E-Jet family fuel-burn performance

The fuel-burn performance of the E-Jet's four variants is analysed on three routes of 207-645nm.

Analysis of the fuel-burn performance of the four E-Jets family members reveals that, for a given distance, the fuel burn per seat-mile is influenced by several factors that include, but are not limited to: operating empty weight (OEW); engine power; weather; and cruise speed.

Aircraft variants

There are four basic variants of the E-Jets family: the E-170, E-175, E-190 and E-195. The E-170/-175 are certified as one type, and the E-190/-195 are certified as another. Standard models have been used for each of the variants.

All the aircraft variants are powered by CF34 engine family. The E-170/-175 aircraft are powered by the CF34-8EA1, while the E-190/-195 are powered by the CF34-10E. The increase in engine thrust for these two larger aircraft is reflected in their higher maximum take-off weights (MTOW). This goes from about 79,000lbs for the E-170 to just over 105,000lbs for the E-195. The OEW and maximum payload for each aircraft variant also increase with thrust, although the range does not follow the same pattern. The fuel capacity is the same for E-170 and E-175 and the E-190 and E-195.

There will be many different thrust and MTOW variants used by different airlines. The basic specifications, as pre-loaded in Jeppesen and as stated by the manufacturer, have been used for these calculations.

Flight profiles

Aircraft performance has been analysed both inbound and outbound for each route in order to illustrate the effects of wind speed, and its direction, on the distance flown. The resulting distance is referred to as the equivalent still air distance (ESAD) or nautical air miles (NAM).

Average weather for the month of June has been used, with 85% reliability winds and 50% reliability temperatures used for that month in the flight plans produced by Jeppesen. The flight profiles in each case are based on International Flight Rules, which include standard assumptions on fuel reserves, diversion fuel and contingency fuel. Having said that, the fuel burn used for the analysis of each sector just includes the fuel used for the trip and taxiing. The optimum routes and levels have been used for every flight, except where it has been necessary to restrict the levels due to airspace or airway restrictions and to comply with standard routes and Eurocontrol restrictions.

A taxi time of 20 minutes has been factored into the fuel burns and added to the flight times to provide block times. The flight plans have all been calculated using long-range cruise (LRC). Although other speeds are more likely on shorter routes, LRC has been chosen so that all routes can be equally compared for all variants without the need to adapt payload figures. LRC enables an aircraft to use less fuel per nautical mile, which means longer block times, but this is the economical and operational compromise between fuel consumption and flight times.

The aircraft being assessed are assumed to have a single-class cabin with a full passenger load of 80 on the E-170, 88 on the E-175, 114 on the E-190 and 122 on the E-195. The standard weight for each passenger and their luggage is assumed, on these short-haul flights, to be 200lbs per person, with no additional cargo in the hold. The payload carried is therefore 16,000lbs for the E-170, 17,600lbs for the E-175, 22,800lbs for the E-190 and 24,400lbs on the E-195. These are maximum seat capacities for the four variants. Most airlines configure their aircraft with fewer seats than this, but a smaller difference in passenger numbers has only a small effect on resulting fuel burn. The passenger numbers chosen still allow an illustrative comparison of fuel-burn performance to be made.

Route analysis

Three routes of varying lengths were analysed, with tracked distances of 207-645nm. All three routes are between the UK and France, and were picked to examine the fuel burn per seat-mile with increasing mission lengths. All the routes are typical of operators of the E-Jets family, which tend to have average flight cycle times of 1.45 flight hours (FH). All routes have been analysed in both directions, in order to provide a better

The largest E-Jets variants have fuel burn per seat superior to that of the smallest jetliners, while the smaller variants outperform most similar-sized regional types.

FUEL-BURN PERFORMANCE OF THE E-JET FAMILY

City-pair	Aircraft variant	Engine model	MTOW lbs	TOW lbs	Fuel burn USG	Block time mins	Seats	Payload lbs	ESAD nm	Fuel per seat	Fuel per seat-mile	Wind speed kts
SOU-CDG	E-170	CF34-8E5A1	79,178	66,273	523	58	80	16,000	207	6.543	0.032	-5
SOU-CDG	E-175	CF34-8E5A1	82,500	69,471	565	57	88	17,600	207	6.425	0.031	-5
SOU-CDG	E-190	CF34-10E5A1	105,138	89,366	633	57	114	22,800	207	5.551	0.027	-5
SOU-CDG	E-195	CF34-10E5	107,338	92,862	624	57	122	24,400	207	5.116	0.025	-5
CDG-SOU	E-170	CF34-8E5A1	79,178	66,545	539	60	80	16,000	223	6.741	0.032	-29
CDG-SOU	E-175	CF34-8E5A1	82,500	69,762	584	60	88	17,600	223	6.632	0.032	-29
CDG-SOU	E-190	CF34-10E5A1	105,138	89,700	653	59	114	22,800	223	5.724	0.028	-28
CDG-SOU	E-195	CF34-10E5	107,338	93,087	646	59	122	24,400	224	5.297	0.025	-28
EXT-EGC	E-170	CF34-8E5A1	79,178	68,267	749	86	80	16,000	415	9.368	0.023	-2
EXT-EGC	E-175	CF34-8E5A1	82,500	71,581	805	84	88	17,600	415	9.152	0.022	-2
EXT-EGC	E-190	CF34-10E5A1	105,138	91,959	920	83	114	22,800	415	8.071	0.019	-1
EXT-EGC	E-195	CF34-10E5	107,338	95,395	910	84	122	24,400	415	7.461	0.018	-2
EGC-EXT	E-170	CF34-8E5A1	79,178	68,429	794	94	80	16,000	437	9.929	0.024	-23
EGC-EXT	E-175	CF34-8E5A1	82,500	71,710	847	93	88	17,600	438	9.622	0.024	-22
EGC-EXT	E-190	CF34-10E5A1	105,138	92,114	971	90	114	22,800	437	8.514	0.021	-23
EGC-EXT	E-195	CF34-10E5	107,338	95,591	962	91	122	24,400	438	7.886	0.019	-23
BHX-TLS	E-170	CF34-8E5A1	79,178	70,103	967	112	80	16,000	606	12.091	0.020	-2
BHX-TLS	E--175	CF34-8E5A1	82,500	73,490	1,033	111	88	17,600	605	11.737	0.019	-2
BHX-TLS	E-190	CF34-10E5A1	105,138	94,274	1,196	111	114	22,800	607	10.491	0.017	-3
BHX-TLS	E-195	CF34-10E5	107,338	97,717	1,186	111	122	24,400	607	9.722	0.016	-3
TLS-BHX	E-170	CF34-8E5A1	79,178	70,498	1,059	125	80	16,000	676	13.235	0.021	-17
TLS-BHX	E-175	CF34-8E5A1	82,500	73,949	1,136	125	88	17,600	675	12.907	0.020	-17
TLS-BHX	E-190	CF34-10E5A1	105,138	94,778	1,313	121	114	22,800	672	11.513	0.018	-17
TLS-BHX	E-195	CF34-10E5	107,338	98,320	1,315	121	122	24,400	673	10.776	0.017	-17

Source: Jeppesen

picture of each aircraft's fuel burn, and the effect of wind.

The first route to be analysed, and the shortest, is Southampton, UK (SOU) to Charles De Gaulle, Paris, France (CDG). This route has a tracked distance of 207nm on the outbound sector and 208nm on the return sector, and is typical of the routes operated by Flybe. There were headwinds of 5 knots on the outbound sector (which seems to have had no effect on the ESAD, which remains at 207nm), but stronger headwinds of 28-29 knots on the return sector (which meant that the ESAD distances increased to 223-224nm). The winds have had a very small effect on the resulting block times, with block times, for all four variants, being close at 57-60 minutes.

The second route was Exeter, UK (EXT) to Bergerac, France (EGC), which is again a route operated by Flybe. The tracked distance is 415nm on the outbound sector, and a shorter 408nm on the return sector, the difference arising from a longer outbound flight routing due to tracks. The outbound sector had headwinds of 1-2 knots that left the ESAD unchanged at 415nm.

The return sector still had much stronger headwinds of 22-23 knots, meaning that the ESAD increased to 437-438nm, despite a shorter tracked distance. Block times on the outbound sector were 83-86 minutes, and with a 7-9-minute longer block time to 90-94 minutes on the return leg.

The third, and longest, route is Birmingham, UK (BHX) to Toulouse, France (TLS). Again this route is typical of the ones operated by Flybe. The outbound distance is 605nm, which, with a slight headwind of 2-3 knots, allows the ESAD to remain similar at 605-607nm. The return sector has a tracked distance of 645nm, but, due to stronger headwinds of 17 knots, the ESAD increases to 672-676nm.

Fuel-burn performance

The fuel-burn performance of the four E-Jet variants is shown for all three routes, both outbound and inbound. The data also include the associated fuel burn per passenger and fuel burn per passenger-mile for both sectors on each route. The fuel burn increases on all sectors as the power and size of aircraft increase, but this is not necessarily the case for fuel burn per passenger or passenger-mile.

On all six sectors, the fuel-burn performance is similar, with the E-170 always burning the least fuel, followed by the E-175. On all except the inbound sector of the last route (which has very close fuel-burn data for both the E-190 and E-195), the E-195 comes third, followed by the E-190.

The lowest fuel burn per seat can predictably be found on the shorter-length route with the E-195 on the outbound sector. The burn per seat on the same route increases with decreasing aircraft size. So the E-170 has the highest burn per seat in all cases.

The highest fuel burn per seat was, also predictably, on the longest route and on the return sector for the E-170, in particular *(see table, this page)*.

The best indication of fuel-burn performance is burn per passenger seat-mile. For this, the best results overall were found on the longer sectors and the worst on the shorter sectors.

For the first, and shortest, route the best performer was the E-195 with 0.025USG per seat-mile. This was followed by the E-190, then the E-175 and finally the E-170 with 0.032USG per seat-mile *(see table, this page)*.

For the second route, the order remained the same with the E-170 getting 0.023-0.024USG per seat-mile, and the E-195 gaining 0.018-0.019USG per seat-mile.

On the last and longest route, the performance order again remained unchanged. The E-170 used 0.02USG per seat-mile and the E-195 used 0.016-0.017USG per seat-mile *(see table, this page)*. AC