selected Set)



"Key Assignees"

- The key assignee trend for the selected set of HEV patents differs slightly from that of the overall HEV patent trend.
- Toyota Motors has the highest number of published patents with 3521 unique patent families, followed by Nissan Motors(747), Honda Motors(452), General Motors(356) and Daimler(199) respectively.
- There is a huge difference in patent publications between Toyota Motors and the other assignees.

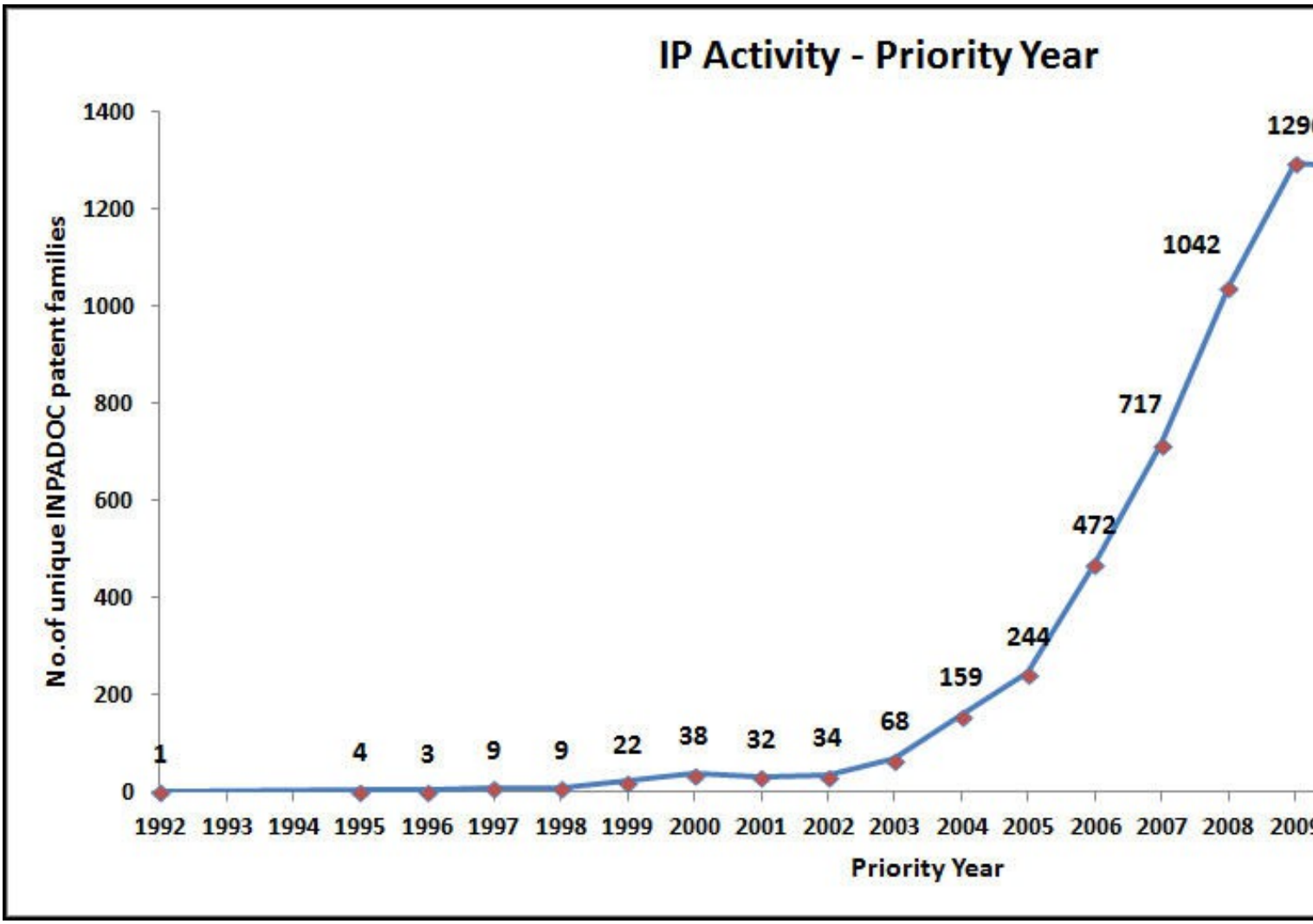
Publication Year Trend (Selected Set)



"Publication year trend - Analyzed"

- In the specific set of patent documents selected for detailed analysis, highest number of patent publications are observed in the year 2013.
- There is a decrease in patent publications observed in the years 2011 and 2014 respectively.

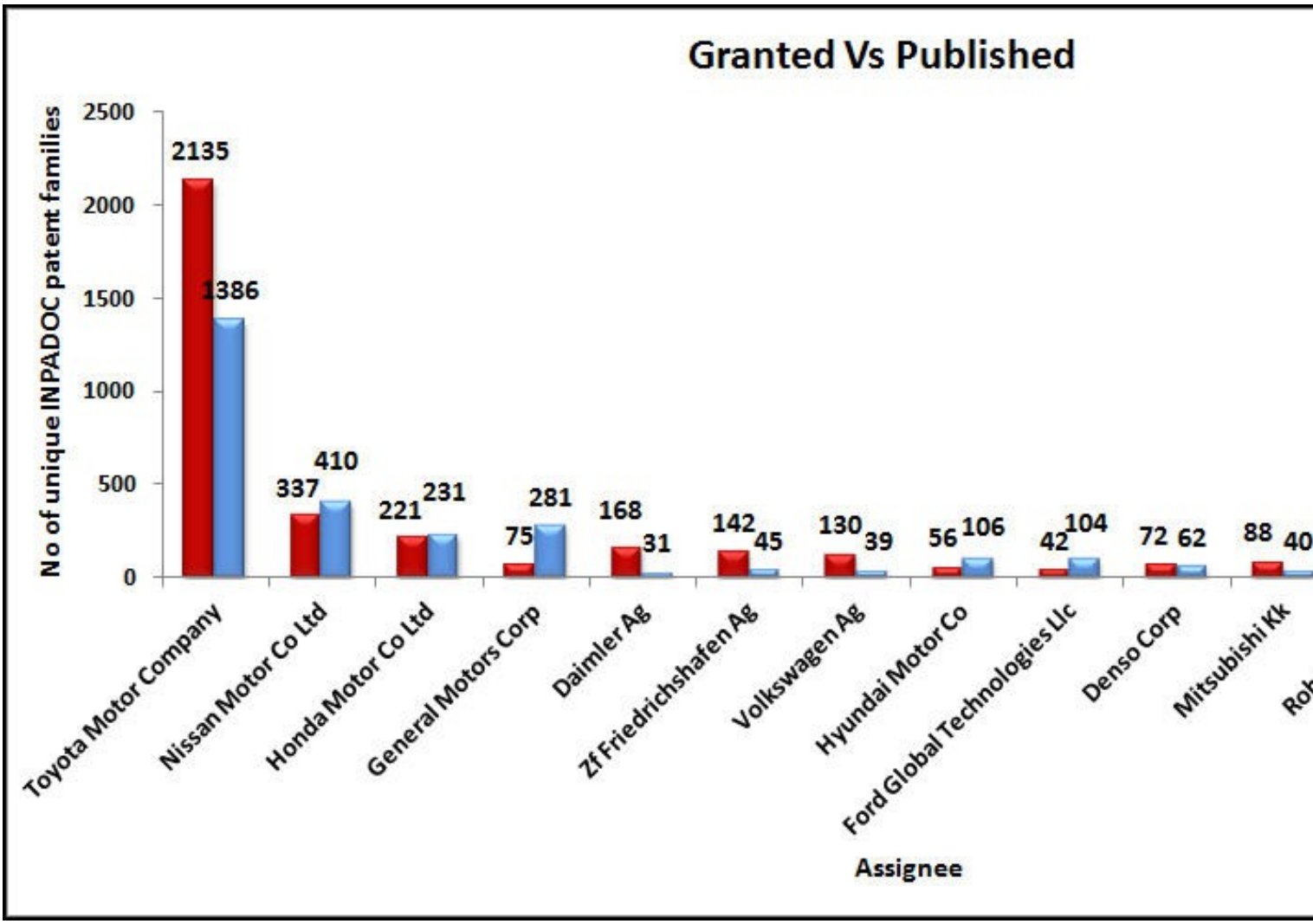
Priority Year Trend (Selected Set)



"Priority year trend - Analyzed"

- For the set of specific patent documents selected for detailed analysis, priority year graph shows increase in filing activity from 2004 to 2009.
- The filing trend was almost constant for a period of 4 years from (2009-2012).

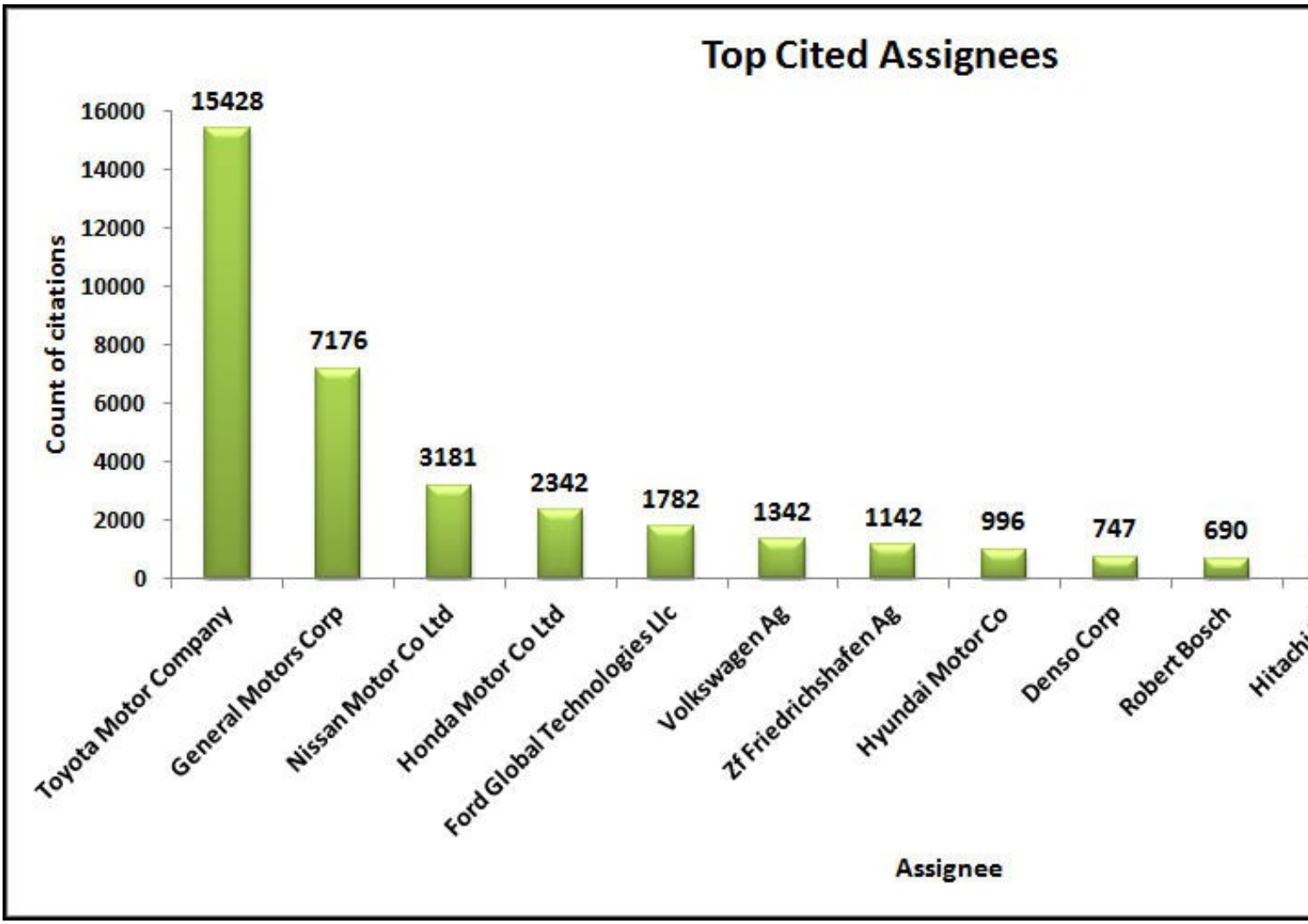
Granted Vs Published Assignee wise (Selected Set)



"Granted Vs Published Assignee wise - Analysed"

- This graph is prepared for the selected set of patent documents considered for detailed analysis.
- The number of granted patents reveals the strength of the patent portfolio of a company.
- Toyota Motors has the highest number of granted(1386) and published(2135) patents.
- Nissan Motors, General Motors, Hyundai Motors, Ford Motors and Mazda Motors have more granted patents than published patents.
- Honda Motors, Denso Corp, Hitachi Ltd, Mazda Corp have almost equal number of granted and published patents.

Top Cited Assignees (Selected Set)



"Top Cited Assignees"

- Toyota Motor Company has the highest number (15428) of patent citation counts. It is followed by General Motors(7176), Nissan Motors(3181), Honda Motors(2342) and Ford Motors(1782) respectively.

Top Cited Patents

- Majority of the top cited patents of this technology are owned by General Motors. (For the selected set only)

S.No	Publication No	Publication Date	Assignee/Applicant	Inventor First	Title	Count of citing patents
1	US7711460B2	2010-05-04	OSHKOSH CORPORATION	Yakes, Christopher K.	Control system and method for electric vehicle	475
2	US8376906B2	2013-02-19	BORGWARNER INC	Koenig, Melissa	Automatic transmission for a hybrid vehicle	272
3	US8448731B2	2013-05-28	GENERAL MOTORS	Heap, Anthony H.	Method and apparatus for determination of fast actuating engine torque for a hybrid powertrain system	236
4	US8092339B2	2012-01-10	GENERAL MOTORS	Heap, Anthony H.	Method and apparatus to prioritize input acceleration and clutch synchronization performance in neutral for a hybrid powertrain system	233
5	US7977896B2	2011-07-12	GENERAL MOTORS	Heap, Anthony H.	Method of determining torque limit with motor torque and battery power constraints	227
6	US8414449B2	2013-04-09	GENERAL MOTORS	Heap, Anthony H.	Method and apparatus to perform asynchronous shifts with oncoming slipping clutch torque for a hybrid powertrain system	216
7	US8285432B2	2012-10-09	GENERAL MOTORS	Heap, Anthony H.	Method and apparatus for developing a control architecture for coordinating shift execution and	214

					engine torque control	
8	US8248023B2	2012-08-21	GENERAL MOTORS	Schwenke, R. Travis	Method of externally charging a powertrain	214
9	US8204664B2	2012-06-19	GENERAL MOTORS	Minarcin, Monika A	Method for controlling regenerative braking in a vehicle	213
10	US8630776B2	2014-01-14	GENERAL MOTORS	Heap, Anthony H.	Method for controlling an engine of a hybrid powertrain in a fuel enrichment mode	213
11	US8504259B2	2013-08-06	GENERAL MOTORS	Heap, Anthony H.	Method for determining inertia effects for a hybrid powertrain system	213
12	US8296027B2	2012-10-23	GENERAL MOTORS	Heap, Anthony H.	Method and apparatus to control off-going clutch torque during torque phase for a hybrid powertrain system	213
13	US8827865B2	2014-09-09	GENERAL MOTORS	Naqvi, Ali K.	Control system for a hybrid powertrain system	212
14	US8897975B2	2014-11-25	GENERAL MOTORS	Heap, Anthony H.	Method for controlling a powertrain system based on penalty costs	211
15	US8847426B2	2014-09-30	GENERAL MOTORS	Heap, Anthony H.	Method for managing electric power in a powertrain system	211
16	US8335623B2	2012-12-18	GENERAL MOTORS	Heap, Anthony H.	Method and apparatus for remediation of and recovery from a clutch slip event in a hybrid powertrain system	211
17	US8489293B2	2013-07-16	GENERAL MOTORS	Heap, Anthony H.	Method and apparatus to control input speed profile during inertia speed phase for a hybrid powertrain system	211
18	US8818660B2	2014-08-26	GENERAL MOTORS	Heap, Anthony H.	Method for managing lash in a driveline	211
19	US8290681B2	2012-10-16	GENERAL MOTORS	Kaminsky, Lawrence A.	Method and apparatus to produce a smooth input speed profile in mode for a hybrid powertrain system	210
20	US8548703B2	2013-10-01	GENERAL MOTORS	Sah, Jy-Jen F.	Method and apparatus to determine clutch slippage in an electro-mechanical transmission	209
21	US8145397B2	2012-03-27	GENERAL MOTORS	Heap, Anthony H.	Optimal selection of blended braking capacity for a hybrid electric vehicle	209

Key Assignee Vs Countries

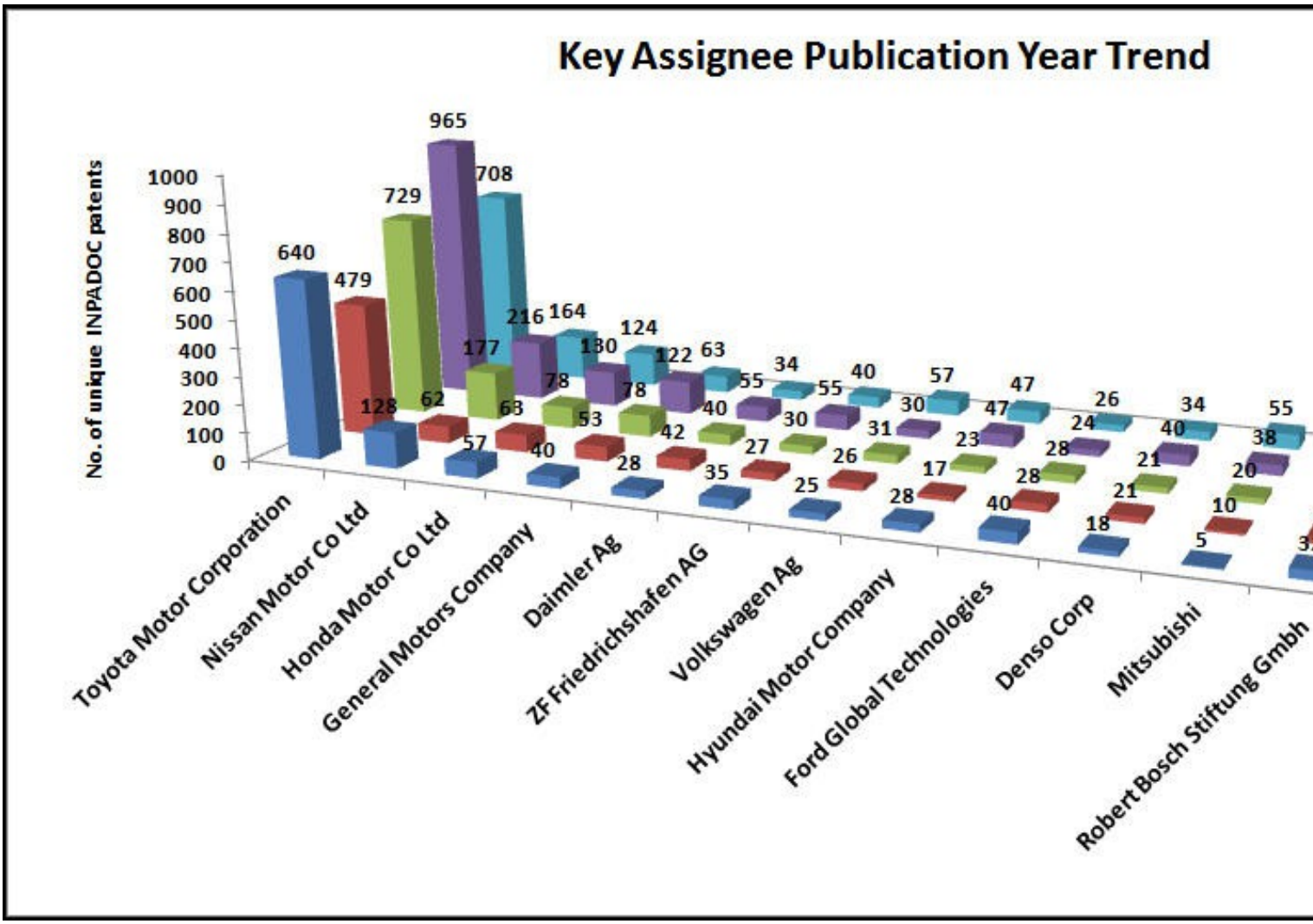
- This table has been prepared considering the total number of INPADOC patent families. Also only the granted patents are considered and its publication is removed, thus eliminating the duplicates.

Country / Assignee/Applicant	Austria	Australia	Brazil	Canada	China	Germany	Europe	Spain	France
Toyota Motor Corporation	14	15	22	22	521	302	321	14	7
Nissan Motor Co. Ltd.	3				67	25	75		
Honda Motor Co., Ltd.	6	3	4	20	79	43	53	11	
General Motors Company		1	2		271	218	56		
Daimler Ag	1				9	80	8		
ZF Friedrichshafen AG	10				35	177	51		
Volkswagen Ag	3		1		29	142	24		6
Hyundai Motor Company					50	40			
Ford Global Technologies		2	1	2	98	81	12		
Denso Corp.					9	14	4		1
Mitsubishi		2			13	7	14		2
Robert Bosch Stiftung Gmbh	7		1		28	102	52		2
Hitachi Ltd.	1	3			22	9	28		
Mazda Motor Corporation					4	4	7		

"Key Assignee Vs Countries"

- The above distribution is done only for the specific set of patent documents taken for detailed analysis.
- Toyota Motors has the highest number(3380) of patent publications in Japan. It has given almost equal importance to publishing patents in China(521) and United States(647).
- Nissan Motors has the highest number of patent publications(683) in Japan. It has almost equal number of patent publications in China(67), Europe(75) and United States(80).
- Honda Motors has also has the highest number of patent publications(426) in Japan.It has 108 patent publications in the United States.
- General Motors has the most number of publications in the United States(309). Also it has almost equal numbers published in China(271) and Germany(218).
- Honda Motors has patents in Argentina, Switzerland, Italy, Norway, Thailand, Taiwan and Vietnam. Volkswagen and Bosch has patents in Italy. Toyota and Bosch have patents in Poland. However, they are not shown in the table as the numbers are few.

Key Assignee Vs Publication Year



"Key Assignee Vs Publication Year"

- Toyota Motors has the highest number of patent publications with 965 unique patent families in the year 2013.
- Nissan Motors(216), Honda Motors(130), General Motors(122) have the highest number of publications in the year 2013.
- Hyundai Motors(47), Ford Motors(26), Mitsubishi(55) and Volkswagen(57) have the highest number of publications in the year 2014.

Key Assignee Vs Type of Hybrid

Type of hybrid / Assignee/Applicant	SERIES	PARALLEL	SERIES-PARALLEL(POWER SPLIT)
Toyota Motor Corporation	24	84	198
Nissan Motor Co. Ltd.	9	12	15
Honda Motor Co., Ltd.	2	19	23
General Motors Company	17	12	22
Daimler Ag	8	18	8
ZF Friedrichshafen AG		31	3
Volkswagen Ag	8	20	4
Hyundai Motor Company	2	6	7
Ford Global Technologies	2	9	20
Denso Corp.	4	4	2
Mitsubishi	9	6	4
Robert Bosch Stiftung Gmbh	7	24	5
Hitachi Ltd.	7	1	6
Mazda Motor Corporation	4	6	1

"Key Assignee Vs Type of hybrid"

- A total of 1326 patents are categorized under this type of hybrid node.
- Toyota Motors has highest number of patents on power split type hybrid electric vehicles with 198 unique patent families, followed by parallel hybrid(84), Plug-in(55) and series type hybrid electric vehicles(24).
- Nissan Motors(15), Honda Motors(23), General motors(22) have also highest number of published patents on power split type hybrids.
- Daimler(18) and ZF friedrischshafen(31) have highest number of published patents on parallel type hybrid electrics.

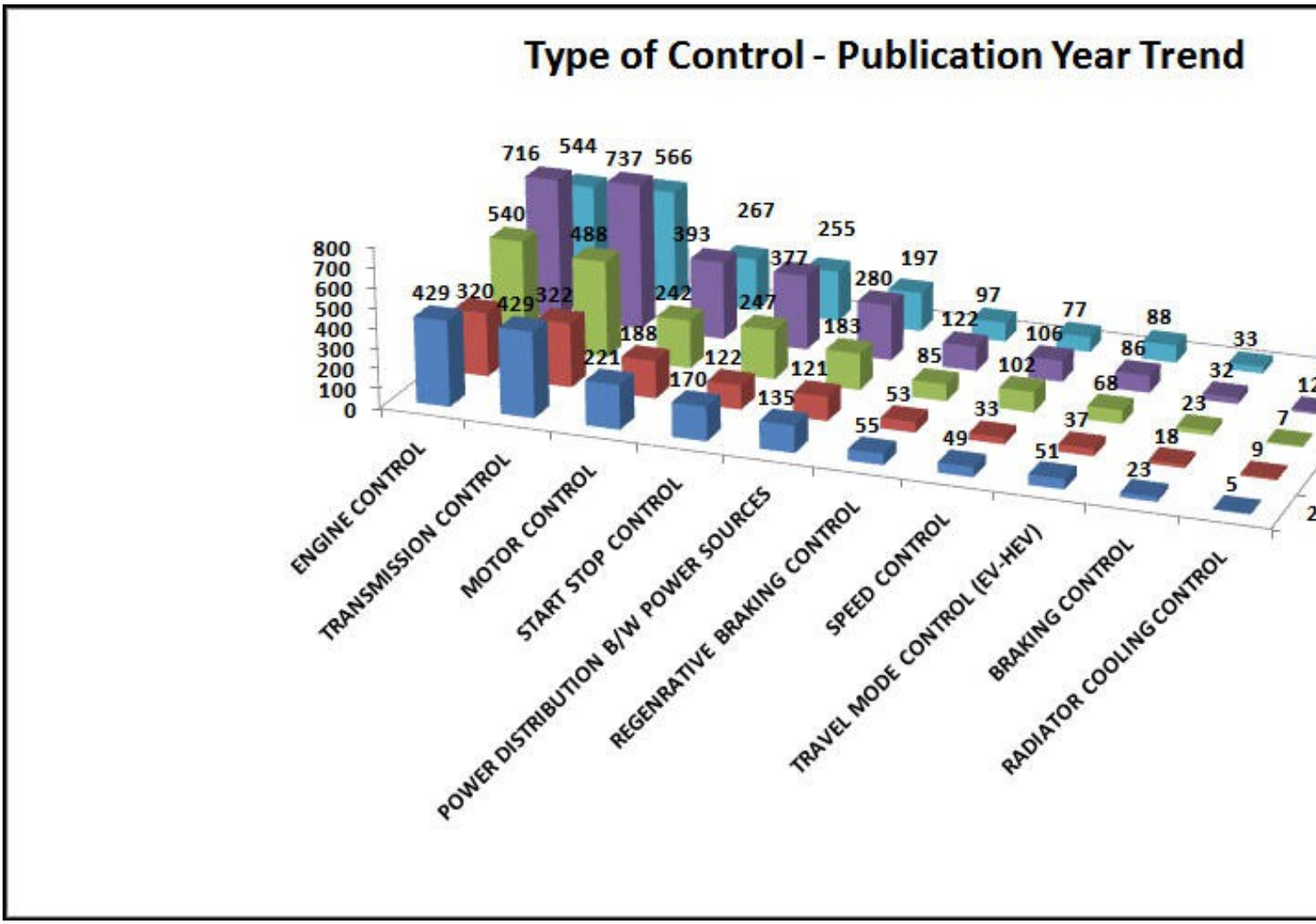
Key Assignee Vs Type of control

Type of control / Assignee/Applicant	TRAVEL MODE CONTROL (EV-HEV)	START STOP CONTROL	SPEED CONTROL	BRAKING CONTROL	REGENRATIVE BRAKING CONTROL	RADIATOR COOLING CONTROL	DI
Toyota Motor Corporation	76	623	167	50	148	20	
Nissan Motor Co. Ltd.	72	200	73	20	56		
Honda Motor Co., Ltd.	7	71	15	6	23		
General Motors Company	15	9	4	1	12		
Daimler Ag	6	41	12	5	26		
ZF Friedrichshafen AG		3	1			1	
Volkswagen Ag	1	1	3	1	1		
Hyundai Motor Company	24	11	4	2	4		
Ford Global Technologies	3	8	4	5	3		
Denso Corp.	3	19	7		5	4	
Mitsubishi	4	20	7	2	10	1	
Robert Bosch Stiftung Gmbh	7	3	1	1			
Hitachi Ltd.	5	13	6	1	5		
Mazda Motor Corporation		19	5	1	5	1	

"Key Assignee Vs Type of control"

- A total of 5942 patents are categorized under the "Type of control" node.
- Toyota Motors has the highest number of patents published on engine control with 1142 unique families, followed by transmission control(979), start-stop control(623) and motor control(502).
- Nissan Motors has the highest number(333) of patents published on transmission control techniques, followed by engine control(269), start-stop control(200) and motor control(175).
- Honda Motors has more patents on engine control with 124 unique families whereas General Motors has more patents on transmission control with 124 unique families.
- Other assignees have mainly concentrated on engine and transmission control techniques.
- Apart from Toyota; Nissan, Honda and Daimler have considerable number of patents on regenerative braking control.
- Toyota, Nissan, Honda and Daimler have a strong patent set on vehicle start stop control as well.
- Only Toyota and Nissan have done considerable work on travel mode control (Switching from EV to HEV).

Type of control Vs Publication Year



"Type of Control Vs Publication Year"

- Highest no of patent publications related to engine control techniques is observed in the year 2013 with 716 unique families.
- Transmission control(737), Motor Control(393), Start-Stop Control(377) have highest number of patents published in the year 2013.
- All control types have highest number of patent publications in the year 2013.
- Travel mode control and braking control have increasing in publication activity over the years 2010-2014.
- Regenerative braking also has an increasing trend with a slight dip at the end.

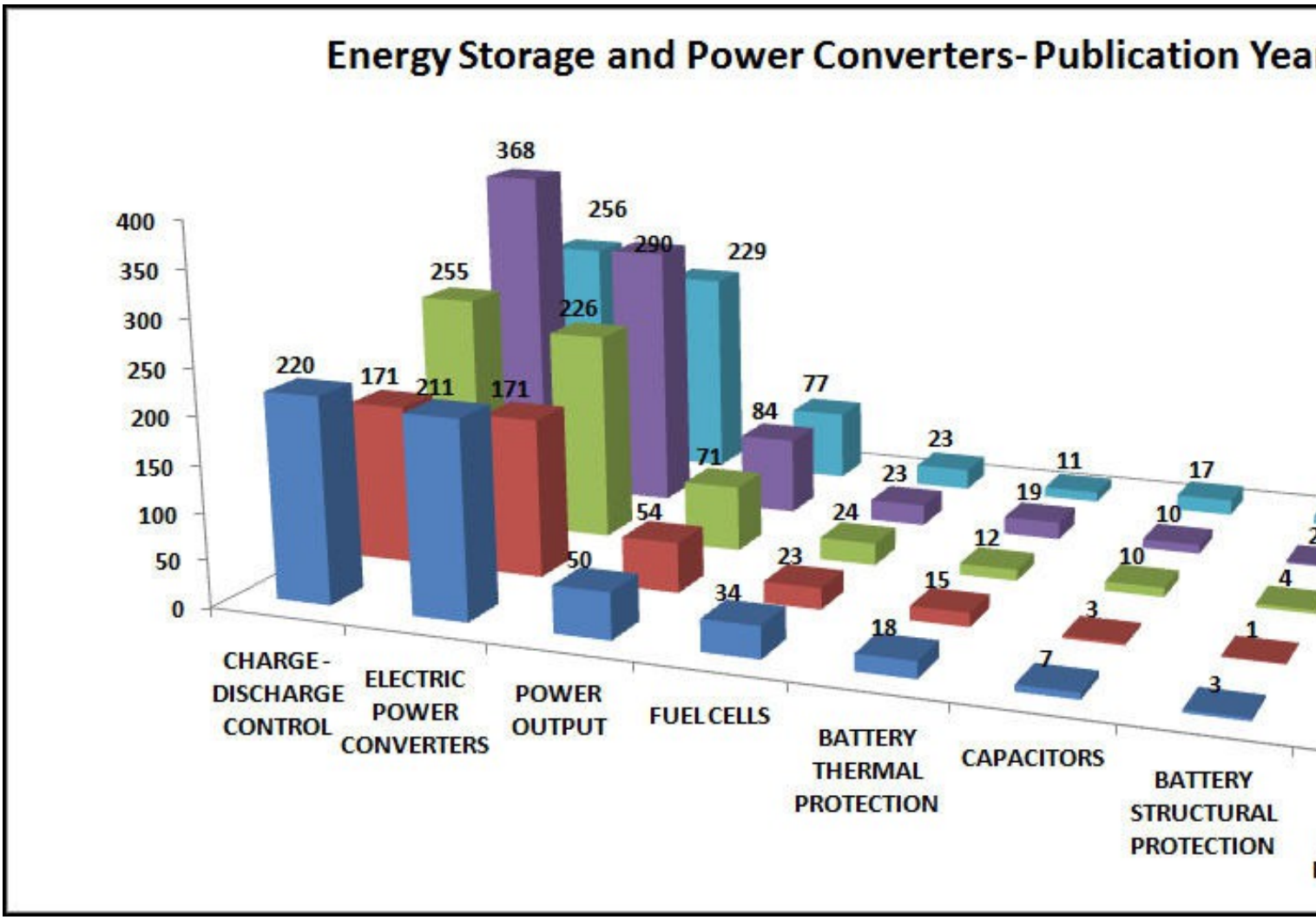
Key Assignee Vs Energy Storage and Electric Power Converters

Assignee/Applicant \ Energy storage	CHARGE - DISCHARGE CONTROL	POWER OUTPUT	BATTERY THERMAL PROTECTION	BATTERY ELECTRICAL PROTECTION	BATTERY STRUCTURAL PROTECTION
Toyota Motor Corporation	462	103	32	10	3
Nissan Motor Co. Ltd.	104	26	3	2	
Honda Motor Co., Ltd.	41	11	2		1
General Motors Company	38	6	1	1	
Daimler Ag	38	12		1	2
ZF Friedrichshafen AG	1	1			
Volkswagen Ag	11	4		1	
Hyundai Motor Company	18	3	4		2
Ford Global Technologies	37	7			
Denso Corp.	37	5	2		
Mitsubishi	38	3	5		
Robert Bosch Stiftung Gmbh	5	4			
Hitachi Ltd.	17	3			
Mazda Motor Corporation	29	2	5		

"Key Assignee Vs Energy storage and electrical power converters"

- A total of 2833 patents are categorized under both energy storage(1706) and power converter(1127) nodes combined.
- Toyota Motors has the highest number of patents on electrical power converters with 517 unique families, charge discharge control(462) and power output control(103).
- Nissan Motors(104), Honda Motors(41), General Motors(38), Daimler(38) have the highest number of patents on charge discharge control of electrical energy storage device.
- Toyota Motors has a lot of patents related to thermal(32), electrical(10), structural(3) protection of electrical energy storage devices.
- Except Toyota, General Motors, Volkswagen and Daimler, all the other assignees have no patent activity related to electric protection of energy storage device.

Energy Storage Vs Publication Year



"Power Management Vs Publication Year"

- Charge discharge control(368), Electrical Power Converters(290), Power Output(84) have the highest number of patent publications in the year 2013.
- Fuel cells has an almost constant filing trend from 2011 -2014.

Key Assignee Vs Type of transmission

Type of transmission / Assignee/Applicant	AUTOMATIC TYPE TRANSMISSION	MECHANICAL TYPE TRANSMISSION	MULTI STAGE TRANSMISSION
Toyota Motor Corporation	297	1033	156
Nissan Motor Co. Ltd.	126	263	42
Honda Motor Co., Ltd.	32	200	54
General Motors Company	41	187	78
Daimler Ag	9	62	19
ZF Friedrichshafen AG	18	109	30
Volkswagen Ag	6	63	13
Hyundai Motor Company	16	69	34
Ford Global Technologies	14	62	16
Denso Corp.	1	21	1
Mitsubishi	1	30	4
Robert Bosch Stiftung Gmbh	6	26	9
Hitachi Ltd.	3	16	5
Mazda Motor Corporation	13	20	

"Key Assignee Vs Type of hybrid"

- A total of 3312 patents are categorized under this node.
- Toyota Motors has highest number of patents published on mechanical type transmission with 1033 unique patent families, followed by automatic type transmission(297) and multistage transmission(156).
- Nissan Motors(263), Honda Motors(200), General Motors(187) also show a lot of patent activity in mechanical type transmission.
- Besides Toyota and Nissan; Honda, General Motors and Hyundai also have considerable number of patents on multi-stage transmission.
- Only Toyota has strong patent activity in Differential gear distribution type.

Alliance Mapping of Key Assignees

Toyota

Partner	No of patents shared	Brief of the company
Denso Corp	54	Denso Corporation is a global automotive components manufacturer headquartered in the city of Kariya, Aichi Prefecture, Japan
Nippon Soken Inc	19	Nippon Soken Inc is a joint research institution of Denso Corporation and Toyota Motors. Soken engages research projects mainly in the fields of power trains, fuel cells, power electronics, information safety and thermal systems.
Fujitsu TEN LTD	14	Fujitsu Ten Ltd. is a Japanese company developing and manufacturing car audio, video, navigation and control systems. The headquarters is located in Kobe, Hy?go Prefecture, Japan.
Nippon Jidosha Buhin Sogo	8	Nippon Jidosha Buhin Sogo is a Japanese company designing and manufacturing power trains, engines, universal joints. The head office and factory are located in Ebina-shi (Kanagawa) and Moka-shi (Tochigi) Japan
Advics Co Ltd	6	ADVICS is a world class brake system supplier which provides advanced high quality brake systems and components to the global market. It offers ABS modulators, ESC modulators, integrated hydraulic

		boosters, brake boosters and master cylinders, load sensing proportioning valves, disc brakes, drum brakes, electric park brakes, foot release parking brake pedals, and brake components for motorcycles; and aftermarket products, such as brake pads. It has Headquarters in Japan.
Kyokuto Kaihatsu Kogyo Co Ltd	3	Kyokuto kaihatsu kogyo Corporation is a comprehensive manufacturer of special purpose trucks. It is headquartered in Nishinomiya, Japan.
Panasonic Inc	2	Panasonic Corporation is a Japanese multinational electronics corporation headquartered in Kadoma,Osaka, Japan.
NSK-Warner K.K	2	NSK-Warner KK develops and manufactures automotive parts. The Company provides one-way clutches, friction products, and clutch assembly products for automobiles and industrial machinery
Fuji Heavy Industries Ltd	1	Fuji Heavy Industries, Ltd., or FHI, is a Japanese multinational corporation and conglomerate primarily involved in aerospace and ground transportation manufacturing, known for its line of Subaru automobiles
University of Kyushu	1	Kyushu University, abbreviated to Kyudai, is a Japanese public university located in Fukuoka, Kyushu.
Kyushu Institute of Technology	1	KYUSHU INSTITUTE OF TECHNOLOGY is a public research institute situated in Kyushu city Japan
Tokai Rika Co Ltd	1	Tokai Rika Co., Ltd. manufactures and sells human machine interface systems, security systems, safety systems, electronics, and other products primarily in Japan and other Asian countries, North America, and Europe.
NOK Corp	1	NOK CORPORATION engages in manufacturing, importing, and selling seal products, industrial mechanical parts, hydraulic and pneumatic equipment, nuclear power equipment, synthetic chemicals, and electronic and other products. The company is headquartered in Tokyo, Japan.
Mitsubishi Motor Corp	1	Mitsubishi Motors Corporation is a multinational automotive manufacturer headquartered in Minato, Tokyo, Japan.
Yazaki Corporation	1	Yazaki is a global automotive parts supplier with a focus on wire harnesses and to a lesser degree instruments and components such as connectors and terminals. The company?s origin and headquarters are in Japan.
Sumitomo Wiring Systems Ltd	1	Sumitomo wiring system ltd product line includes manufacture and sales of wiring harnesses, harness components and other electric wires. It is headquartered in Japan.
Daihatsu Motor Co Ltd	1	Daihatsu Motor Co Ltd is the oldest Japanese car manufacturer, mostly known for its range of smaller models and off-road vehicles. The headquarters are located in Ikeda, Osaka Prefecture.
Toshiba	1	Toshiba is a Japanese multinational conglomerate corporation headquartered in Tokyo, Japan. Its diversified products and services include information technology and communications equipment and systems, electronic components and materials, power systems, industrial and social infrastructure systems, consumer electronics, household appliances, medical equipment, office equipment, lighting and logistics..

Nissan Motors

Partner	No of patents shared	Brief of the company
Renault S.A	6	Renault S.A. is a French multinational vehicle manufacturer established in 1899. The company produces a range of cars and vans, and in the past has manufactured trucks, tractors, tanks, buses/coaches and autorail vehicles.
Hitachi Ltd	4	Hitachi, Ltd. is a Japanese multinational conglomerate company headquartered in Chiyoda, Tokyo, Japan. Hitachi is a highly diversified company that operates eleven business segments: Information & Telecommunication Systems, Social Infrastructure, High Functional Materials & Components, Financial Services, Power Systems, Electronic Systems & Equipment, Automotive Systems, Railway & Urban Systems, Digital Media & Consumer Products, Construction Machinery and Other Components & Systems
NOK CORPORATION	1	NOK CORPORATION engages in manufacturing, importing, and selling seal products, industrial mechanical parts, hydraulic and pneumatic equipment, nuclear power equipment, synthetic chemicals, and electronic and other products. The company is headquartered in Tokyo, Japan.

General Motors

Partner	No of patents shared	Brief of the company
BMW	32	Bayerische Motoren Werke AG, is a German automobile, motorcycle and engine manufacturing company founded in 1916. BMW is headquartered in Munich, Bavaria
Daimler Ag	32	Daimler AG is a German multinational automotive corporation. Daimler AG is headquartered in Stuttgart, Baden-Württemberg, Germany

Daimler Ag

Partner	No of patents shared	Brief of the company

BMW	32	Bayerische Motoren Werke AG, is a German automobile, motorcycle and engine manufacturing company founded in 1916. BMW is headquartered in Munich, Bavaria
General Motors	32	General Motors Company, commonly known as GM, is an American multinational corporation headquartered in Detroit, Michigan, that designs, manufactures, markets and distributes vehicles and vehicle parts and sells financial services

ZF

Partner	No of patents shared	Brief of the company
Volswagen	1	Volkswagen is a German automobile manufacturer headquartered in Germany. Established in 1937, Volkswagen is the top-selling and namesake marque of the Volkswagen Group is now the biggest automaker in both Germany and Europe.

Volkswagen AG

Partner	No of patents shared	Brief of the company
Karlsruher Institut für Technologie	1	KIT was created in 2009 when the University of Karlsruhe (Universität Karlsruhe), founded in 1825 as public research university and also known as "Fridericiana", merged with the Karlsruhe Research Centre Forschungszentrum Karlsruhe.
Green propulsion	1	Green Propulsion is a Belgian research and development centre specialising in battery electric and hybrid vehicles. The Imperia GP car is developed by Green Propulsion.
Robert Bosch	1	Robert Bosch GmbH or Bosch, is a German multinational engineering and electronics company headquartered in Gerlingen, near Stuttgart, Germany.
ZF friedrichshafen	1	ZF Friedrichshafen AG, also known as ZF Group, is a German car parts maker headquartered in Friedrichshafen, in the south-west German region of Baden-Württemberg.

Hyundai Motors

Partner	No of patents shared	Brief of the company
RESEARCH & BUSINESS FOUNDATION SUNGKYUNKWAN UNIVERSITY	1	Sungkyunkwan University (also known as SKKU or simply Seongdae) is a private research university with campuses in Seoul and Suwon.

Ford Motors

Partner	No of patents shared	Brief of the company
Visteon Global	1	Visteon Corporation (VC) is an American global automotive parts supply company spun off from the Ford Motor Company in 2000. It is headquartered In Van Buren Township, Michigan, USA

Denso Corporation

Partner	No of patents shared	Brief of the company
Toyota	54	Toyota Motor Corporation is a Japanese automotive manufacturer headquartered in Toyota, Aichi, Japan
Nippon Soken Inc	5	Nippon Soken Inc is a joint research institution of Denso Corporation and Toyota Motors. Soken engages research projects mainly in the fields of power trains, fuel cells, power electronics, information safety and thermal systems.
Mazda Motor Corp	2	Mazda Motor Corporation is a Japanese automaker based in Fuch?, Aki District, Hiroshima Prefecture, Japan.
Nippon Jidosha Buhin Sogo	2	Nippon Jidosha Buhin Sogo is a Japanese company designing and manufacturing power trains, engines, universal joints. The head office and factory are located in Ebina-shi (Kanagawa) and Moka-shi (Tochigi) Japan