

Methodology for identifying fossil fuel supply related technologies in patent data

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1. Structure of the cartography

This cartography has been developed by the EPO and the IEA to identify patent applications related to technologies contributing to the exploration for and extraction of fossil fuels, as well as their transformation and the delivery of fossil fuel products to users. Technologies that are designed to improve devices for the combustion or other energy-related uses of fossil fuels, including reducing their greenhouse gas emissions, are not included due to significant overlaps with energy efficiency technologies among the LCE end-use technologies. In addition, the large volume of patenting activity for fossil fuel end technologies such as engines would skew the sample heavily towards these activities. While such improvements to end-use technologies improve the attractiveness of continued fossil fuel use, many could also support non-fossil fuel energy such as bioenergy or hydrogen.

It is based on a rigorous selection of inventions that are related to the supply of fossil fuel. These inventions are further divided into three main sectors, namely “upstream”, “processing and downstream” and “transmission and distribution”, each of which are subdivided into several technology fields.

The first grouping, *upstream*, corresponds to the sourcing of fossil fuels, which include oil (petroleum oils and liquefied petroleum gas), natural gas, coal and other solid fossil fuels. It consists of inventions that are directly related to the exploration and extraction of these resources from conventional and unconventional sources. The table gives a short definition of these core technology fields.

Table 1.1

Overview of upstream technology fields

Field	Definition	Examples
Conventional oil and gas exploration and extraction	Technologies related to the exploration and extraction of conventional oil and gas	Seismography, offshore platform, earth drilling
Unconventional oil and gas exploration and extraction	Technologies related to the exploration and extraction of unconventional oil and gas	Fracking, directional drilling
Coal and solid fuels exploration and mining	Technologies related to the exploration and mining of coal	Coal separating plant, mine cars

The second grouping encompasses technologies related to *processing and downstream*, including transformation of fossil fuels into products such as motor fuels, aviation fuel, synthetic gas, hydrogen and others.

Table 1.2

Overview of processing and downstream technology fields

Field	Definition	Examples
Oil refining	Technologies related to refining of oil into combustible products for the end-user	Cracking of Hydrocarbons, Refining of Hydrocarbons
Gas conditioning	Technologies related to conditioning of gas into combustible products for the end-user	Purifying combustible gases
Solid fuel conditioning	Technologies related to conditioning of coal into combustible products for the end-user	Methods of shaping, briquetting
Coal-to-gas	Technologies related to the transformation of coal into gas for application as combustible products	Coke ovens, cooling or quenching coke
Coal-to-liquids and gas-to-liquids	Technologies related to the transformation of coal into liquids or gas into liquids for application as combustible products	Production of combustibles gases containing carbon monoxide from solid carbonaceous fuels
Hydrogen fuel production	Technologies related to the production of hydrogen as source of fuel for the end-user	Production of hydrogen by decomposition of gaseous or liquid organic compound

The third grouping, *transmission and distribution*, encompasses technologies involved in the distribution of fossil fuels to end-users via pipes, ships, fuelling stations and including fuel storage. It has been divided into eighteen different technology application fields.

Table 1.3

Overview of transmission and distribution technology fields

Field	Definition
Liquid fuel pipelines	Technologies related to transport of liquid fuel by means of pipeline
Gas fuel pipelines	Technologies related to transport of gaseous fuel by means of pipeline
Liquid fuel tanker shipping	Technologies related to transport of liquid fuel by means of ships
Liquefied gaseous fuel shipping	Technologies related to transport of gaseous fuel by means of ships
Compressed gaseous fuel shipping	Technologies related to transport of compressed gaseous fuel by means of ships
Solid fuel shipping	Technologies related to transport of solid fuel by means of ships
Road tanker liquid fuels transport	Technologies related to transport of liquid fuel by means of road vehicles
Road tanker gaseous fuels transport	Technologies related to transport of gaseous fuel by means of road vehicles
Rail tanker liquid fuels transport	Technologies related to transport of liquid fuel by means of trains
Rail tanker gaseous fuels transport	Technologies related to transport of gaseous fuel by means of trains
Rail solid fuel transport	Technologies related to transport of solid fuel by means of trains
Underground liquid fuels storage	Technologies related to underground storage of liquid fuel
Underground gaseous fuels storage	Technologies related to underground storage of gaseous fuel
Stationary tank storage for liquids	Technologies related to surface storage of liquid fuel
Stationary tank storage for gases	Technologies related to surface storage of gaseous fuel
Solid fuel storage	Technologies related to storage of solid fuel
Liquid fuel distribution (gas stations)	Technologies related to distribution of liquid fuel
Gaseous fuel distribution	Technologies related to distribution of gaseous fuel

2. Linking fossil fuel supply technologies to patent data

The cartography of fossil fuel supply technologies was created in three steps.

Step 1: Mapping the cartography to the patent classification scheme

The cartography is derived from a classification system initially developed by the IEA that has been further refined by patent classification experts from all technical areas of the EPO. The resulting concordance table contains CPC field ranges in all technical areas associated with their corresponding fields within the fossil fuel supply cartography.

Examples

CPC range	Description	Fossil fuel supply fields
E21B1/00 to E21B41/00	Earth Drilling	Upstream – conventional oil and gas exploration and extraction
C10F5/00 to C10F7/00	Drying or working-up of peat	Processing and downstream – solid fuel conditioning

Step 2: Identifying fossil fuel supply patent applications

Full-text search queries have been applied to all patent documents in the identified CPC ranges in order to identify documents related to the definition of fossil fuel supply with the highest degree of certainty. To ensure optimal coverage of the search strategy, the search queries were built in all three of the EPO official languages: English, French and German.

Step 3: Classifying patent applications to the cartography fields

Once all CPC classes relevant for fossil fuel supply have been confirmed with the patent classification experts (step 1) and when necessary with the help of a corresponding keyword search queries (step 2); a table of all these CPC fields and their descriptive has been assembled. IEA experts have then matched the CPC fields to each field of the fossil fuel supply cartography. This iterative process between the IEA and the EPO ensured an accurate matching between the fields of the cartography and the CPC classes by the patent classification experts. Data was then extracted in a single dataset with corresponding labelling of the fossil fuel supply cartography.

The granularity developed in the cartography is crucial for both an accurate construction of a dataset at aggregated level and for potential future studies.

3. Concordance table of CPC ranges and fossil fuel supply fields

In the following table, the CPC classes have been associated to the fossil fuel supply cartography developed with IEA. The CPC classes requiring additional filtering are indicated. Some CPC classes do not require any additional filtering and correspond as a whole to fossil fuel supply; whereas other require filtering CPC classes either including and/or excluding search queries as defined in chapter 4.

A marker “/LOW” has been placed at the end of some of the CPC classes below; this indicates that for each of these CPC classes not only the class itself but also its respective subclasses should be taken into account for the corresponding cartography label.

Fossil fuel supply category	Fossil fuel supply subcategory	CPC class/range	Filtering including queries (Chapter 4)	Filtering excluding queries (Chapter 4)
Upstream	Conventional oil and gas exploration and extraction	B03B9/02		
		B03D2203/006		
		B63B35/4413	[1], [2], [4]	
		B63B2035/442	[1], [2], [4]	
		B63B2035/448	[1], [2], [4]	
		B63B75/00	[1], [2], [4]	
		C09K8/low		
		C10L5/04		
		E02B17/00	[1], [8]	[12]
		E02B17/0004 to E02B2017/0039/low	[1], [8]	[12]
		E02B2017/0056/low to E02B2201/00/low	[1], [8]	[12]
				E21B43/26/low OR E21B7/04/low OR E21B7/06/low OR E21B43/16/low OR E21B43/24/low OR E21B43/006 OR E21B41/0099
		E21B1/00/low to E21B41/00/low	[1], [2], [4], [8]	
				E21B43/26/low OR E21B7/04/low OR E21B7/06/low OR E21B43/16/low OR E21B43/24/low OR E21B43/006 OR E21B41/0099
		E21B43/00	[1], [2], [4], [8]	

Fossil fuel supply category	Fossil fuel supply subcategory	CPC class/range	Filtering including queries (Chapter 4)	Filtering excluding queries (Chapter 4)
Upstream	Conventional oil and gas exploration and extraction	E21B43/003	[1], [2], [4], [8]	E21B43/26/low OR E21B7/04/low OR E21B7/06/low OR E21B43/16/low OR E21B43/24/low OR E21B43/006 OR E21B41/0099
		E21B43/006	[1], [2], [4], [8]	E21B43/26/low OR E21B7/04/low OR E21B7/06/low OR E21B43/16/low OR E21B43/24/low OR E21B43/006 OR E21B41/0099
		E21B43/01/low	[1], [2], [4], [8]	E21B43/26/low OR E21B7/04/low OR E21B7/06/low OR E21B43/16/low OR E21B43/24/low OR E21B43/006 OR E21B41/0099
		E21B43/02/low to E21B43/12/low	[1], [2], [4], [8]	E21B43/26/low OR E21B7/04/low OR E21B7/06/low OR E21B43/16/low OR E21B43/24/low OR E21B43/006 OR E21B41/0099
		E21B43/14	[1], [2], [4], [8]	E21B43/26/low OR E21B7/04/low OR E21B7/06/low OR E21B43/16/low OR E21B43/24/low OR E21B43/006 OR E21B41/0099
		E21B43/16/low	[1], [2], [4], [8]	E21B43/26/low OR E21B7/04/low OR E21B7/06/low OR E21B43/16/low OR E21B43/24/low OR E21B43/006 OR E21B41/0099
		E21B43/25/low	[1], [2], [4], [8]	E21B43/26/low OR E21B7/04/low OR E21B7/06/low OR E21B43/16/low OR E21B43/24/low OR E21B43/006 OR E21B41/0099
		E21B43/28/low to E21B43/34/low	[1], [2], [4], [8]	E21B43/26/low OR E21B7/04/low OR E21B7/06/low OR E21B43/16/low OR E21B43/24/low OR E21B43/006 OR E21B41/0099
		E21B44/00/low to E21B49/00/low	[1], [2], [4], [8]	E21B43/26/low OR E21B7/04/low OR E21B7/06/low OR E21B43/16/low OR E21B43/24/low OR E21B43/006 OR E21B41/0099

Fossil fuel supply category	Fossil fuel supply subcategory	CPC class/range	Filtering including queries (Chapter 4)	Filtering excluding queries (Chapter 4)
Upstream	Unconventional oil and gas exploration and extraction	E21B43/26/low	[1], [2], [4], [8]	
		E21B7/04/low	[1], [2], [4], [8]	
		E21B43/16/low	[1], [2], [4], [8]	
		E21B43/006	[1], [2], [4], [8]	
		E21B41/0099	[1], [2], [4], [8]	
	Coal and solid fuels exploration and mining	B03B9/005		
		B03B1/00/low	[1], [3]	
		B03D2203/08		
		B61D11/00/low	[1], [3]	
		E21C25/00/low to E21C51/00/low	[1], [3]	
Processing and downstream	Oil refining	C10G2/00/low to C10G99/00/low		
		C10G1/00, C10G1/002 to C10G1/042, C10G1/047 to C10G1/10		
		C10L1/00/low	[1], [2], [5]	[10] OR C10L2200/0469/low
	Gas conditioning	C10K1/00/low		
		C10K3/00/low		
		C10L3/06/low	[4], [6]	[10] OR C10L2200/0469/low
		F25J3/0209/low		
		F25J3/061/low		
	Solid fuel conditioning	C10F5/00/low to C10F7/00/low		
		C10L5/06/low	[3], [7]	[10] OR C10L2200/0469/low
		C10L5/24	[3], [7]	[10] OR C10L2200/0469/low
		C10L5/26/low	[3], [7]	[10] OR C10L2200/0469/low
		C10L5/34/low	[3], [7]	[10] OR C10L2200/0469/low
	Coal-to-gas	C10B1/00/low to C10B51/00/low		
		C10B53/04 to C10B53/08		
		C10B55/00/low to C10B57/00/low		
		C10J1/00/low to C10J3/00/low		
	Coal-to-liquids and gas-to-liquids	C01B3/22/low	C01B2203/062	
		C01B3/32/low	C01B2203/062	
		C10J3/00/low	C10G2/30/low	
	Hydrogen fuel production	C01B3/22/low		
		C01B3/32/low		

Fossil fuel supply category	Fossil fuel supply subcategory	CPC class/range	Filtering including queries (Chapter 4)	Filtering excluding queries (Chapter 4)
Transmission and distribution	Liquid fuel pipelines	B63B27/34	[2], [5]	
		B63B27/24/low	[2], [5]	
		F17D1/00/low to F17D5/00/low	[2], [5]	
	Gas fuel pipelines	B63B27/24/low	[4], [6]	
		F17D1/04/low	[4], [6]	
		F17D1/065/low	[4], [6]	
	Liquid fuel tanker shipping	B63B25/08/low	[2], [5]	
		B67D9/00/low	[2], [5]	
	Liquefied gaseous fuel shipping	F25J1/0022/low		
	Compressed gaseous fuel shipping	B63B2025/087	[4], [6]	
		B63B25/14	[4], [6]	
		B63B25/16	[4], [6]	
	Solid fuel shipping	B63B25/04	[3]	
	Road tanker liquid fuels transport	B60P3/22/low	(+tank+ OR reservoir OR citerne) s [5]	
	Road tanker gaseous fuels transport	B60P3/22/low	(+tank+ OR reservoir OR citerne) s [6]	
	Rail tanker liquid fuels transport	B61D5/00/low	[2], [5]	
		B61D3/00/low	[2], [5]	
		B61D15/00/low	[2], [5]	
		B61D49/00/low	[2], [5]	
	Rail tanker gaseous fuels transport	B61D3/00/low	[4], [6]	
		B61D15/00/low	[4], [6]	
		B61D49/00/low	[4], [6]	
	Rail solid fuel transport	B61D7/00/low	[3], [7]	
		B61D9/00/low	[3], [7]	
		B61D3/00/low	[3], [7]	
		B61D15/00/low	[3], [7]	
		B61D49/00/low	[3], [7]	
	Underground liquid fuels storage	B65G5/00/low	[1], [2], [5]	
	Underground gaseous fuels storage	F17C2270/0142/low	[4], [6]	
	Stationary tank storage for liquids	E02D27/38	[2], [5]	
Transmission and distribution	Stationary tank storage for gases	F17B1/26	[4], [6]	
		F17C1/00/low to F17C13/00/low	[4], [6]	
		F17C2221/032/low		
	Solid fuel storage	B65G3/00/low	[3], [7]	
	Liquid fuel distribution (gas stations)	G01M3/2892		
		G01M3/32/low	[5]	
	Gaseous fuel distribution	F17C2265/06/low	[4], [6]	

4. Full text queries

The cartography for fossil fuel supply developed with IEA distinguishes between fuel types: liquid, solid or gas.

Also, as a matter of efficiency, the different queries developed by the patent classification experts could be sorted in accordance with the supply stage of the fossil fuel: at extraction stage, at transport stage or at end-user stage. Accordingly, the search queries could be concentrated in 13 search queries adapted for the different CPC fields.

4.1 English queries

To be applied to the corresponding CPC Fields	
Queries in English	Corresponding short label
fossil OR (non w renewable) OR hydrocarbon? OR petrol+	[1]
petroleum OR (crude w oil) OR oil	[2]
coal OR mineral? OR coke OR peat OR BKB OR briquette OR asphaltite OR ortholignite OR metaanthracite OR lignite OR hardcoal OR browncoal OR (brown w coal) OR (oil 2w deposit) OR (oil w bear+) OR bitumen OR bituminous OR (tar w sand) OR (oil w sand)	[3]
methane OR (natural w gas) OR hydrate? OR (petroleum w gas+) OR hydrogen OR (boil 2w gas+) OR BOG OR LNG OR LPG OR (liqui+ 2w (fuel? OR petroleum)) OR (liqui+ 2w gas+) OR (gaseous w fuel?)	[4]
LNG OR LPG OR (liquid w fuel?) OR diesel OR gasoline OR (jet w fuel?) OR (fuel w oil) OR (bunker w fuel?) OR kerosene OR (oil w product?) OR octane OR cetane OR propane OR butane	[5]
methane OR (natural w gas+) OR CNG OR LNG OR PLNG OR propane OR butane OR LPG OR Hydrate? OR (petroleum w gas+) OR hydrogen OR liquefied OR (compressed w gas+)	[6]
coal OR BKB OR briquette OR asphaltite, ortholignite OR metaanthracite OR lignite OR hardcoal OR browncoal	[7]
drilling OR offshore OR onshore OR oil OR hydrocarbon? OR gas+ OR subsea OR seabed OR reservoir OR petroleum OR methane OR formation OR riser? OR (well w head) OR bop OR (blowout w prevent+) OR fracturing OR frack+ OR ((bottom OR down) w hole)	[8]
(oil 3w (spill?, containment?)) OR hydrocarbon? OR petrol+ OR (crude w oil) OR (light w oil) OR (hazardous w material?) OR chemical? OR (raw w oil) OR tanker? OR (liquid w pollutant?) OR ((subsea OR underwater) w emission?)	[9]
biomass OR biofuel OR bioethanol OR biodiesel	[10]
plastic OR (floating w debris) OR (floating w waste) OR leaves OR (solid w waste) OR (waste w matter) OR (floating w matter) OR pollutant?	[11]
(wind w turbine) OR tower OR mast OR ((power OR electric) 3w generat+)	[12]
(tar w sand?) OR (oil w sand?) OR (bituminous w sand?) OR frack+ OR (produced w water) OR drilling	[13]

4.2 French queries

To be applied to the corresponding CPC Fields	
Queries in French	Corresponding short label
fossile? OR (non w renouvelable?) OR hydrocarbure? OR pétrol+	[1]
pétrol+ OR brut OR huile	[2]
charbon OR mineral+ OR coke+ OR houill+ OR tourb+ OR (briqueette 2w lignite) OR briqueette? OR asphalt+ OR +anthracite OR lignite OR (veine? 2w charbon) OR (dépôt? 2w (huile OR charbon)) OR bitum+ OR (bassin 3w houill+)	[3]
méthane OR ((gas OR gaz) w naturel?) OR hydrate? OR ((gas OR gaz) 3w pétrol) OR hydrogène OR ((gas OR gaz) 2w évaporation) OR GNL OR GPL OR ((gas OR gaz) 2w liquéf+)	[4]
GNL OR ((gas OR gaz) 2w liquéf+) OR GPL OR diesel OR gasoil OR essence OR (sans w plomb) OR kéro+ OR fioul? OR mazout+ OR (produit? 3w pétrol+) OR octane OR cétane OR combustible? OR carburant? OR propane OR butane	[5]
méthane OR ((gas OR gaz) w naturel?) OR hydrate? OR ((gas OR gaz) 3w pétrol) OR hydrogène OR ((gas OR gaz) 2w comprimé?) OR GNC OR GNL OR propane OR butane OR GPL OR hydrogène OR liquéf+	[6]
charbon OR briqueette? OR asphalt+ OR ortholignite, anthracite OR lignite OR tourb+ OR bitum+ OR houill+	[7]
forage OR offshore OR onshore OR huile OR hydrocarbure? OR (gas OR gaz) OR (sub w surface) OR (sous w marin) OR (plancher w océan+) OR (fond? w mar+) OR réserv+ OR pétrol+ OR méthan+ OR formation? OR tube? OR (tête? 2w puit?) OR obturateur? OR érupt+ OR fractur+ OR frack+ OR (fond 2w trou)	[8]
(marée w noire) OR ((pollution?, dévers+) 3w pétrol+) OR hydrocarbure? OR pétrol+ OR huile? OR brut OR (huile? w légère?) OR ((matér+ OR matière? OR produit?) w (dangereu? OR chimique? OR pétrol+)) OR tanker? OR (liquide? W polluant?) OR (pollution? 3w (sous w marine))	[9]
biomasse OR biodiesel OR bioéthanol	[10]
plastique? OR (déchet? w (flottant? OR solide?)) OR déchet? OR polluant? OR feuilles OR (objet? W flottant?)	[11]
éolien+ OR mât? OR pylône? OR ((génér+ OR produ+) 3w électricité)	[12]
bitumineux OR frack+ OR (eau 2w production) OR forage?	[13]

4.3 German queries

To be applied to the corresponding CPC Fields	
Queries in German	Corresponding short label
fossil? OR (nicht w erneuerbar?) OR kohlenwasserstoff+ OR benzin+ or ottokraftstoff+	[1]
petroleum OR erdöl OR erdoel OR rohöl OR öl OR oel	[2]
kohle+ OR mineral? OR koks OR torf+ OR brikett+ OR presskohle+ OR asphaltit+ OR braunkohle+ OR rohbraunkohle+ OR weichbraunkohle+ OR anthrazit+ OR steinkohle+ OR ((öl or oel) 2w ablagerung+) OR ölablagerung+ OR oelablagerung+ OR oelhaltig+ OR ölhaltig OR bitumen OR erdharz OR erdpech OR bituminös OR teersand+ OR (teer w sand+) OR oilsand+ OR ölsand+ OR erdölsand+	[3]
methan OR naturgas OR erdgas OR hydrat+ OR erdölgas OR ölgas OR oelgas OR wasserstoff OR (boil 2w off) OR (LNG w abdampf+) OR BOG OR LNG OR LPG OR flüssiggas+ OR fluessiggas+ OR propangas+ OR flüssigbrennstoff+ OR (brenn+ w gas) OR brenngas	[4]
LNG OR LPG OR flüssigbrennstoff+ OR diesel OR benzin OR ottokraftstoff OR gasolin OR motorenbenzin OR flugzeugtreibstoff OR düsentreibstoff OR schweröl OR schweroel OR heizöl OR heizuel or bunkeröl OR bunkeroel or treiböl OR marinedieselöl OR kerosin OR flugturbinenkraftstoff OR ölprodukt+ OR oelprodukte OR oktan OR cetan OR propan+ OR butan+	[5]
methan OR naturgas OR CNG OR LNG OR PLNG OR propan+ OR butan+ OR LPG OR hydrat? OR erdgas OR erdölgas OR wasserstoff OR verflüssigt OR druckgas OR (komprimiertes w erdgas) OR druck?erdgas	[6]
kohle+ OR brikett+ OR presskohle+ OR asphaltit+ OR braunkohle+ OR rohbraunkohle+ OR weichbraunkohle+ OR anthrazit+ OR steinkohle+	[7]
bohrung+ OR bohren OR offshore OR öl OR oel OR kohlenwasserstoff+ OR gas+ OR tiefsee OR untersee+ OR meeres+ OR ((meeres or ozean) w (grund or boden)) OR reservoir+ OR lagerstätte+ OR speicher+ OR petroleum OR methan OR formation+ OR steigleitung+ OR steigrohr+ OR bohrloch+ OR ausbruchschieber OR bohrlochsicherungsgarnitur+ OR bohrlochschieber OR ausbruchschieber OR fract+ OR brechen OR aufbrechen OR frack+ OR bohrlochsohle+ OR schrägbohrloch OR schrägbohrlöcher OR schrägloch OR schräglöcher	[8]
ölverschmutzung+ OR oelverschmutzung+ OR ölpest OR oelpest OR ölkatastrophe+ OR ölspill OR ölbekämpfung+ OR ((öl OR oel) w (eindämm+ OR eingrenz+ OR zurückhalt+)) OR kohlenwasserstoff+ OR benzin+ OR ottokraftstoff+ OR erdöl OR erdoel OR rohöl OR leichtöl OR leichtoel OR (umweltgefährdende+ w stoff+) OR gefahrstoff+ OR gefahrgut+ OR gefahrgüter+ OR (gesundheitsgefährdend+ w stoff+) OR chemisch+ OR rohöl OR rohoel OR tanker OR tankschiff+ OR tankwagen OR (flüssig+ w (verunreinigung+ or verschmutzung+ or kontaminant+)) OR ((unterseeisch+ OR meeres+ OR unterwasser+) w (emission+ OR austritt+ OR aussto+))	[9]
biomasse OR biotreibstoff+ OR biokraftstoff+ OR biodiesel OR bioethanol	[10]
plastik+ OR kunststoff+ OR ((schwimmend+ OR treibend+) w (trümmer+ OR abfall+ OR müll+)) OR blätter OR laub OR feststoffabf+ OR (feste+ w abfall+) OR festmüll OR festabf+ OR verunreinigung+ OR verschmutzung+ OR kontaminant+ OR schadstoff+ OR schutzstoff OR umweltschadstoff+	[11]
(wind w turbine+) OR turm OR türme OR mast OR masten OR (elektrisch+ 3w (generat+ OR stromgenerat+ OR erzeuger OR stromerzeuger))	[12]
bituminös OR teersand+ OR (teer w sand+) OR oilsand+ OR ölsand+ OR erdölsand+	[13]

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